

**Government of the People's Republic of Bangladesh
Local Government Engineering Department**

(.....Name of Project.....)

**TENDER DOCUMENTS FOR PROCUREMENT OF WORKS
FOR**

CONSTRUCTION OF ** AND RELATED WORKS OF
*** SUBPROJECT (SP ID- ***)
UNDER UPAZILA: ***, DISTRICT: *****

VOLUME 1 OF 2

Invitation for Tender No: _____

Issued to: _____, on _____

Tender Package No:

LGED/ (...project name...) /(.... Loan No. ...)/..year../SP.... – Structures

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<i>This work shall comprise of boring and construction of bored cast in place piles for foundation of the bridge structures. The item includes the provisions of all labour, materials, equipment, boring and all incidentals necessary to complete the work in accordance with these Specifications, in conformity with the requirements of the Drawings, as required in the other places of the Contract Document and/or as per direction of the Engineer.....</i>	
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When reinforcing dowels grouted in to holes drilled in the existing concrete is required at such construction joints, the holes shall be drilled by methods that will not damage the concrete around the holes. The diameters of the holes shall be 6mm larger than the nominal diameter of the dowels unless shown otherwise on the Drawings. The dowel bars shall be round mild steel bar of the diameter and length as indicated on the Drawings and/or as per the directions of the Engineer. The grout shall be a neat cement paste of Portland cement and water or an epoxy. Immediately prior to placing the dowel bars, the holes shall be cleaned off dust and other deleterious materials, shall be thoroughly saturated with water, have all free water removed and shall be dried to a saturated surface dry condition. Sufficient grout or an epoxy shall be placed inside the holes so as not to remain any void after the dowels are inserted. Grout shall be cured for a period of at least 3 (three) days or until dowel bars are encased in concrete. When an epoxy is used, the mixing and placing shall conform to the manufacturer's recommendations.	
	654

When forms at construction joints overlap previously placed concrete, they shall be re-tightened before depositing new concrete. Exposed face edges of all joints shall be neatly formed with straight bulk heads or grade strips, or otherwise properly finished true to line and elevation.	654
<i>Construction Joints shall not be measured. Expansion and Contraction joints shall be measured in linear meter of the joints. There will be no additional measurement for joint fillers, sealed joints, Water Stops, miscellaneous metal devices etc.</i>	<i>658</i>
20. REPAIR OF EXISTING CONCRETE STRUCTURES	660
<i>Concrete shall conform to the specifications contained in the Sub-section on 'Concrete for Structures' of this Specification.</i>	<i>660</i>
<i>Cement mortar shall comply with the specifications contained in the Sub-section on 'Brick Masonry Works' of this Specification except that the mix may vary as shown on the Drawings.</i>	<i>660</i>
<i>The Contractor and the Engineer shall jointly survey structures to be repaired and the location of all repairs shall be permanently marked in paint on each structure. The repair works shall be carried out by skilled and experienced personnel well conversant with this work.</i>	<i>660</i>
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Section 1. Instructions to Tenderers

A. General

- 1. Scope of Tender**
 - 1.1 The Procuring Entity, as indicated in the Tender Data Sheet (**TDS**) issues this Tender Document for the procurement of Works and associated Services incidental thereto as specified in the **TDS** and as detailed in **Section 9: Bill of Quantities**. The name of the Tender and the number and identification of its constituent lot(s) are stated in the **TDS**.
- 2. Corrupt, Fraudulent, Collusive or Coercive Practices**
 - 2.1 The Government requires that Procuring Entities, as well as Tenderers and Suppliers shall, during the Procurement proceedings and the execution of Contracts under public funds, ensure-
 - (a) strict compliance with the provisions of Section 64 of the Public Procurement Act 2006 (Act 24 of 2006);
 - (b) abiding by the code of ethics as mentioned in the Rule 127 of the Public Procurement Rules, 2008;
 - (c) that neither it's any officer nor any staff or any other agents or intermediaries working on its behalf engages in any practice as detailed in the Rule 127.
 - 2.2 If corrupt, fraudulent, collusive or coercive practices of any kind determined by the Procuring Entity against any Tenderer alleged to have carried out such practices, the Procuring Entity shall -
 - (a) exclude the concerned Tenderer from further participation in the particular Procurement proceeding; or
 - (b) reject any recommendation for award that had been proposed for that concerned Tenderer;
or
 - (c) declare, at its discretion, the concerned Tenderer to be ineligible to participate in further Procurement proceedings, either indefinitely or for a specific period of time.
- 3. Eligible Tenderers**
 - 3.1 If so specified in **TDS**, only Enlisted Tenderers of the categories specified in the **TDS** are eligible to participate in the Tender under **Limited Tendering Method**.
 - 3.2 In case of **Open Tendering Method**, invitation for Tenders is open to all potential Tenderers.
 - 3.3 The Tenderer shall have the legal capacity to enter into the Contract.
 - 3.4 Tenderers and all parties constituting the Tenderer shall not have a conflict of interest pursuant to Rule 55 of the Public Procurement Rules, 2008.

- 3.5 The Tenderer in its own name or its other names or also in the case of its Persons in different names, shall not be under a declaration of ineligibility for corrupt, fraudulent, collusive or coercive practices as stated under ITT Clause 2.
- 3.6 The Tenderer is solvent, e.g. the Tenderer is financially capable to perform the contract for the proposed Procurement.
- 3.7 The Tenderer shall have fulfilled its obligations to pay taxes under the provisions of laws and regulations of Bangladesh.

B. Tender Document

- 4. **Clarification of Tender Document**
 - 4.1 A prospective Tenderer requiring any clarification of the Tender Document shall contact the Procuring Entity in writing at the Procuring Entity's address indicated in the **TDS** before two-third of time allowed for preparation and submission of Tender elapses.
- 5. **Addendum to Tender Document**
 - 5.1 At any time prior to the deadline for submission of Tenders, the Procuring Entity on its own initiative or in response to a clarification request in writing from a Tenderer, may revise the Tender Document by issuing an addendum pursuant to Rule 95 of the Public Procurement Rules, 2008.

C. Qualification Criteria

- 6. **General**
 - 6.1 Tenderer to be qualified by meeting predefined, precise minimum requirements, which entails setting pass/fail criteria, which if not met by the Tenderer, will be considered as non-responsive.
 - 6.2 To qualify for a multiple number of lots in a package for which Tenders are invited in the invitation for Tenders, the Tenderers shall demonstrate having resource and experience sufficient to meet the aggregate of the qualifying criteria for individual lots.
- 7. **Experience Criteria**
 - 7.1 The Tenderer shall have the construction experience of satisfactory completion of similar works of a minimum value under a single or multiple numbers of contracts over a period, as specified in the **TDS**.
- 8. **Financial Criteria**
 - 8.1 The Tenderer shall have the following minimum level of financial capacity to qualify for the performance of the Works under the Contract.
 - (a) the average annual construction turnover as specified in the **TDS** during the period specified in the **TDS**
 - (b) availability of minimum liquid assets or working capital or credit facilities from a Bank, as specified in the **TDS**.
- 9. **Subcontractor(s)**
 - 9.1 The successful Tenderer shall under no circumstances assign the Works or any part of it to the Subcontractor(s).

D. Tender Preparation

10. Only one Tender	10.1 The Tenderer who submits or participates in more than one (1) Tender in one (1) lot will cause all the Tenders of that particular Tenderer to be rejected
11. Language of Tender	11.1 The Tender shall be written in the English language. Correspondences and documents relating to the Tender may be written in English or <i>Bangla</i> .
12. Contents of Tender	12.1 The Tender prepared by the Tenderer shall comprise the following: (a) Tender Submission Letter (Form PW2-1), which shall be completed without any alterations to its format, filling in all blank spaces with the information requested, failing which the Tender may be considered as non-responsive as being incomplete; (b) Tenderer Information (Form PW2-2); (c) The priced Bill of Quantities using the form(s) furnished in Section 9: Bill of Quantities; (d) Tender Security as stated under ITT Clauses 17 & 18; (e) Valid Trade License; (f) The original and copy of the Tender, signed by the Person duly authorized to sign on behalf of the Tenderer. This authorization shall consist of a written authorization and shall be attached to the Tender Submission Letter (Form PW2-1); (g) an affidavit confirming that the Tenderer is not insolvent as stated under ITT Sub Clause 3.6; (h) a certificate, that the Tenderer is a Tax payer having valid Tax Identification Number (TIN) and VAT registration number as a proof of fulfilment of taxation obligations as stated under ITT Sub Clause 3.7; (i) Documentary evidence as stated under ITT Clause 15; and (j) any other document as specified in the TDS.
13. Tender Prices	13.1 The Tenderer shall fill in unit rates or prices for all items of the Works both in figures and in words as described in the BOQ. The price to be quoted in the Tender Submission Letter shall be the total price of the Tender. 13.2 All applicable taxes, custom duties, VAT and other levies payable by the Contractor under the Contract shall be included in the unit rates, prices and the total Tender price submitted by the Tenderer. 13.3 The items quantified in the BOQ for which no unit rates or prices have been quoted by the Tenderer will not be paid for, by the Procuring Entity when executed and shall be deemed covered by the amounts of other rates or prices in the BOQ and, it shall not be a reason to change the Tender price. 13.4 The price of a Contract shall be fixed in which case the unit rates or prices may not be modified in response to changes in economic or commercial conditions.
14. Tender Currency	14.1 The Tenderer shall quote all prices in the Tender Submission Letter and in the Bill of Quantities in Bangladesh Taka.

15. Documents Establishing the Tenderer's Qualification	15.1 Tenderers shall complete and submit the Tenderer Information (Form PW2-2) and shall include documentary evidence, as applicable to satisfy the following: (a) details of specific experience in construction works of similar nature and size on case-by-case procurement proceedings performed for each of the last years along with the sums, dates and recipients; public or private as stated under ITT clause 7. (b) details of average annual construction turnover for a period as stated under ITT Sub Clause 8.1(a); (c) details of adequacy of working capital for this Contract i.e. access to line(s) of credit and availability of other financial resources as stated under ITT Sub Clause 8.1(b); (d) details of Procuring Entities who may be contacted, if necessary, by this Procuring Entity; and (e) authority to seek references from the Tenderer's bankers or any other sources.
16. Validity Period of Tender	16.1 Tenders shall remain valid for the period specified in the TDS after the date of Tender submission deadline prescribed by the Procuring Entity. 16.2 A Tender valid for a period shorter than that specified shall be considered as non-responsive.
17. Tender Security	17.1 Tender Security as specified is TDS.
18. Form of Tender Security	18.1 The Tender Security shall be at the Tenderer's option, be either in the form of a bank draft or pay order. 18.2 The Tender Security may be in the form of an irrevocable bank guarantee issued by a scheduled Bank of Bangladesh, in the format (Form PW2-3) furnished in Section 5: Tender and Contract Forms. 18.3 The Tender Security shall remain valid for at least twenty eight (28) days beyond the expiry date of the Tender Validity. 18.4 Tender not accompanied by a valid Tender Security shall be considered as non-responsive.
19. Forfeiture of Tender Security	19.1 The Tender security pursuant to Rule 25 of the Public Procurement Rules, 2008 may be forfeited if a Tenderer: (a) withdraws its Tender after opening of Tenders but within the validity of the Tender; or (b) refuses to accept a Notification of Award ; or (c) fails to furnish performance security; or (d) refuses to sign the Contract ; or (e) does not accept the correction of the Tender price following the correction of arithmetic errors

E. Tender Submission

20. Sealing & Marking of Tender	20.1 The Tenderer shall prepare one (1) original of the documents comprising the Tender as described in ITT Clause 12 and clearly mark it "ORIGINAL." In addition, the Tenderer shall prepare one (1) copy of the tender, and clearly mark "COPY." In the event of any discrepancy between the original and the copy, the ORIGINAL shall prevail.
21. Deadline for Submission of Tender	21.1 Tenders shall be delivered by hand or by mail, including courier services at the address(s) as specified in the TDS and no later than the date and time specified in the TDS . Late submissions will not be considered.
22. Modification, Substitution or Withdrawal of Tender	22.1 A Tenderer may modify, substitute or withdraw its Tender after it has been submitted by sending a written notice duly signed by the authorized signatory and properly sealed, and shall include a copy of the authorization; provided that such written notice including the affidavit is received by the Procuring Entity prior to the deadline for submission of Tenders as stated under ITT Clause 21.
23. Tender Modification	23.1 The Tenderer shall not be allowed to retrieve its original Tender, but shall be allowed to submit corresponding modification to its original Tender marked as " MODIFICATION ".
24. Tender Substitution	24.1 The Tenderer shall not be allowed to retrieve its original Tender, but shall be allowed to submit another Tender marked as " SUBSTITUTION ".
25. Withdrawal of Tender	25.1 The Tenderer shall be allowed to withdraw its Tender by a Letter of Withdrawal marked as " WITHDRAWAL ".

F. Tender Opening & Evaluation

26. Tender Opening	26.1 Tenders shall be opened pursuant to Rule 97 following steps in Part D of Schedule IV of the Public Procurement Rules, 2008. 26.2 Tenders shall be opened immediately after the deadline for submission of Tenders at the primary place as specified in the TDS but no later than ONE HOUR after expiry of the submission deadline at the same primary place.
27. Evaluation of Tenders	27.1 The Tender Evaluation Committee (TEC) may consider a Tender as responsive in the Evaluation, only if it is submitted in compliance with the mandatory requirements set out in the Tender Document. The evaluation process should begin immediately after tender opening following four broad steps: (a) Preliminary examination (b) Technical examination and responsiveness (c) Financial evaluation and price comparison (d) Post-qualification of the lowest evaluated responsive Tender.

28. Preliminary Examination

- 28.1 The TEC shall **firstly** examine the Tenders to confirm that all documentation requested in ITT Clause 12 has been provided. Examination of the compliance, adequacy and authenticity of the documentary evidence may follow the order below.
- (a) verification of the completeness of the eligibility declarations in the Tender Submission Sheet (**Form PW2-1**);
 - (b) verification of the Trade License.
 - (c) verification of the eligibility in terms of legal capacity and fulfilment of taxation obligations by the Tenderer as stated under ITT Clause **3 & 12**
 - (d) verification of that the Tenderer is not insolvent as stated under ITT Clause **3 & 12**
 - (e) verification of that the written authorisation confirming the signatory of the Tenderer to commit the Tender has been attached with the Tender Submission Letter (**Form PW2-1**).
 - (f) verification of the validity and authenticity of the Tender Security as stated under ITT Clause **17 & 18**, if any
- 28.2 The TEC shall confirm that the above documents and information have been provided in the Tender and the completeness of the documents and compliance of instructions given in corresponding ITT Clauses shall be verified, failing which the tender shall be considered as non-responsive.

29. Technical Examination & Responsiveness

- 29.1 Only those Tenders surviving preliminary examination need to be examined in this phase
- 29.2 **Secondly**, the TEC will examine the adequacy and authenticity of the documentary evidence as stated under ITT Clause 15.
- 29.3 The TEC will further examine the terms and conditions specified in Section 6: General Specifications and Section 7: Particular Specifications.
- 29.4 If after the examination, TEC determines that the Tender has complied the terms and conditions and the technical aspects, set out in ITT Sub Clause **29.2 & 29.3**, it shall be considered responsive.

30. Clarification on Tender

- 30.1 The TEC may ask Tenderers for clarifications of their Tenders, including breakdowns of unit rates, in order to assist the examination and evaluation of the Tenders.
- 30.2 If the lowest Evaluated Tender is not balanced or is front loaded in the opinion of the TEC, the TEC may require the Tenderer to produce detailed breakdown of unit price or rates for any or all items of the BOQ, to demonstrate the internal consistency of those prices with the construction methods and schedule proposed.
- 30.3 If a Tenderer does not provide clarifications of its Tender by the date and time set in the TEC's written request for clarification, its Tender shall not be considered in the evaluation.

31. Correction of Arithmetical Errors	31.1 The TEC shall correct any arithmetic errors that are discovered during the examination of Tenders, and shall promptly notify the concerned Tenderer(s) of any such correction(s) pursuant to Rule 98(11) of the Public Procurement Rule, 2008. 31.2 Any Tenderer that does not accept the correction of the Tender amount following correction of arithmetic errors as determined by the application of ITT Sub-Clause 31.1 shall be considered as non-responsive.
32. Financial Evaluation	32.1 Thirdly the TEC, pursuant to Rule 98 of the Public Procurement Rules, 2008, will evaluate each Tender that has been determined, up to this stage of the evaluation, to be responsive to the mandatory requirements set out in the Tender Document. 32.2 To evaluate a Tender, the TEC will consider the following: (a) the Tender price as stated under ITT Clause 13; (b) adjustments for correction of arithmetical errors pursuant to ITT Clause 31 .
33. Price Comparison	33.1 The TEC will compare all responsive Tenders to determine the lowest-evaluated Tender, in accordance with ITT Clause 32.
34. Negotiations	34.1 No negotiations shall be held during the Tender evaluation or award with the lowest or any other Tenderer pursuant to Rule 99 of the Public Procurement Rules, 2008.
35. Post-qualification	35.1 After determining the lowest evaluated responsive Tender in accordance with ITT Clause 33, the Procuring Entity's TEC pursuant to Rule 100 of the Public Procurement Rules, 2008, shall carry out the Post-qualification of the Tenderer, using only the requirements specified in Sub-section C: Qualification Criteria.

G. Contract Award

36. Notification of Award	36.1 Prior to the expiry of the Tender Validity period and within seven (7) working days of receipt of the approval of the award by the Approving Authority, the Procuring Entity pursuant to Rule 36(4) (a) and 102 of the Public Procurement Rules, 2008, shall issue the Notification of Award (NOA) to the successful Tenderer.
37. Performance Security	37.1 The Performance Security shall be provided by the successful Tenderer in the amount as specified in the TDS. 37.2 Within Seven (7) working days from the date of acceptance of the Notification of Award (NOA) but not later than the date specified therein, the successful Tenderer shall furnish the Performance Security 37.3 The Performance Security shall be in the form of a Bank draft, pay order or an irrevocable Bank Guarantee in the format (Form PW2-6), issued by any scheduled bank of Bangladesh acceptable to the Procuring Entity.

- 37.4 The Procuring Entity may increase the amount of the Performance Security above the amounts as stated under ITT Sub Clause 37.1 pursuant to Rule 27(2) & Rule 98(13) of the Public Procurement Rules, 2008 but not exceeding twenty (20) percent of the Contract price, if it is found that the Tender is unbalanced and/or front loaded as stated under ITT Sub-Clause 30.2.
- 38. Validity of Performance Security** 38.1 The Performance Security shall be required to be valid until a date twenty eight (28) days beyond the Intended Completion Date as specified in Tender Document.
- 39. Authenticity of Performance Security** 39.1 The Procuring Entity shall verify the authenticity of the Performance Security submitted by the successful Tenderer by sending a written request to the branch of the bank issuing the Pay Order, Bank Draft or irrevocable Bank Guarantee in specified format.
- 40. Contract Signing** 40.1 Within fourteen (14) working days of issuance of the NOA, the successful Tenderer and the Procuring Entity shall sign the contract provided that the Performance Security submitted by the Tenderer is found to be genuine.
- 41. Right to Complain** 41.1 Any Tenderer has the right to complain if it has suffered or likely to suffer loss or damage due to a failure of a duty imposed on the Procuring Entity to fulfil its obligations in accordance with Section 29 of the Public Procurement Act 2006 and Part 12 of Chapter Three of the Public Procurement Rules, 2008.

Section 2. Tender Data Sheet

Instructions for completing Tender Data Sheet are provided in italics in parenthesis for the relevant ITT clauses

ITT Clause	Amendments of, and Supplements to, Clauses in the Instructions to Tenderers
A. General	
ITT 1.1	The Procuring Entity is: EXECUTIVE ENGINEER, LGED, *** DISTRICT
	The Name of the Tender is: Construction of *** and Related Works of *** Subproject (SP ID-31***) Title of the Works: Part-A: *** Part-B: *** Part-C: *** Part-D: *** Part-E: *** Part-F: *** Part-G: *** Tender Ref: LGED/SSWRDP-JICA/BD-P57/2010/31*** - Structures
ITT 3.1	Not Applicable.
B. Tender Document	
ITT 4.1	For <u>clarification of Tender Document purposes</u> only, the Procuring Entity's address is: Attention: Executive Engineer Address: LGED, *** District Telephone: *** Fax No.: *** e-mail address: ***
C. Qualification Criteria	
ITT 7.1	A satisfactory completion of hydraulic structures and related works of at least Tk ***around 50% of estimated cost*** under 3 (three) contracts over a period of 5 (five) years shall be required.

ITT 8.1(a)	The required average construction turnover shall be greater than Tk ***around 50% of estimated cost*** over the last 5 (five) years.
ITT 8.1(b)	The minimum amount of liquid assets or working capital or credit facilities of the Tenderer shall be Tk ***around 25% of estimated cost***.
<i>D. Tender Preparation</i>	
ITT 12.1(j)	The Tenderer shall submit with its Tender, the following additional documents: Work Schedule.
ITT 16.1	The Tender Validity period shall be 90 (ninety) days .
ITT 17.1	The amount of the Tender Security shall be Tk ***around 2% of estimated cost***.
<i>E. Tender Submission</i>	
ITT 21.1	For <u>Tender submission purposes</u> only, the Procuring Entity's address is: Attention: Executive Engineer Address: LGED, *** District The deadline for the Tender submission is: Time & Date: As per Tender Notice
<i>F. Tender Opening and Evaluation</i>	
ITT 26.2	The Tender opening shall take place at : Address: Office of the Executive Engineer, LGED, *** District Time & Date: As per Tender Notice
<i>G. Contract Award</i>	
ITT37.1	The amount of Performance Security shall be 10 (ten) percent of the Contract Price.

Section 3. General Conditions of Contract

A. General

1. Definitions

1.1 In the Conditions of Contract, which include Particular Conditions and these General Conditions, the following words and expressions shall have the meaning hereby assigned to them. Boldface type is used to identify the defined terms:

- (a) **Act** means The Public Procurement Act, 2006 (Act 24 of 2006).
- (b) **Approving Authority** means the authority which, in accordance with the Delegation of Financial Powers, approves the award of contract.
- (c) **Bill of Quantities** (BOQ) means the priced and completed Bill of Quantities forming part of the Contract defined in GCC Clause 21.
- (d) **Contractor** means the Person under contract with the Procuring Entity for the execution of Works under the Rules and the Act as stated in the **PCC**.
- (e) **Completion Date** is the actual date of completion of the Works and Physical services certified by the Project Manager, in accordance with GCC Clause 31 & 32.
- (f) **Day** means calendar day unless otherwise specified as working days.
- (g) **Defect** is any part of the work not completed in accordance with the Contract.
- (h) **Equipment** is the Contractor's apparatus, machinery, vehicles and other things required for the execution and completion of the Works and remedying any defects excluding Temporary Works and the Procuring Entity's Equipment (if any), Plant, Materials and any other things to form or forming part of the Permanent Works.
- (i) **Force Majeure** means an event or situation beyond the control of the Contractor that is not foreseeable, is unavoidable, and its origins not due to negligence or lack of care on the part of the Contractor; such events may include, but not be limited to, acts of the Government in its sovereign capacity, wars or revolutions, fires, floods, epidemics, quarantine restrictions, and freight embargoes.
- (j) **Goods** mean the Contractor's Equipment, Materials, Plant and Temporary Works, or any of them as appropriate
- (k) **GCC** means the General Conditions of Contract.
- (l) **Government** means the Government of the People's Republic of Bangladesh.

- (m) **"Head of the Procuring Entity"** means the Secretary of a Ministry or a Division, the Head of a Government Department or Directorate; or the Chief Executive, by whatever designation called, of a local Government agency, an autonomous or semi-autonomous body or a corporation, or a corporate body established under the Companies Act;
- (n) **Materials** means things of all kinds other than Plant intended to form or forming part of the Permanent Works, including the supply-only materials, if any, to be supplied by the Contractor under the Contract.
- (o) **Month** means calendar month.
- (p) **Original Contract Price** is the Contract Price stated in the Procuring Entity's Notification of Award and further clearly determined in the Contract.
- (q) **Permanent works** means the permanent works to be executed by the Contractor under the Contract.
- (r) **PCC** means the Particular Conditions of Contract.
- (s) **Plant** means the apparatus, machinery and other equipment intended to form or forming part of the Permanent Works, including vehicles purchased for the Procuring Entity and relating to the construction of the Works and Physical services.
- (t) **Procuring Entity** means a Procuring Entity having administrative and financial powers to undertake procurement of Works and Physical services using public funds and is as named in the **PCC** who employs the Contractor to carry out the Works.
- (u) **Project Manager** is the person named in the **PCC** or any other competent person appointed by the Procuring Entity and notified to the Contractor who is responsible for supervising the execution and completion of the Works and Physical services and administering the Contract.
- (v) **Site** means the places where the Permanent Works are to be executed including storage and working areas and to which Plant and Materials are to be delivered, and any other places as may be specified in the **PCC** as forming part of the Site.
- (w) **Site Investigation Reports** are those that were included in the Tender Document and are factual and interpretative reports about the surface and subsurface conditions at the Site.
- (x) **Specification** means the Specification of the Works **included** in the Contract and any modifications or additions to the specifications made or approved by the Project Manager in accordance with the Contract.
- (y) **Temporary Works** means all temporary works of every kind other than Contractor's Equipment required on the Site for the execution and completion of the Permanent Works and remedying of any defects.

- (z) **Variation** means any change to the Works directly procured from the original Contractor under some specific conditions and circumstances following approved procedures, which is instructed as a Variation under GCC Clause 23 by the Project Manager that varies the Works.
- (aa) **Works** means all works associated with the construction, reconstruction, site preparation, demolition, repair, maintenance or renovation of railways, roads, highways, or a building, an infrastructure or structure or an installation or any construction work relating to excavation, installation of equipment and materials, decoration, as well as physical services ancillary to works as detailed in the **PCC**, if the value of those services does not exceed that of the Works themselves.
- (bb) **Writing** means communication written by hand or machine duly signed and includes properly authenticated messages by facsimile or electronic mail.
- 2. Corrupt, Fraudulent, Collusive or Coercive Practices**
- 2.1 The Government requires that Procuring Entities, as well as Tenderers and Suppliers shall, during the Procurement proceedings and the execution of Contracts under public funds, ensure-
- (a) strict compliance with the provisions of Section 64 of the Public Procurement Act 2006 (Act 24 of 2006);
 - (b) abiding by the code of ethics as mentioned in the Rule 127 of the Public Procurement Rules, 2008;
 - (c) that neither it's any officer nor any staff or any other agents or intermediaries working on its behalf engages in any practice as detailed in the Rule 127.
- 2.2 If corrupt, fraudulent, collusive or coercive practices of any kind determined by the Procuring Entity against any Tenderer alleged to have carried out such practices, the Procuring Entity shall -
- (a) exclude the concerned Tenderer from further participation in the particular Procurement proceeding; or
 - (b) reject any recommendation for award that had been proposed for that concerned Tenderer or;
 - (c) declare, at its discretion, the concerned Tenderer to be ineligible to participate in further Procurement proceedings, either indefinitely or for a specific period of time.
- 3. Documents Forming the Contract and Priority of Documents**
- 3.1 The following documents forming the Contract shall be interpreted in the following order of priority:
- (a) the signed Contract Agreement (**Form PW2-5**);
 - (b) the Notification of Award (**PW2-4**);
 - (c) the completed Tender and the appendix to the Tender;
 - (d) the Particular Conditions of Contract;

- (e) the General Conditions of Contract;
 - (f) the Technical Specifications;
 - (g) the General Specifications;
 - (h) the Drawings;
 - (i) the priced Bill of Quantities and the Schedules; and
 - (j) any other document listed in the **PCC** forming part of the Contract.
- 4. Eligibility** 4.1 The Contractor shall be a Bangladeshi national.
- 5. Possession of the Site** 5.1 The Procuring Entity shall give possession of the Site to the Contractor on the date stated in the **PCC**.
- 6. Procuring Entity's Responsibilities** 6.1 The Procuring Entity shall pay the Contractor, in consideration of the satisfactory progress of execution and completion of the Works and Physical services, and the remedying of defects therein, the Contract price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract Agreement.
- 7. Contractor's Responsibilities** 7.1 The Contractor shall execute and complete the Works and remedy any defects therein in conformity in all respects with the provisions of the Contract Agreement.
- 8. Taxes and Duties** 8.1 The Contractor shall be entirely responsible for all taxes, duties, fees, and other such levies imposed inside and outside Bangladesh.
- 9. Contractor's Personnel** 9.1 If the Project Manager asks the Contractor to remove a particular person who is a member of the Contractor's staff or work force from the Site, he or she shall state the reasons, and the Contractor shall ensure that the person leaves the Site within three (3) days and has no further connection with the work in the Contract.

B. Time Control

- 10. Start Date** 10.1 Start Date is the date defined in the **PCC** and it is the last date when the Contractor shall commence execution of the Works under the Contract.
- 11. Intended Completion Date** 11.1 Intended Completion Date is the date calculated from the start Date as specified in the **PCC**, on which it is intended that the Contractor shall complete the Works and Physical services as specified in the Contract and may be revised only by the Project Manager by issuing an extension of time.
- 12. Programme of Works** 12.1 Within the time stated in the **PCC**, the Contractor shall submit to the Project Manager, for approval a Programme showing the general methods, arrangements, order, and timing for all the activities in the Works.

13. Extension of the intended completion time

- 13.1 The Contractor shall be entitled to an extension of the Intended Completion Date, if and to the extent that completion of the Works or any part thereof is or will be delayed by Compensation Events or a Variation Order.
- 13.2 The Procuring Entity may **extend the Intended Completion Date** by twenty (20) percent of the original Contract time as stated under GCC Sub Clause 13.1
- 13.3 In the case an extension of the Intended Completion Date required more than twenty (20) percent of the original Contract time, approval of the Head of the Procuring Entity for the same shall be required to be obtained.

C. Quality Control

14. Execution of Works

- 14.1 The Contractor shall construct, install and carry out the Works and Physical services in accordance with the Specifications and Drawings as scheduled in GCC Clause 3.

15. Identifying Defects

- 15.1 The Project Manager shall check the works executed by the Contractor and notify the Contractor of any Defects found.

16. Testing

- 16.1 The Contractor shall carry out routine Tests of materials and works based on the progress of works to ensure the quality of completed works in accordance with standard methods determined by the Project Manager.
- 16.2 If the Project Manager instructs the Contractor to carry out a test not specified in the Specification to check whether any work has a Defect and the test shows that it does, the Contractor shall pay for the test and any samples.

17. Rejection of Works

- 17.1 If, as a result of an examination, inspection, measurement or testing, of Works it is found to be defective or otherwise not in accordance with the Contract, the Project Manager may reject the Works by giving notice to the Contractor, with reasons. The Contractor shall then promptly make good the defect and ensure that the rejected Works subsequently complies with the Contract.

18. Remedial Work

- 18.1 Notwithstanding any test, the Project Manager by visual inspection or field tests may instruct the Contractor to:
- (a) remove from the Site and replace any Plant or Materials which is not in accordance with the Contract,
 - (b) remove and re-execute any other work which is not in accordance with the Contract, and
 - (c) execute any work which is urgently required for the safety of the Works, whether because of an accident, unforeseeable event or otherwise.

19. Correction of Defects

- 19.1 The Project Manager shall issue a **Defects Liability Schedule** for

correction of Defects within thirty (30) days from the Contractor's request for **Final Payment** stating the scope of corrections or additions that are necessary.

- 19.2 The Project Manager shall give notice to the Contractor, with a copy to the Procuring Entity and others concerned, of any Defects before the end of the **Defects Liability Period**, which begins at Completion Date, and is defined in the **PCC**. The Defects Liability Period shall be extended for as long as Defects remain to be corrected.

D. Cost Control

20. Contract Price

- 20.1 The Contract price shall be agreed or determined based on that the Contractor shall pay all taxes, duties and fees required to be paid by him or her under the Contract pursuant to GCC Clause 8.1
- 20.2 The contract Price shall be specified in the **PCC**.

21. Bill of Quantities (BOQ)

- 21.1 Except as otherwise stated in the Contract and notwithstanding any other practice
- (a) measurement shall be made of the net actual quantity of each item of the Permanent Works , and
 - (b) the method of measurement shall be in accordance with the BOQ.
- 21.2 Items of works quantified in the BOQ for which no rates or prices have been quoted shall be deemed covered by the amounts at rates and prices of other items in the Contract and shall not be separately paid for.

22. Changes in the Quantities and Unit Rate or Price

- 22.1 A new rate or price for items included in the BOQ shall, however, be appropriate for an item of work if:
- (a) the final measured quantity of the work done for any particular item in the BOQ is increased or decreased by more than twenty five (25) percent from the quantity of this item in the BOQ,
provided that; the cost resulting from such increase or decrease in quantity of this particular item in the Bill of Quantities multiplied by its specified rate or price is exceeded by one (1) percent of the original Contract price.
 - (b) this particular item is not specified in the Contract as a "fixed rate item";
 - (c) this particular item is not specified in the Contract as for which no rates or prices have been quoted and deemed covered by the amounts at rates and prices of other items in the Bill of Quantities stated under GCC Sub Clause 21.2; and
- 22.2 The new rate or price for the particular item of work included in the Bill of Quantities described under GCC Sub Clause 22.1 shall be

derived by the Project Manager from any relevant rates or prices within the Contract by taking into consideration the context and threshold of the **Variation Order** as stated under GCC Clause 23.

23. Variations

23.1 The Procuring Entity may issue a Variation Order for Procurement of Works and Physical services in favour of the original Contractor to cover any increase or decrease in quantities, including the introduction of new work items that are either due to change of plans, design or alignment to suit actual field conditions, within the **general scope** and **physical boundaries** of this Contract.

23.2 Variations may include;

- (a) changes to the quantities of any item of work included in the Bill of Quantities as stated under GCC Sub Clause 22.1; not necessarily however, shall always constitute a Variation until the algebraic summation of costs resulting from such increases or decreases in quantities of changing items included in the Bill of Quantities under the Contract exceeds one (1) percent of the original Contract price;
- (b) changes to the quality and other characteristics of any item of work;
- (c) changes to the levels, positions and/or dimensions of any part of the Works;
- (d) omissions of any work unless it is to be carried out by others;
- (e) any additional work, Plant, Materials, or services necessary for the permanent works, including any associated testing, boreholes and other testing and exploratory work; or
- (f) changes to the sequence or timing of execution of the Works.

23.3 The Contractor shall, under no circumstances, proceed to commence the works under any Variation Order unless it has been approved by the **Approving Authority**.

24. Costing of Variation Orders

24.1 The Contractor shall submit a quotation for carrying out the Variation within 7 (seven) days of being requested by the Project Manager.

24.2 If the items of works under Variation Order are exactly the same or similar to those in the Bill of Quantities of the original Contract, the applicable unit rates or prices of those work items in the Bill of Quantities of the original Contract shall be used for costing of those additional work items.

24.3 If not, the unit rates or prices of those new work items shall be based on ;

- (i) the direct unit costs used in the Bill of Quantities of original Contract for other items (e.g. unit cost of cement, steel rebar, formwork, labour rate, equipment rental, etc) as indicated in the Contractor's price

- breakdown of the cost estimate, if available; or
- (ii) fixed prices acceptable to both the Procuring Entity and the Contractor based on market prices; or
 - (iii) the direct cost of the new work items based on (i) and (ii) above shall then be combined with the mark-up factor (i.e. taxes, overheads and profit) used by the Contractor in his or her Tender to determine the unit rate or price of the new work item.
- 24.4 If the Contractor's quotation is found to be unreasonable, the Project Manager shall exercise his own judgement to fix the Unit rate (s).
- 25. Payment Certificates**
- 25.1 The basis for payment certificates shall be BOQ used to determine the Contract price.
- 25.2 The Contractor shall submit to the Project Manager monthly statements of the estimated value of the works executed less the cumulative amount certified previously.
- 25.3 The Project Manager may in any payment certificate make any correction or modification that should properly be made to any previous payment certificate.
- 25.4 The Project Manager may withhold the cost of rectification or replacement until such rectification or replacement has been completed, if any thing supplied or work done by the Contractor is not in accordance with the Contract.
- 26. Payments to the Contractor**
- 26.1 The Procuring Entity shall pay the Contractor in Bangladesh Taka currency, the amounts certified by the Project Manager after due adjustments.
- 27. Compensation Events**
- 27.1 The following shall be Compensation Events:
- (a) The Procuring Entity does not give access to or possession of the Site or part of the Site by the Site Possession Date stated in the GCC Sub Clause 5.1;
 - (b) Ground conditions are substantially more adverse than could reasonably have been assumed before issuance of the Notification of Award;
 - (c) Other Contractors, public authorities, utilities, or the Procuring Entity do not work within the dates and other constraints stated in the Contract, and they cause delay or extra cost to the Contractor;
 - (d) The Project Manager unreasonably delays issuing a Completion Certificate;
 - (e) The Project Manager instructs the Contractor to uncover or to carry out additional tests upon work, which is then found to have no Defects;
 - (f) Other Compensation Events described in the Contract or determined by the Project Manager in the **PCC** shall apply

- 27.2 If a Compensation Event would cause additional cost or would prevent the work being completed before the Intended Completion Date, the Contract price shall be increased and/or the Intended Completion Date shall be extended.
- 28. Retention Money**
- 28.1 The Procuring Entity shall retain from each progressive payment due to the Contractor at the percentage specified in the **PCC** until completion of the whole of the Works under the Contract.
- 28.2 On completion of the whole of the Works, the first half the total amount retained under GCC Sub Clause 28.1 shall be repaid to the Contractor and the remaining second half after the Defects Liability Period has passed.
- 28.3 If the provision of Retention Money is not included in this Contract these Sub Clauses shall not apply except the relevant ones.
- 29. Liquidated Damages**
- 29.1 The Contractor shall be liable to pay Liquidated Damages or in other words the Delay Damages to the Procuring Entity at the rate per day as specified in the **PCC** for each day of delay from the Intended Completion Date, for the uncompleted Works or for any part thereof.
- 29.2 The total amount of Liquidated Damages shall not exceed the amount defined in the **PCC**.
- 29.3 Payment of Liquidated Damages by the Contractor shall not relieve the Contractor from its obligations.
- 30. Performance Security**
- 30.1 The Performance Security furnished at the time of signing of the Contract Agreement, shall be substituted by a new Security covering fifty (50) percent of the amount of the Performance Security to cover the Defects Liability Period.
- 30.2 The Procuring Entity may claim against the security if any of the following events occurs for fourteen (14) days or more.
- (a) The Contractor is in breach of the Contract and the Procuring Entity has duly notified him or her ; and
 - (b) The Contractor has not paid an amount due to the Procuring Entity and the Procuring Entity has duly notified him or her.
- 30.3 In the event the Contractor is liable to pay compensation under the Contract amounting to the full value of the Performance Security or more, the Procuring Entity may call the full amount of the Performance Security.
- 30.4 If there is no reason to call the Performance Security, the Performance Security shall be discharged by the Procuring Entity and returned to the Contractor not later than twenty-eight (28) days after the Defects Liability Period has passed.

E. Completion of Contract

31. Completion	31.1 The Contractor shall apply by notice to the Project Manager for issuing a Completion Certificate of the Works, and the Project Manager shall do so upon deciding that the work is completed.
32. Completion Certificate and Taking Over	32.1 The Project Manager shall, within fourteen (14) days after receiving the Contractor's application stated under GCC Sub Clause 31.1; (a) issue the Completion Certificate to the Contractor, stating the date on which the Works or part thereof were completed in accordance with the Contract, except for any minor outstanding work and defects which may not substantially affect the use of the Works or part thereof for their intended purpose (either until or whilst this work is completed and these defects are remedied); or (b) reject the application, giving reasons and specifying the work required to be done by the Contractor to enable the Completion Certificate to be issued. The Contractor shall then complete this work before issuing a further notice under this Sub Clause. 32.2 The Procuring Entity shall Take-Over the Site and the Works within fifteen (15) days of the Project Manager issuing a Completion Certificate under GCC Sub Clause 32.1 .
33. Amendment to Contract	33.1 The amendment to Contract shall generally include extension of time to the Intended Completion Date, increase or decrease in original Contract price and any other changes acceptable under the conditions of the Contract.
34. Final Account	34.1 The Contractor shall submit with a detailed account of the total amount that the Contractor considers payable under the Contract to the Project Manager before the end of the Defects Liability Period. 34.2 The Project Manager shall certify the Final Payment within thirty days (30) days of receiving the Contractor's account if the payable amount claimed by the Contractor is correct and the corresponding works are completed. 34.3 If it is not, the Project Manager shall issue within thirty (30) days a Defects Liability Schedule under GCC Sub Clause 19.1 that states the scope of the corrections or additions that are necessary.
35. Release from Performance	35.1 If any event or circumstance outside the control of the parties (including, but not limited to, Force Majeure) arises which makes it impossible or unlawful for either or both parties to fulfil its or their contractual obligations or which, under the law governing the Contract, entitles the parties to be released from further performance of the Contract, then upon notice by either party to the other party of such event or circumstance: (a) the parties shall be discharged from further performance, without prejudice to the rights of either party in respect of any previous breach of the Contract.

F. Termination and Settlement of Disputes

36. Termination

36.1 Termination for Default

- (a) The Procuring Entity or the Contractor, without prejudice to any other remedy for breach of Contract, by giving twenty eight (28) days written notice of default to the other party, may terminate the Contract in whole or in part if the other party causes a fundamental breach of Contract.
- (b) Fundamental breaches of the Contract shall include, but shall not be limited to, the following:
 - (i) the Contractor stops work for twenty-eight (28) days when no stoppage of work is shown on the current Programme and the stoppage has not been authorized by the Project Manager;
 - (ii) the Project Manager gives Notice that failure to correct a particular Defect is a fundamental breach of Contract and the Contractor fails to correct it within a reasonable period of time determined by the Project Manager;
 - (iii) the Contractor has delayed the completion of the Works by the number of days for which the maximum amount of Liquidated Damages can be paid, as specified in GCC Sub Clause 29.2;
 - (iv) the Contractor has subcontracted the whole of the Works or has assigned the Contract without the required agreement and without the approval of the Project Manager;
 - (v) the Contractor, in the judgment of the Procuring Entity has engaged in corrupt or fraudulent practices as defined in GCC Clause 2, in competing for or in executing the Contract.

37. Payment upon Termination

- 37.1 If the Contract is terminated because of a fundamental breach of Contract under GCC Sub Clause 36.1.1 by the Contractor, the Project Manager shall issue a certificate for the value of the Works done and Plant and Materials ordered less advance payments received up to the date of the issue of the certificate and less the amount from percentage to apply to the contract value of the works not completed, as indicated in the **PCC**.

38. Property

- 38.1 All Materials on the Site, Plant, Equipment, Temporary Works, and Works shall be deemed to be the property of the Procuring Entity if the Contract is terminated because of the Contractor's default. .

G. Disputes and Arbitration

39. Settlement of Disputes 39.1 Amicable settlement

The procuring Entity and the Contractor shall use their best efforts to settle amicably all possible disputes arising out of or in connection with this Contract or its interpretation.

39.2 Arbitration

- (a) If the parties are unable to reach a settlement as per GCC Clause 39.1 within twenty-eight (28) days of the first written correspondence on the matter of disagreement, then either party may give notice to the other party of its intention to commence arbitration.
- (b) The arbitration shall be conducted in accordance with the Arbitration Act (**Act No 1 of 2001**) of Bangladesh as at present in force and in the place shown in the **PCC**.

Section 4. Particular Conditions of Contract

Instructions for completing the Particular Conditions of Contract are provided in italics in parenthesis for the relevant GCC Clauses.

GCC Clause	Amendments of, and Supplements to, Clauses in the General Conditions of Contract
GCC 1.1(d)	The Contractor is _____ <i>[Name, address]</i>
GCC 1.1(t)	The Procuring Entity is EXECUTIVE ENGINEER, LGED, *** DISTRICT
GCC 1.1(u)	The Project Manager is EXECUTIVE ENGINEER, OR HIS AUTHORIZED PERSON LGED, *** DISTRICT
GCC 1.1(v)	The Site is located at *** Upazila, *** District, and is defined in the Index Map presented in Section 8. Drawings (Volume II) .
GCC 1.1(aa)	The Works consist of: Part-A: *** Part-B: *** Part-C: *** Part-D: *** Part-E: *** Part-F: *** Part-G: ***
GCC 3.1 (j)	Other documents forming part of the Contract are Not Applicable.
GCC 5.1	Possession of the Site to the Contractor shall be given on the following date: _____ <i>[state date of possession of site]</i>
GCC 10.1	The Start Date shall be: _____ <i>[insert date]</i>
GCC 11.1	The Intended Completion Date for the whole of the Works shall be: _____ <i>[insert date]</i>

GCC 12.1	The Contractor shall submit a Programme for the Works within 10 (ten) days of signing the Contract.
GCC 15.1	The WMCA Construction Monitoring Committee shall also check the works executed by the Contractor. The Contractor shall allow this Committee access to the Site. This Committee monitors construction materials and activities using standards Forms. If the Committee is not satisfied with construction quality, it shall lodge complains to LGED using prescribed Forms and procedures.
GCC 19.2	The Defects Liability Period is 12 (twelve) months .
GCC 20.2	The Contract price is: _____ <i>[insert the amount]</i>
GCC 27.1(f)	The following additional events shall also be the Compensation Events: Not Applicable
GCC 28.1	The proportion of payments to be retained is 10 (ten) percent .
GCC 29.1	The amount of Liquidated Damages or in other words Delay Damages is 0.10% (0.1 of one percent) of final Contract price <u>of the uncompleted Works</u> , or any part thereof, per day of delay.
GCC 29.2	The maximum amount of Liquidated Damages for the uncompleted Works or any part thereof is 10 (ten) percent of the final Contract price of the whole of the Works.
GCC 34.2	The Final Payment shall also be certified by the Project Consultant.
GCC 37.1	The percentage to apply to the contract value of the works not completed, representing the Procuring Entity's additional cost for completing the uncompleted Works, is 15% (fifteen) percent.
GCC 39.2(b)	The arbitration shall be conducted in the place mentioned below: LGED HEADQUARTERS, AGARGAON, DHAKA

Section 5. Tender & Contract Forms

Form	Title

Tender Forms	

PW2 – 1	Tender Submission Letter
PW2 – 2	Tenderer's Information
PW2 – 3	Bank Guarantee for Tender Security (<i>when this option is chosen</i>)

Contract Forms	

PW2 – 4	Notification of Award
PW2 – 5	Contract Agreement
PW2 – 6	Bank Guarantee for Performance Security (<i>when this option is chosen</i>)

Forms **PW2-1** to **PW2-3** comprises part of the Tender Format and should be completed as stated in ITT Clauses.12.1

Forms **PW2-4** to **PW-6** comprises part of the Contract as stated in GCC Clause 3.

Tender Submission Letter (Form PW2-1)

[This letter should be completed and signed by the Authorised Signatory preferably on the Letter-Head Pad of the Tenderer]

To:		Date :
<i>[Name and address of Procuring Entity]</i>		
Invitation for Tender No:	Tender Package No:	Lot No:

In accordance with ITT Clauses 13, the following prices apply to our Tender:

The Tender Price is: (ITT Clause 13)	<i>Taka [state amount in figures] and Taka[state amount in words]</i>

In signing this letter, and in submitting our Tender, we also confirm that:

- (a) our Tender shall be valid for the period stated in the Tender Data Sheet (ITT Sub Clause 16.1) and it shall remain binding upon us and may be accepted at any time before the expiration of that period;
- (b) a Tender Security is attached in the form of a *[pay order/ bank draft/ bank guarantee]* in the amount stated in the Tender Data Sheet (ITT Sub Clause 17.1) and valid for a period of twenty eight (28) days beyond the Tender validity date;
- (c) if our Tender is accepted, we commit to furnishing a Performance Security within the time stated under ITT Sub Clause 37.2 in the amount stated in the Tender Data Sheet (ITT Sub Clause 37.1) and valid for a period of twenty eight (28) days beyond the date of issue of the Completion Certificate of the Works;
- (d) we have examined and have no reservations to the Tender Document, issued by you on *[insert date]*;
- (e) We, declare that we are eligible to participate in this Tender and meet the eligibility criteria specified in the Tender Document (ITT Clause 3);
- (f) furthermore, we are aware of ITT Clause 2.2 concerning such practices and pledge not to indulge in such practices in competing for or in executing the Contract
- (g) we are not participating as Tenderers in more than one Tender in this Tendering process. We understand that your written Notification of Award shall constitute the acceptance of our Tender and shall become a binding Contract between us, until a formal Contract is prepared and executed;

Signature:

[insert signature of authorised representative of the Tenderer]

Name:

[insert full name of signatory with National ID Number]

In the capacity of:

[insert capacity of signatory]

Duly authorised to sign the Tender for and on behalf of the Tenderer

Attachment 1: Written confirmation authorising the above signatory(ies) to commit the Tenderer [ITT Sub Clause 12.1]

Tenderer Information (Form PW2-2)

[This Form should be completed only by the Tenderer, preferably on its Letter-Head Pad]

Invitation for Tender No:	Tender Package No:	Lot No:

1. Eligibility Information of the Tenderer [ITT –Clauses 3 & 12]				
1.1	Tenderer's legal title			
1.2	Tenderer's registered address			
1.3	Tenderer's year of registration			
1.4	(VAT) Number			
1.5	(TIN) Number			
2. Qualification Information of the Tenderer				
2.1	Specific Experience in Construction Works of Tenderer [ITT – Clause 7.1]			
	Completed Contracts of similar nature, complexity and methods/construction technology			
	Contract No	[insert reference no] of [insert year]		
	Name of Contract	[insert name]		
	Role in Contract <i>[tick relevant box].</i>	Prime Contractor	Subcontractor	Management Contractor
	Award date	[insert date]		
	Completion date	[insert date]		
	Total Contract Value	[insert amount]		
	Procuring Entity's Name & Address			
2.2	Average annual construction turnover [ITT Sub Clause 8.1(a)]			
	<i>[Certificate of payments received for each year of works in progress or completed, at the end of the period reported]</i>			
	Year	Amount	Taka	
2.3	Financial Resources available to meet the construction cash flow [ITT Sub Clause 8.1(b)]			
	No	Source of Financing	Amount Available	
In order to confirm the above statements the Tenderer shall submit , as applicable, the documents mentioned in ITT Sub Clause 15.1(a), (b) & (c).				
2.4	Contact Details [ITT Sub Clause 15.1 (d) & (e)]			
	Name, address, and other contact details of Tenderer's Bankers and other Procuring Entity(s) that may provide references, if contacted by this Procuring Entity			

Bank Guarantee for Tender Security (Form PW2-3)

[This is the format for the Tender Security to be issued by a scheduled Bank of Bangladesh in accordance with ITT Sub Clause 18.2]

Invitation for Tender No:

Date:

Tender Package / Lot No:

To: [Name and address of the Procuring Entity]

TENDER GUARANTEE No:

We have been informed that *[name of Tenderer]* (hereinafter called “the Tenderer”) intends to submit to you its Tender dated *[date of Tender]* (hereinafter called “the Tender”) for the execution of the Works of *[description of works]* under the above Invitation for Tenders (hereinafter called “the IFT”).

Furthermore, we understand that, according to your conditions, the Tender must be supported by a Bank Guarantee for Tender Security.

At the request of the Tenderer, we *[name of bank]* hereby irrevocably undertake to pay you, without cavil or argument, any sum or sums not exceeding in total an amount of Tk *[insert amount in figures and words]* upon receipt by us of your first written demand accompanied by a written statement that the Tenderer is in breach of its obligation(s) under the Tender conditions, because the Tenderer:

- a. has withdrawn its Tender after opening of Tenders but within the validity of the Tender Security; or
- b. refused to accept the Notification of Award (NOA) within the period as stated under ITT; or
- c. failed to furnish Performance Security within the period stipulated in the NOA; or
- d. refused to sign the Contract Agreement by the time specified in the NOA; or
- e. did not accept the correction of the Tender price following the correction of the arithmetic errors as stated under ITT.

This guarantee will expire

- (a) if the Tenderer is the successful Tenderer, upon our receipt of a copy of the Contract Agreement signed by the Tenderer or a copy of the Performance Security issued to you in accordance with the ITT; or
- (b) if the Tenderer is not the successful Tenderer, twenty eight (28) days after the expiration of the Tenderer’s Tender validity period, being *[date of expiration of the Tender validity plus twenty eight (28) days]*.

Consequently, we must receive at the above-mentioned office any demand for payment under this guarantee on or before that date.

Signature

Signature

Notification of Award (Form PW2-4)

Contract No:
To:

Date:

[Name of Contractor]

This is to notify you that your Tender dated *[insert date]* for the execution of the Works for *[name of project/Contract]* for the Contract Price of Tk *[state amount in figures and in words]*, as corrected and modified in accordance with the Instructions to Tenderers, has been approved by *[name of Procuring Entity]*.

You are thus requested to take following actions:

- i. accept in writing the Notification of Award within seven (7) working days of its issuance pursuant to ITT Sub Clause 36.1
- ii. furnish a Performance Security in the amount of Tk *[state amount in figures and words]*, within seven (7) working days of acceptance of this Notification of Award but not later than *(specify date)*, in accordance with ITT Clause 37.2
- iii. sign the Contract within fourteen (14) working days of issuance of this Notification of Award but not later than *(specify date)*, in accordance with ITT Sub Clause 40.1

You may proceed with the execution of the Works only upon completion of the above tasks. You may also please note that this Notification of Award shall constitute the formation of this Contract which shall become binding upon you.

We attach the draft Contract and all other documents for your perusal and signature.

Signed

Duly authorised to sign for and on behalf of
[name of Procuring Entity]

Date:

Contract Agreement (Form PW2-5)

THIS AGREEMENT made the (day) day of between *[name and address of Procuring Entity]* (hereinafter called "the Procuring Entity") of the one part and *[name and address of Contractor]* (hereinafter called "the Contractor") of the other part:

WHEREAS the Procuring Entity invited Tenders for certain works, viz, *[brief description of works]* and has accepted a Tender by the Contractor for the execution of those works in the sum of Taka *[Contract price in figures and in words]* (hereinafter called "the Contract Price").

NOW THIS AGREEMENT WITNESSETH AS FOLLOWS:

1. In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the General Conditions of Contract hereafter referred to.
2. The documents forming the Contract shall be interpreted in the following order of priority:
 - (a) the signed Contract Agreement
 - (b) the Notification of Award
 - (c) the completed Tender and the appendices to the Tender
 - (d) the Particular Conditions of Contract
 - (e) the General Conditions of Contract
 - (f) the Technical Specifications
 - (g) the General Specifications
 - (h) the Drawings
 - (i) the priced Bill of Quantities and the Schedules
 - (j) any other document listed in the PCC forming part of the Contract.
3. In consideration of the payments to be made by the Procuring Entity to the Contractor as hereinafter mentioned, the Contractor hereby covenants with the Procuring Entity to execute and complete the works and to remedy any defects therein in conformity in all respects with the provisions of the Contract.
4. The Procuring Entity hereby covenants to pay the Contractor in consideration of the execution and completion of the works and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract.

IN WITNESS whereof the parties hereto have caused this Agreement to be executed in accordance with the laws of Bangladesh on the day, month and year first written above.

For the Procuring Entity For the Contractor

Signature

Name

National ID No.

Title

In the presence of

Name

Address

Bank Guarantee for Performance Security (Form PW2-6)

[This is the format for the Performance Security to be issued by a scheduled bank of Bangladesh in accordance with ITT Clauses 37, 38 & 39]

Contract No: [insert reference number]

Date: [insert date]

To:

[insert Name and address of Procuring Entity]

PERFORMANCE GUARANTEE No:

We have been informed that *[name of Contractor]* (hereinafter called “the Contractor”) has undertaken, pursuant to Contract No *[insert reference number of Contract]* dated *[insert date of Contract]* (hereinafter called “the Contract”), the execution of works *[description of works]* under the Contract.

Furthermore, we understand that, according to your conditions, the Contract must be supported by a Bank Guarantee for Performance Security.

At the request of the Contractor, we *[name of bank]* hereby irrevocably undertake to pay you, without cavil or argument, any sum or sums not exceeding in total an amount of Tk *[insert amount in figures and in words]* upon receipt by us of your first written demand accompanied by a written statement that the Contractor is in breach of its obligation(s) under the Contract conditions, without you needing to prove or show grounds or reasons for your demand of the sum specified therein.

This guarantee is valid until *[date of validity of guarantee]*, consequently, we must receive at the above-mentioned office any demand for payment under this guarantee on or before that date.

Signature

Signature

Section 6. General Specifications

(The General Specifications of works are presented in the following pages.)

TECHNICAL SPECIFICATIONS FOR CONSTRUCTION OF WORKS¹

PART 1:	MATERIALS TESTING	: page 36-38
PART 2:	EARTHWORKS	: page 39-47
PART 3:	HYDRAULIC STRUCTURES	: page 48-84
PART 4:	BURIED IRRIGATION PIPE SYSTEMS	: page 85-96
PART 5:	SMALL BUILDINGS (with CI Sheet Roof)	:page 97-108
PART 6:	BUILDINGS (Standard Buildings)	: page 111-449
PART 7:	ROADS	: page 451-527
PART 8:	BIRDGES & CULVERTS	: page 528-721
PART 9:	ENVIRONMENTAL & HEALTH SAFETY	: page 722-745
PART 10:	SOCIAL ASPECT S	: page 746-747
PART 11:	INCIDENTAL WORKS	: page 748-753

NOTE

Tender Document of Specific Subprojects will be prepared on copies of this template. Only the Parts necessary for the works of the subproject will be kept in this page, others will be deleted along with texts of those Parts from the following pages.

¹ Technical Specifications included herein are the same as has been used by LGED in previous SSWR Development and Rural Infrastructure Development Projects.

PART 1: MATERIALS TESTING

1.1 Quality Control Tests: Notwithstanding the requirements stated in the detailed specifications for individual items, the following minimum tests shall be carried out in the LGED laboratories and in the field. In cases the testing facilities are not available in the LGED laboratory, the tests shall be performed elsewhere as directed by the Engineer. All test types and quantities described in the following sections 1.2 to 1.4 are considered "Normal Testing", whereas anything beyond that in type and quantity is considered as "Special Testing". The Engineer may increase the frequency of testing as required. The testing frequencies of the flowing works shall be as follows:

1.2 Embankment: Compaction test shall be carried out for each 500m² per layer of earth fill in embankment/dykes and each 50m² per layer for structure approach. Minimum 85% compaction of the maximum dry density shall be obtained.

1.3 Concrete

1.3.1 Cement: Setting Time and Strength tests shall be carried out to determine the setting time and strength for each batch of cement prior to this cement being incorporated into the works.

1.3.2 Aggregates

1.3.2.1 Coarse Aggregate: Gradation, Water Absorption, Aggregate Impact Value (AIV) Los Angeles Abrasion (LAA) and Specific Gravity tests shall be carried out for each day's casting or per 10 m³ of concrete, whichever provides the greater number of tests.

1.3.2.2 Fine Aggregate: Grading and FM tests shall be carried out for each day's casting or per 10 m³ of concrete, which ever provides the greater number of tests.

1.3.3 Workability: Slump test shall be carried out as frequently as directed by the Engineer and not less than one per hour during concreting operations.

1.3.4 Concrete Strength: At least 3 cubes/cylinders shall be kept from each class of concrete for each days casting or 15m³ of concrete for testing at 7 days and 28 days. The location in the structure of the concrete from which the samples were taken should be recorded.

1.4 Reinforcement: Diameter, unit weight and tensile strength tests shall be carried out when requested by the Engineer, for each batch and diameter of reinforcing bar provided per structure or as directed by the Engineer. The Engineer shall accept only test Certificates issued by BUET/BIT.

1.5 Testing Geotextiles: Tests of mass per unit area, thickness, and tensile strength in accordance with the Standards listed in Clause 1807 shall be carried out by an approved testing laboratory on samples taken from each quantity of 1000 m² of geotextile fabric supplied. The water permeability coefficient (k) and the filter effective opening size (O₉₀)² values shall be tested on samples taken from every 50,000 m² of geotextile fabric supplied. Seams shall be tested for tensile strength every 10,000 m of seam. The geotechnical test results of the underlying embankment soil together with the manufacturer's specification and installation instructions for the proposed cloth, including permeability and porosity (with methods of testing) and a sample of the cloth shall be submitted for the approval of the Engineer. The sample size for the fabric shall be 2 m² and shall be marked to indicate its upper side, longitudinal and transverse directions, type of geotextile and the date that the sample was taken. Seam samples shall be at least one meter in length and the ends of the threads are to be firmly tied off by the Contractor or Supplier at the time the samples are taken. Each test shall be carried out on at least five samples. The Contractor shall bear the expenses of all routine tests. Notwithstanding the submission of reports to the effect that the geotextile conforms to the Specification, the Engineer shall all times be entitled to have additional samples of geotextile tested if he is of the opinion that the geotextile does not conform to the Specification. The Engineer shall only select samples from ends of geotextile rolls or geotextile, which has been cut already. A

² O₉₀ defined as being the grain size of a standard sand corresponding to 90% retention by weight on a sample of the geotextile in a vibrating sieve apparatus, shall be measured in a wet apparatus using the BAW (Bundesanstalt für Wasserbau- German Federal Institute for Waterways Engineering) method.

geotextile will be regarded as defective if any of the specified values are not achieved other than those of unit weight and effective opening size, for which the following tolerances will be permitted:

- (a) Single layered geotextiles: Unit weight - minus 10%
O₉₀ - plus or minus 20%
- (b) Composite geotextiles: Total weight - minus 15%
Single layer weight - minus 20%
O₉₀ - plus or minus 20%

1.6 Payment

1.6.1 Normal Testing: The cost of providing and transporting samples to the Laboratory specified by the Engineer, shall be borne by the contractor. The cost of all normal testing as specified in sections 1.2 to 1.5 are to be borne by the contractor at LGED current Standard Rates, or if they cannot be carried out by the LGED laboratory, at the rate charged by the respective laboratory.

1.6.2 Special Testing: The cost of tests instructed by the Engineer in type and quantity beyond those specified in sections 1.2 to 1.5 shall be paid to the contractor. The cost of these tests is covered by a provisional sum. Only in case of failure of the test results to meet the required Specifications, the cost will be charged to the contractor.

PART 2: EARTHWORKS

2.1 Setting Out: Prior to starting of earth works the Contractor shall set-out the necessary alignment and grade boards for proper control of the Works. All earth works shall have to be made to the required grades and sizes as per the drawings, specifications and directions of the Engineer. The Contractor shall maintain the setting-out undisturbed during the course of earth work and subsequent construction, and arrangements shall be provided for reference bench marks/ reduced levels so that the levels can be checked and measured as and when necessary.

2.2 Clearing and grubbing

2.2.1 Description: This work shall consist of cutting, removal and disposal of all trees, vegetation, stumps roots and other debris within the limits of the right of way or from the area designated by the Engineer and completed in all respect as per direction of the Engineer.

2.2.2 Construction Method: All trees and other vegetation as designated by the Engineer to be saved shall be carefully protected from damage during construction operation. All other timber logs, trees, stumps, roots, bush and other objectionable obstructions shall be removed, piled and burned or otherwise disposed of to the approval of the Engineer so as to leave the road way and adjacent areas with a neat and finished appearance free from any unsightly debris. All areas within the construction lines shall be grubbed of all objectionable matter on or projecting throughout the ground surface. All fill areas shall be grubbed to a depth of at least 300mm below the natural ground and back filled and compacted with suitable materials approved by the Engineer. This site clearing must be kept at least 150 metres in advance of other earth works. In case the crest of the embankment is to be widened, trees, stumps etc. should be completely uprooted to provide good bonding between the existing embankment and the new soil to be placed for such widening.

2.2.3 Measurement: Measurement of completed and accepted clearing and grubbing shall be per square metre measured horizontally.

2.2.4 Payment: Payment at the contract price for clearing and grubbing and uprooting shall be full compensation for furnishing all labour, materials, equipment, tools and incidentals necessary to complete the works. Payment will be made in per sqm of clearing and grubbing.

2.3 Removal of Existing Structures

2.3.1 Description: This work shall consist of the satisfactory dismantling, removal and disposal or salvage, wholly or partly, of all the existing structures, substructures, bridges, buildings, culverts etc., within the Site as indicated on the Drawings or as instructed by the Engineer. All properties within the Site may have been removed by the owners before the Contractor takes occupation of the site. All remaining fences buildings, structures or encumbrances of any character, except those still to be removed or ordered to be salvaged upon or within the limits of the Site, shall be removed by the Contractor and placed carefully on the abutting property, or otherwise disposed of as indicated on the Drawings or as directed by the Engineer. Materials so removed, including any existing steel bridges, drain or culvert pipes, which the Engineer may order to be salvaged, shall be carefully removed and shall become the property of the Department. Where a structure is to be replaced the existing structure shall be demolished to the level of the underside of the foundation of the new structure or as directed by the Engineer. All materials obtained from demolished existing structures shall be removed except as otherwise specified or directed by the Engineer. For all other areas that will be used for any other purpose with the exception of roadways, existing structures shall be demolished to a level lower than the lowest elevation of the finished ground level as indicated on the Drawings or as provided in the Specifications or as directed by the Engineer.

2.3.2 Materials: Removed materials shall be the property of the Department unless otherwise stated in the Contract. Any materials not required by the Department shall be classed as waste and shall be disposed of by the Contractor at his own expense.

2.3.3 Construction methods: If the superstructure or any portion of the structure is deemed fit for use elsewhere, the usable portions shall be marked and removed without damage and stockpiled neatly at an accessible point above high water level. Recovered structural steel work and Bailey bridge components shall, on the instructions of the Engineer, be removed from site to the Executive Engineer's office compound as directed by the Engineer. All other usable materials shall be neatly stockpiled within the site at points approved by the Engineer. All material, which is not considered of value by the Engineer, shall

be removed by the contractor from site but within the limits of the site at his own expense. Use of explosives will not be permitted except by the instruction of the Engineer.

2.3.4 Payment: Removal of existing buildings, bridges, culverts, etc. shall be paid on a lump sum basis. The payment shall be full compensation for all removal and disposal of all materials including labour, equipment, tools and incidentals necessary to complete the work. Pay item shall be made in lump sum basis.

2.4 Embankment

2.4.1 Description: This work shall consist of the construction of embankment and fill by furnishing, placing, compacting and shaping suitable material of acceptable quality obtained from approved sources in accordance with these specifications and to the lines, levels, grades, dimensions and cross sections shown on the Drawings or as required by the Engineer. The location of borrow pit shall be approved by the Engineer and must be at a minimum distance of 3.0m or 1.5 times the height of the embankment, whichever is greater from the toe of embankment. The depth of excavation in borrow pits shall not exceed 800 mm under normal conditions.

2.4.2 Materials: All fill materials shall be free from roots, sods or other deleterious materials. Materials for embankments shall be stockpiled outside the working areas. Materials shall be tested and approved by the Engineer. The selected fill so stockpiled shall satisfy the following criteria:

- (a) Liquid limit of fraction passing 425 micron sieve shall not exceed - 50%
- (b) Plasticity index of fraction passing 425 micron sieve shall not exceed - 20%
- (c) Embankment fill shall be spread in 150 mm layers and clods broken to maximum size of 50 mm and compacted by rammer using manual compaction method to achieve at least 85% of the standard proctor maximum dry density.
- (d) The moisture content at the time of compaction shall be the optimum moisture content $\pm$ 5%.
- (e) Sampling to be carried out as per Standard Testing Procedure (STP).
- (f) In case if the embankment material is sand, side slopes and shoulders shall be covered by cohesive soil of PI value in between 8-20%. The thickness of covering layer shall be 250 - 300 mm or as directed by the Engineer.

2.4.3 Borrow Pits

- (a) The Contractor shall be responsible for arranging land and the purchase and supply of borrow material from pits for the permanent Works. Prior to the excavation of any material from the borrow pit the area shall be cleared and stripped.
- (b) Borrow areas shall be located on the river/sea side of the embankment wherever possible. The minimum distance of the borrow area from the toe of the embankment shall not be less than 1.5 multiplied by the height of embankment or 3m whichever is greater.
- (c) Borrow areas located on the river/sea side of the embankment shall be not more than 30 m in length and shall be separated by gaps of undisturbed ground of not less than 6m length measured parallel with the embankment.

2.4.4 Construction Methods

2.4.4.1 Preparation of Foundation for Embankment: Prior to placing any embankment upon any area, all clearing and grubbing operations shall have been completed in accordance with Section 2.2 and excavation under carriage ways shall be carried out in accordance with Section 2.5. The original ground surface should be prepared by scarifying, watering, aerating and compacting. The dry density after compaction shall not be less than 85% of MDD. Embankments in swamps or water shall be constructed as indicated on the drawings and as described in these Specifications. The Contractor shall, when ordered by the Engineer, excavate or displace swampy ground and backfill with suitable material. Such backfill shall be river or beach sand unless otherwise directed by the Engineer.

2.4.4.2 Placing of Embankment

- (a) **General** - Except as otherwise required by the Drawings, all embankments shall be constructed in layers. During construction of embankment, a smooth grade having an adequate crown shall be maintained at all times to provide drainage. The placing of fill shall be carried out in successive layers for the full width of fill as shown on the Drawings.

The layers shall not exceed 150mm in thickness on completion of compaction. When embankment fill is placed adjacent to structures it shall be performed in accordance with the direction of the Engineer.

(b) Placing Embankment over Swampy Ground - Where new embankment will overlay existing canals, ditches, ponds or other waterways, these shall be filled in exclusively with sand as specified in the design. Prior to filling, cofferdams shall be made to allow pumping and the bed shall be left to dry until approved by the Engineer for filling. The works of damping, pumping and drying will not be an item for payment, but will be considered to be included in the rates for earthworks fill.

(c) Widening Existing Embankment - Where embankment fill is being carried out to widen an existing embankment the new fill material shall be fully keyed into the old embankment by means of benching which shall be in steps each not less than 300mm high and 600mm wide. Steps shall be cut in advance of the filling. Material cut in benches may be used as fill if it complies with section 2.4.2 above or may be disposed as directed by the Engineer.

2.4.4.3 Procedure of Manual Embankment Compaction: Earth excavated from the borrow pit shall be placed in the embankment in horizontal layers parallel to the finished grade not exceeding a loose thickness of 150 mm. The earth of each basket is to be placed near to the earth placed before it and spread systematically. Throwing of earth in heap will not be allowed. The clods of earth shall be broken down to 50 mm size or less by striking the clods with the back of a spade or by other suitable method before the next basket of earth is thrown close to it. The earth shall be compacted manually using rammers made of wood, iron or concrete weighing 6 to 7 kg, fitted with shafts of about 1.5 m long. Ramming shall reduce the voids and until no further shrinkage of earth is possible by ramming. Before commencing ramming, the moisture content of the soil shall be increased or decreased as necessary by sprinkling the soil with water or by allowing natural drying of the soil as necessary so that the ramming can achieve the compaction as specified. Both wetting and drying may be aided by furrowing the fill and then re-spreading when the moisture content is suitable. The preceding operations shall continue layer after layer until the top of the embankment is reached.

2.4.4.4 Overfilling: To ensure that, the embankment is properly compacted up to the edges of each layer, overfilling and compaction of approx. 300mm horizontally on both sides of the embankment is required, which later on has to be cut and removed. No extra payment will be made for this procedure.

2.4.5 Measurement: Embankment shall be measured in cubic metres based on cross sections compacted and accepted in place. The volume to be measured will be the net volume of required and accepted embankment, actually constructed and completed in accordance with the Specification, to the lines, levels, grades and cross sections required or as directed by the Engineer. The cross section to be used will be the area bound by the sub-grade (below improved sub-grade or sub-base) the side slopes or edge limits and the original ground line. No allowance will be made for material cut in benching operations. The final volume of embankment fill shall not include the voids for bridges and box-culverts. The voids for pipes, manholes, catch basins and the like will not be deducted.

2.4.6 Payment: This work measured as provided above shall be paid for at the Contract unit prices per cubic metre. Payment shall be full compensation for performing the work, furnishing the materials and providing all labour, equipment, tools and incidentals necessary to complete the work, including all payments for obtaining, carrying and stockpiling of the embankment fill. Pay items shall be:

	<u>Unit</u>
Embankment fill from any approved source outside the site	- Cubic metre
Embankment fill from roadway excavation	- Cubic metre
Sand backfill to Swamp	- Cubic metre

2.5 Earthwork in Foundation

2.5.1 Excavation: All excavations shall be taken to the required depths and sizes as per drawing and direction of the Engineer. While excavating, at least 150 mm of the depth shall initially be left un-excavated which shall be dug out carefully in the final dressing after checking of the levels. If any portion of the foundation or trench is excavated to a greater depth than specified, the excess depth shall be filled-up with sand at the Contractor's own cost. If foundation bed is wet due to rains or due to slow seepage of water, care shall be taken to dry it up before the foundation is laid. Dry sand is to be laid to

the required thickness for this purpose at Contractor's cost. The excavated earth shall be kept sufficiently away from the side walls to avoid collapse of the excavations due to the pressure of the surcharged earth and also in such a manner that it does not interfere with traffic or approach to private or public properties. When excavation is made on metalled, tarred, and concrete or brick paved roads, the Contractor shall remove the salvageable cut materials, stack them away from the trenches and preserve them separately from excavated earth. Any excess excavated earth shall be removed from site within 24 hours of excavation.

2.5.2 Shoring and Boxing: Shoring and boxing work should be done in cases where loose soil is encountered, masonry structures are close to the excavations, depth of cutting exceeds 1.5 metres, and/or utilities require safeguarding, etc., to avoid side collapse, and should be done simultaneously with the earth work excavation. Design of the shoring or boxing shall be determined by the site conditions and shall be subject to the approval of the Engineer. Sufficient space shall be provided while making boxing arrangements in the trench bottom for sumps for efficient dewatering facilities with a minimum 150 mm clear width on either side of the trenches. The process of boxing and shoring shall be continued until the excavation reaches the required depth of cutting. All boxing and shoring materials such as planks, runners and struts shall be withdrawn from the excavations prior to completion of back filling.

2.5.3 Piling in Foundations: When piling is necessary at least 300 mm earth over the bed level should be kept uncut. After driving piles up to the desired depth the last layer of earth shall be excavated.

2.6 Protection of Embankment Slope

2.6.1 Description: This item shall consist of applying turfing to stabilize the earthen shoulder and slopes of the embankment. Turfing shall be furnished and placed on completed, prepared and accepted earthen shoulder and side-slopes of road embankment in order to protect the shoulder and side slopes from erosion resulting from water action and flow of rain water.

2.6.2 Construction: The existing embankment earthen shoulder and slopes shall be prepared and brought to correct shape as shown on the drawings using additional soil as necessary. The slope areas shall be compacted by hammer or by any other approved means and prepared in an approved manner to receive the turfing.

2.6.3 Construction Method: Sodding or turfing shall be done by planting sods or turf to give continuous cover over the whole area. They shall be planted with their root system substantially undamaged, well buried in firm materials, and packed around with moist earth in which they have grown. Fertilizer shall be added at the time of planting, if necessary, to ensure good cover within the required time. The contractor shall maintain the turfed areas at his own expense until the end of the period of maintenance. Maintenance shall consist of preserving; protecting and replacing turf and such other works as may be necessary to keep in a satisfactory condition to prevent erosion and to provide a dense and uniform appearance. The contractor shall be responsible for satisfactory growth and shall water at such intervals as will ensure good ground cover of live grass all through the period of maintenance.

2.6.4 Measurement: The quantity measured for payment shall be the number of square metres of turfed or sodded surface whether horizontal or sloping of required and accepted turf well established in place.

2.6.5 Payment: This work measured as provided above shall be paid for at the contract unit price per square metre. Compensation for furnishing all materials, labour, equipment, tools and incidental necessary to complete the work to the satisfaction of the Engineer.

2.7 Excavation/Re-excavation of Channel

2.7.1 Description: This work shall consist of excavation for channels, ditches and ponds and for discharging water from side ditches as shown on the Drawings, required in the Specifications or directed by the Engineer. The work shall include the proper utilization and hauling or disposal of all excavated materials, and constructing, shaping and finishing of all earthworks.

2.7.2 Materials: Excavated materials shall be classified as unsuitable and suitable materials. To be suitable as fill material as described above, the soil must not contain muck, roots, sod or other deleterious materials and must conform to the requirements of Section 2.4.2. The Engineer will decide if the soil is

suitable or unsuitable and whether such soil can be used in the embankment, or shall be waste for the disposal by the Contractor at his own expense.

2.7.3 Construction methods: (a) Alignment and Levels - Channel work shall be constructed in a neat and workmanlike manner correct to alignments, levels, grades and cross sections shown on the Drawings, in the Specifications or as directed by the Engineer.

(b) **Excavation** - Deepening and realignment of existing canals and channels shall be carried out in a way to allow free flow of the water. During excavation of new channels these shall as far as possible be kept drained. All suitable materials removed from the excavation shall be used as far as practicable in constructing the embankment, or be spread over a layer not more than 150 mm high.

(c) **Filling of Obsolete Channels** - Any obsolete canals and channels within the embankment area shall be cleaned up and backfilled with sand to obtain sufficient stability. When sand fill is at a level of 500mm above water level, compaction shall be carried out as specified in Section 2.4.4.3

(d) **Waste** - Unsuitable material from channel excavations shall be known as waste. Waste shall be removed from the site and disposed of by the Contractor at his own expense and to the satisfaction of the Engineer.

2.7.4 Measurement: Quantities of channel excavation in any material shall be measured in cubic metres determined by average end area methods computed from the original and final geometric cross sections of the authorized and completed excavation. Payment for backfilling existing channels shall be in accordance with Section 2.4.5

2.7.5 Payment: This work measured as provided above shall be paid for at the Contract unit price per cubic metre. The payment shall be full compensation for all excavation, for maintaining free flow in the channel where necessary and for all labour, materials, tools, equipment and incidentals necessary to complete the work. The above prices and payments shall be full compensation for all work involved in performing the channel excavation completely as shown on the Drawings and as specified herein and as directed by the Engineer. Pay item shall be in Cubic Metre for the channel excavation in any material and disposal, to fill, stockpile or otherwise.

2.8 Backfill for Structures

2.8.1 Materials

(a) **Foundation Fill Material:** Material for foundation fill shall consist of suitably graded sand, gravel or stone as shown on the Drawings or blinding concrete mix 1:3:6 or directed by the Engineer.

(b) **Backfill Material:** Backfill materials below top level of pile caps shall consist of sand with not more than 10% of material passing the 75-micron sieve. If stated on the Drawings or ordered by the Engineer, other compactable soil material may be used. Backfill above top level of pile caps but outside embankment and road areas shall be excavated material if suitable and approved by the Engineer.

2.8.2 Construction Methods

(a) **General:** Prior to starting excavation operations in any area, all necessary clearing and grubbing shall have been performed. The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross section elevations and measurement may be taken of the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the Engineer. The contractor shall be responsible for the safety and stability of the excavation and shall provide all protective supports, bracings, shorings and side slopes where necessary. Trenches and foundation pits for structures and structure footings shall be excavated to the lines, grades and elevations shown on the Drawings or as directed by the Engineer. The elevations of the bottoms of footings shown on the Drawings are approximate only and the Engineer may order in writing such changes in the dimension or elevations of footings as may be deemed necessary to secure a satisfactory foundation. Should contractor over excavate or cut earth beyond the specified lines or levels then the contractor shall fill the over excavated area with sand in

layers and thoroughly compact the backfilling or with blinding concrete as directed by the engineer at contractors own expense. Boulders, logs and other objectionable material encountered in excavation shall be removed. After each excavation is completed the Contractor shall notify the Engineer to that effect and no footings, bedding material or structure shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material. The foundation material shall be cleared of all loose material and cut to a firm surface, either level or stepped or serrated, as specified or shown on the Drawings or directed by the Engineer.

- (b) **Foundation Directly on the Ground:** When the footing is to rest on the ground and not on piles, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall be deferred until just before the footing is to be placed. When, in the opinion of the Engineer, the foundation material is soft or otherwise unsuitable, the Contractor shall remove the unsuitable material and insert foundation fill material or concrete as specified or shown on the Drawings or directed by the Engineer. If foundation fill material is required it shall be placed and compacted in layers not more than 150mm thick or as directed by the Engineer.
- (c) **Foundation on Piles:** When the ground between the piles is too soft to support the green concrete, the Contractor shall submit his proposal for a bottom form to the Engineer for his approval. Extra excavation and foundation fill or concrete fill in such case will not be paid for separately. If the bottom form is carried out by such strengthening of the ground the Contractor shall, if requested, submit calculations showing that the pile cap will not be harmed during hardening due to differential settlements between the piles and the strengthened ground.
- (d) **Disposal of Excavated Material:** All excavated material so far as suitable, shall be utilized as backfill or embankment fill. The surplus material shall be carried to waste as described in Section 2.7.3.(d). Excavated material suitable for use, as backfill shall be deposited by the Contractor in stockpile at points convenient for re-handling of the material during the backfilling operation. Excavated material shall be deposited in such places and in such a manner as not to cause damage to roads, services or property either within or outside the Site and so as to cause no impediment to the drainage of the site or surrounding area. The location of spoil heaps shall be subject to the approval of the Engineer who may require that the reference lines and the traverse lines of any part of the structure be kept free of obstruction.

2.8.3 Cofferdams: The term "cofferdam" denotes any temporary or removable structure, constructed to hold the surrounding earth, water or both, out of the excavation, whether such structure is constructed of earth, timber, steel, concrete or any combination of these. The term includes earth dikes, timber cribs, sheet piling, removable steel shells and all bracing; and it shall be understood to include excavation enclosed by pumping wells and well points. The cost of cofferdams is always to be included as part of the bid price for the work. The Contractor shall submit upon request, Drawings showing his proposed method of cofferdam construction. Approval of the Drawings by the Engineer will not in any way relieve the Contractor of the responsibility for the adequacy of the design for strength and stability or for the safety of the people working therein. The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction and removal of any required forms and the inspection of the interior and to permit pumping. If possible, cofferdams shall be so designed that no cross bracing shall be left in place. If this is not possible, bracing left in place shall be of structural steel. The end of such structural members that would be exposed when the structure is completed shall be boxed back at least 50mm behind the concrete face. The resulting holes shall be completely filled with concrete. When foundation piles are to be driven inside a cofferdam and it is judged impossible to de-water the cofferdam before placing a concrete seal, the excavation may be extended below the designed level to a depth sufficient to allow for swell of the material during pile driving operations. Any material that rises to a level above the design level shall be removed. Where it is possible to de-water the cofferdam, the foundation material shall be removed to exact grade after the foundation piles are driven. Backfilling in a foundation to compensate for excavation, which has been extended below the required grade, shall be at the expense of the Contractor. Backfilling shall be with concrete or foundation fill material as indicated on the Drawings, or as directed by the Engineer. If no material is indicated, backfilling shall be concrete of the same kind as required for the structure to be constructed in the excavation. Unless otherwise permitted no excavation shall be made outside of caissons or cribs or cofferdams or sheet piling and the natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the site of the structure before cribs, or cofferdams are in place, the Contractor shall after the foundation is in place, backfill all such excavation to the original ground surface

or stream bed with material satisfactory to the Engineer. Material deposited within the stream area from foundations or other excavations or from the filling of cofferdams shall be removed and the stream area freed from obstruction. Cofferdams, which have tilted or moved laterally during construction, shall be corrected as necessary at the expense of the Contractor. Unless otherwise provided cofferdams shall be removed after the completion of the sub-structure. The removal shall be effected in such a manner as not to disturb or mar the finished work. The Engineer may order the Contractor to leave any part or the whole of the cofferdam in place and this shall not entitle the Contractor to any additional payment. When conditions which, in the opinion of the Engineer, render it impossible to de-water the foundation before placing the footing are encountered, the Engineer may require the construction of a concrete foundation or seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as shown on the Drawings or as directed by the Engineer. The foundation shall then be de-watered and the footing placed. When weighted cribs are used and the weight is used to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage's such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal. When a foundation seal is placed under water the cofferdam shall be vented at low water as directed. Cofferdams shall be constructed so as to protect newly cast concrete from sudden rising of the water and to prevent damage to the foundation by erosion.

2.8.4 Pumping and Bailing: Pumping and bailing from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through or alongside any concrete being placed. No pumping or bailing will be permitted during the placing of concrete and for a period of at least 24 hours thereafter unless it is done from a suitable pump separated from the concrete work by a watertight wall or from well points. Excavations shall be as dry as possible prior to and during placing concrete. Placing concrete under water will only be permitted if indicated on the Drawings or approved by the Engineer.

2.8.5 Dewatering Systems: The Contractor may adopt one or both of the following dewatering systems, considering the actual field conditions and requirements for proper execution of work.

2.8.5.1 Dewatering by Sub-surface Water Control System: Dewatering by Sub-surface Water Control System is defined as controlling water accumulated from any source requiring the use of well point or tubewell system. The Procedure is described below:

- (a) Works to be performed under this clause include furnishing, installing, maintaining, operation and removing the sub-surface water control system so that the required excavation can be safely and properly performed and the structure built and backfilled to the elevation as shown on the Drawings.
- (b) Excavation shall not be made below a level 1 m above the ground water level shown to exist by the water level in the observation wells. If the distance to the groundwater table becomes less than 1 m, or the Engineer has any reason to believe that rising ground water is likely to endanger either the open excavation or the structure, backfill may be ordered by the Engineer to be placed as a precaution against failure.
- (c) If for any reason, ground water control is lost and ground water appears in any portion of the excavation, the Contractor shall take immediate action to control and confine the flow. Any portion of the final grade which, in the opinion of the Engineer, has been damaged by the action of the ground water, shall be excavated as directed by the Engineer and backfilled in accordance with the Specifications at no extra cost to the Contract.
- (d) If it becomes necessary for any reason to stop the sub-surface de-watering operations before the construction of sub-structure is complete, the Engineer may order the site to be flooded up to the surrounding ground water level as de-watering is discontinued. Under no circumstances shall the site be flooded by allowing the ground water to rise through the soil. If it becomes necessary to flood the site as described above, all equipment that can be damaged shall be removed to safety.
- (e) The cost of all such backfilling, flooding and subsequent draining and re-excavation, shall be included in the lump sum price for dewatering and no extra payment will be allowed.
- (f) **Operation :** The sub-surface Dewatering System shall be operated 24 hours per day, seven days per week during the period that dewatering is required. The Contractor shall take advance precautions against failure of any part of the system.
- (g) **Monitoring Wells:** Observation wells of 38 mm diameter GI pipes with 1.25 metres long wire mesh strainer and full filters shall be installed by the Contractor to suitably monitor

the ground water levels maintained by the Contractor's dewatering system. The depth of wells shall be a minimum of 3.0 m below the lowest level of the foundation excavation. The Contractor shall provide a means for locking the access to the observation wells, and shall maintain a log book with daily readings of sub-soil water levels recorded every three hours, available at all times for inspection. The log book shall be periodically checked and authentication by Engineer's Representative.

- (h) **Removal of System:** The dewatering system shall be removed when the construction has progressed to a stage that site dewatering is no longer required, but only after receiving the written permission of the Engineer. Certain portions of the Contractor's dewatering system may be left in the ground when construction procedures so require and when written permission of the Engineer is obtained. Any such portion of the dewatering system shall be plugged, capped and/or otherwise rendered harmless to the work and the public.

2.8.5.2 Dewatering by Surface Water Control System: Dewatering by Surface Water Control System is defined as controlling surface water levels within the ring bunds by use of pumps, sump pump, gravel drain or other mechanical devices, but without requiring the use of a well point or tube well system. Such water may accumulate from percolation, rain or pumping flood water into the ring bunds, or any other source or combination of sources. The water levels inside the ring bunds shall not exceed the levels as directed by the Engineer. The Procedure is described below:

- (a) Work to be performed under this clause include furnishing, installing, maintaining, operating and removal of the surface water control system for dewatering the accumulated water from the area within the ring bunds so that the desired construction can be safely and properly performed. The discharge line/drainage system for the disposal of the evacuated water shall be constructed by the Contractor at his own cost as per approved drawing including the arrangement of private land, if needed.
- (b) **Operation of Dewatering System:** The Contractor shall make all arrangements for pumps, fuel, lubricants, maintenance and operation of the equipment and the whole Surface Dewatering System and shall take precautions in advance, against failure of any part of the system.
- (c) **Removal of System:** The Surface Dewatering System shall be removed, upon written permission of the Engineer when the construction has progressed to a stage that site dewatering is no longer required.

2.8.5.3 Contractor's Responsibilities: (1) The Contractor shall be solely responsible, and include in his rates, for the following tasks:

- (a) The design of the dewatering system including the collection of the requisite data, preparation of plans and drawing of the necessary de-watering system.
 - (b) Providing all equipments and accessories required for dewatering by the Surface Water Control System and Sub-surface Water Control System for satisfactory execution of the work.
 - (c) Transportation, furnishing, installation, safe operation and maintaining of the system, including operators, mechanics, supply of power, fuel, lubricants, spares, repairing, etc throughout and removal of the equipment at the end of the construction period under this Contract.
- (2) The Contractor shall provide continuous supervision of the system by persons competent to recognize adverse conditions as they develop and take immediate corrective measures. The supervisor whose name and hours of duty duly furnished to the Engineer by the Contractor, shall have thorough knowledge of the system, including the ability to make minor emergency repairs.
- (3) The control of water throughout the time of this Contract shall be the sole responsibility of the Contractor. The ground water table shall be maintained at minimum of 0.90 m below the lowest designed excavation level. Control methods shall be subject to the approval of the Engineer, including the Contractor's equipment, plans, methods and installation and operation procedures etc.
- (4) The control methods adopted by the Contractor shall be subject to the approval of the Engineer, including equipment, plans, methods, installation, operation, maintenance procedures and precautions against the failure of any part of the system. The precautions shall include sufficient standby pumping plant and essential spare parts. The standby pumping plant shall comprise at least one pump and the standby pumping capacity shall be at least 10% of the total working capacity.

2.8.6 Backfilling: All spaces excavated under this Specification and not occupied by the permanent structure shall be backfilled. Backfilled material shall be free from large lumps, wood and other extraneous material. Backfill under top level of pile caps shall always be made with compacted sand fill free from chemical contamination. Over top level of the pile cap but outside embankment and road areas, the backfill shall be excavated materials if suitable and free from chemical contamination, and approved by the Engineer. If the excavated material is not suitable, the Engineer may order sand filling up to agreed level. Backfill outside the embankment and road areas shall be placed in layers not more than 250mm in depth (loose measurement) and shall be compacted to a density comparable with the adjacent undisturbed material. Backfill within the embankment and road areas shall be made in accordance with Section 2.4. In placing backfill and embankment, the material shall be placed insofar as possible to approximately the same height on both sides of the structure. If conditions require backfilling appreciably higher on one side, the additional material on the higher side shall not be placed until permission is given by the Engineer nor until the Engineer is satisfied that the structure has enough strength to withstand any pressure created. Backfill and embankment fill shall not be placed behind the walls of bridges or box culverts until the top slab has been placed for a sufficiently long period and not less than three days. Backfill and embankment behind abutments held at the top by superstructure shall be carried up simultaneously behind opposite abutments and side walls. No backfilling shall be placed against any structure until permission shall have been given by the Engineer. Special care shall be taken to prevent any unduly high pressure against the structures. The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be a horizontal beam of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled. Adequate provision shall be made for drainage.

2.8.7 Measurement: The volume of excavation and backfill shall be measured in cubic metres of excavated undisturbed material. The quantity of excavation for structures to be measured for payment shall include excavation for all structures. The measured volume shall be bounded on the bottom by the plane of the bottom of the reinforced concrete footing and on the top by the surface of the existing ground and on the sides by vertical planes of the footings. Backfill with concrete or sand where directed by the Engineer including concrete seals shall be measured separately as the volume within the plan outline and top and bottom surfaces. Concrete or sand placed to backfill excavation beyond the excavation required will not be measured for payment. The plan outline referred to is the excavation plan outline as defined above. If sand fill is ordered over top level of pile cap, the fill shall be the specified filling volume measured on the Drawings up to profiles agreed upon in writing by the Engineer. Removal of slides, cave-ins, silting or filling shall not be measured nor paid for. The Contractor shall be deemed to have included in his bided rates for excavation and subsequent backfilling of all working space around foundation structures. No separate measurement or payment shall therefore be made for this.

2.8.8 Payment: This work measured as provided above shall be paid for at the Contract unit prices per cubic metre for each particular item. The payment shall be full compensation for all excavation and backfill including compaction, constructing and removing all cofferdams, all dewatering, pumping and bailing, and for furnishing all materials, labour, equipment, tools, sheeting, bracing, cofferdams, pumps, and incidentals necessary to complete the work. Payment for backfilling shall be included in the pay item for "Excavation and Backfill for Structures" except for sand fill and concrete fill. These fill types shall be measured as provided above and paid for at the concerned Contract unit prices, but no compensation in the pay item "Excavation and Backfill for Structures" shall be made for less backfilling with excavated material or more surplus to waste. All payment for the backfilling and compaction of those areas, which were removed as structural excavation, shall be included in the appropriate unit rates below. Filling or backfilling of areas above the natural ground level or above the limits of road excavation or channel excavation section shall be paid for under Section 2.4. Cofferdams for structures without excavation, for example for pile caps over water shall be deemed to be included in the unit prices for the concerned pile cap.

Pay items shall be:

Excavation and Backfill for Structures
Concrete Backfill for Structures
Sand Backfill for Structures
Brick bats filling

Unit

Cubic Metre
Cubic Metre
Cubic Metre
CubicMetre

PART 3: HYDRAULIC STRUCTURES

3.1 CONCRETE FOR STRUCTURE

3.1.1 Materials

3.1.1.1 Course Aggregate: Course aggregate for all types of concrete with the exception of blinding concrete shall consist of hard durable crushed or broken rock and conform to the requirements of AASHTO Standard Specification for coarse aggregate, shall be clean, free from dust and other deleterious materials when tested with standard test Procedures. Samples shall be collected from a stockpile of 20 cum. of stone chips or more as per AASHTO Test No. T2-84. The aggregates shall conform to one of the following grading depending on the nominal size of aggregate specified in the schedule and drawings. The unit weight shall be determined in accordance with standard test Procedures. The unit weight test shall be carried out on the materials as sampled after drying. The unit weight shall not be less than 1610 kg/cum. The abrasion shall be determined in accordance with standard test Procedures. Aggregate with Nominal sizes 63 mm, 40 mm, and 20 mm shall be tested in accordance with Grade 'B' materials. Aggregate with nominal sizes 14 mm and 10 mm shall be tested in accordance with Grade C materials. The percentage of wear shall not exceed 30%. The weighted average loss after five cycles shall not be more than 12 percent when the coarse aggregate is subjected to the sodium sulphate soundness test, AASHTO Designation T 104.

Percentage by weight passing of nominal aggregate size

Nominal size/ Sieve size	63mm	40mm	20mm	14mm	10mm
75.0 mm	100%	-	-	-	-
63.0 mm	100%	100%	-	-	-
37.5 mm	0-30%	85-100%	100	-	-
20.0 mm	05%	0-25%	85-100%	100%	-
14.0 mm	-	-	-	85-100%	-
10.0 mm	-	0-5%	0-25%	0-50%	85-100%
5.0 mm	-	-	-	0-10%	0-25%
2.0 mm	-	-	-	-	0-5%

3.1.1.2 Fine Aggregate: Fine Aggregate shall consist of natural sand conforming to the requirements of AASHTO standard specifications. Sand shall be sampled in accordance with Standard Test Procedures. Samples thus collected shall be tested for grading, F.M, and any other tests instructed by the Engineer. Sample shall be collected from a source of 20 cum. of sand or more. Sand shall be completely non-plastic and free of all clay, roots and other organic materials. The particle size distribution shall be determined in accordance with standard Test Procedures. The FM shall be calculated in accordance with Standard Test Procedures. The grading of the various sizes of sands shall be as shown in the following tables.

Grading Limits for Sands

Nominal FM	2.8-3.1	1.5-2.8	1.0-1.5	0.8-1.0	0.5-0.8
Sieve Size	% Passing				
10.0 mm	100	100	100	100	100
4.8 mm	90-95	90-100	100	100	100
2.4 mm	70-90	90-100	100	100	100
1.1 mm	45-70	70-95	95-100	100	100
600 micron	25-45	45-85	85-95	95-100	100
300 micron	10-20	20-50	50-70	70-80	80-90
150 micron	0-2	0-2	20-35	35-40	40-60

3.1.1.3 Cement: Cement shall be sampled in accordance with Standard Test Procedures. Samples thus collected will be tested for fineness, setting time and strength. Samples shall be collected from every 20 tonnes of cement supplied. Cement shall be free from any hardened lumps and any foreign material. The fineness of cement shall be determined in accordance with Standard Test Procedures. Cement shall have a minimum of 90% of particles by weight passing through the 75-micron sieve. Setting time shall be determined in accordance with Standard Test Procedures. Cement shall have an initial setting time in excess of 45 minutes and a final setting time not greater than 7 hours. The test shall

be carried out at 30 degrees Centigrade. The strength of cement shall be determined in accordance with Standard Test Procedures. The crushing strength of 100mm standard concrete cubes shall not be less than 9 N/mm² at 3 days and 16 N/mm² at 7 days.

3.1.1.4 Water: All sources of water for use in concrete shall be subjected to the approval of the "Engineer". Water shall be reasonably clear, free from injurious quantities of oil, alkali, salts and organic substances and shall not contain any visibly solid materials. Water whose concentration of chloride ion is in excess of 3,000 ppm (parts per million) shall not be used for the manufacture of concrete. If requested by the "Engineer" water shall be tested by comparison with water of known satisfactory quality. Such comparison shall be made by means of standard cement tests for soundness, time of setting and mortar strength. Any indication of unsoundness, change in time of setting of plus or minus 30 minutes or more, or reduction of more than 10 percent in mortar strength shall be sufficient cause for rejection of the water in question. Water submitted for tests to determine its compliance with these specifications shall be tested by the latest revision of AASHTO Method T26.

3.1.1.5 Admixtures: Approval of the "Engineer" shall be required prior to the use of admixtures such as water reducing agents or any other admixtures.

3.1.2 Storage of Materials

3.1.2.1 Concrete aggregates: The handling and storage of concrete aggregates shall be such as to prevent segregation or the inclusion of foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations. When specified in the documents, the coarse aggregate shall be separated into two or more sizes in order to secure greater uniformity of the concrete mixture. Different sizes of aggregates shall be stored in separate stockpiles sufficiently apart from each other to prevent the materials at the edges of the piles from becoming intermixed.

3.1.2.2 Cement: Cement shall be delivered in sound undamaged bags uncontaminated by moisture, oil or any other substance. The nominal weight of a bag of cement shall be 50kg. Individual bags, which vary by more than 5% from the nominal weight, shall be rejected. Where the average weight of 5 bags taken at random from any one consignment is less than the nominal weight, the whole consignment shall be rejected. Every bag shall be marked with the manufacture's brand, the type of cement, identification number or numbers relating to the testing and certification of the cement, and the date the bag was filled. The contents of broken or damaged bags shall not be rebagged. Cement not conforming to the requirements of this Clause shall not be used in the works. The following requirements shall apply to the storage and handling of cement at site or at any intermediate transfer or storage point:

- (a) All methods for transporting, handling and storing bagged cement shall be planned and arranged to ensure the use or transfer of cement in the approximate chronological order of manufacture.
- (b) Batches of cement procured at different times shall be stored separately and shall not be mixed.
- (c) All loading and unloading facilities for cement shall be under cover and weatherproof to the satisfaction of the "Engineer".
- (d) All bagged cement shall be stored at all times upto its use in the works in completely weatherproof structures which shall include a timber floor raised not less than 300mm above the surrounding ground and be adequately ventilated to prevent the accumulation of moisture.
- (e) All storage of bagged cement shall be arranged to permit easy access for inspection and definite identification of all cement in the storage.
- (f) The temperature of the cement at any time shall not exceed 60°C.

3.1.3 Composition of Concrete

3.1.3.1 Trial Mixes: The proportion in which the various ingredients shall be used in the concrete mix for different parts of the work, shall be designed in accordance with the specified strength as defined in the drawings and schedules. Trial mixes with the materials to be used shall be prepared in a standard approved (by LGED) laboratory at least 30 days before the commencement of concrete. No concrete shall be placed in the work until the "Engineer" has approved the relevant mix. The trial mixes will

determine the amount of cement, water, fine and coarse aggregate and admixture (where necessary), required per one cubic metre of each class of concrete, and shall be used to determine the weight and volume of each component required to produce one batch of concrete from the mixers proposed for use by the contractor. The Table in clause 3.1.3.3 below is a guide only. The minimum specified strength must be obtained with proper mix design & trial mixes. In this regard the Engineer shall have the right to increase the quantity of cement or to adjust other materials as he finds suitable for the work. No extra claim, whatsoever, by the contractor will be entertained. The Contractor shall have to obtain a written approval from Engineer of the mix/proportion to be used for different type of specified strength. This approval shall not relieve the Contractor from his contractual responsibility. As the work progresses, the Engineer reserves the right to change the proportions from time to time, if conditions warrant such changes, to produce concrete complying with specification requirements. No change in the source or character of materials shall be made without due notice and approval of the Engineer. No new materials shall be used until the Engineer has accepted such materials and has approved new proportions based on tests by trial mixes.

3.1.3.2 Average Strength of Trial Mixes: The required average compressive strengths of trial mix for concrete of the specified strengths is in the following table:

Class of concrete	Specified Strength N/mm ² (Minimum)	Trial mix required average strength N/mm ² (Minimum)	Indicative Mix Proportions by volume
A	35	47	-
B	25	35	-
C	21	30	1 : 1.5 : 3
D	15	23	1 : 2 : 4
E	10	16	1 : 3 : 6

3.1.3.3 Standard Classes of Concrete: The class of concrete and properties applicable to the concrete in various parts of structures shall be as specified in the following table.

Class of concrete	Maximum size of aggregate (mm)	Maximum water cement ratio by weight	Minimum cement content (kg/m ³)	Maximum slump (mm)	28day cylinder strength (N/mm ²)
A	20	0.40	400	66	35
B	25	0.50	360	75	25
C	25	0.52	350	75	21
D	25	0.70	250	75	15
E	25	0.70	200	75	10

The maximum cement content in any mix shall not exceed 510 kg/m³.

3.1.3.4 Location of Concrete by Class: The various classes of concrete shall be placed in the locations specified below and elsewhere as directed.

Type of mix to be used in structures

<u>Class of Concrete</u>	<u>Location</u>
A	Not generally used
B	Not generally used
C	Reinforced concrete for structural members (retaining walls, abutments, piers, girders, bridge decks, header tanks, hand rails and rail post.
D	General Mass concrete (with /without anti-crack steel)
E	Blanding concrete / concrete blocks

3.1.3.5 Regulation of Water Content: The amount of water used in the concrete for volume batching shall be regulated to adjust for any variation of the moisture content or grading of the aggregates. The batched volume of damp fine aggregate shall be corrected to the equivalent volume of dry aggregate. The volume of moisture in the aggregates shall be deducted from the free water to be added to the mix. To expedite correction to fine aggregate a "bulking curve" showing the relation between moisture content and increase over dry volume shall be prepared in advance by tests on the fine aggregate used. The Engineer may direct the use of a slump less than that specified above whenever concrete of such lesser slump can be consolidated into place by means of vibration specified herein. Addition of water to overcome stiffening of the concrete before placing will not be permitted. Concrete shall have uniform

consistency from batch to batch. Aggregate shall not be batched for concrete when free water is dripping from the aggregate. All costs shall be deemed to be included in the rates bided for the various item of concrete construction.

3.1.4 Batching and Mixing

3.1.4.1 Plant: All plant and equipment used for batching and mixing shall be approved by the Engineer and shall be capable of supplying concrete at a rate adequate to meet the requirements of the Contract. All concrete used in the works shall be produced using a motor driven mixer of adequate capacity.

3.1.4.2 Measuring and Tolerances: Cement, fine aggregate and each size of coarse aggregate shall all be measured separately using calibrated containers. Water shall be weighed separately on an individual scale or may be measured by volume.

3.1.4.3 Mixing Equipment: When loaded to their rated capacity, mixers shall be capable of combining the ingredients within the time specified in Clause 3.1.4.4 and of discharging the concrete with a degree of uniformity such that when samples taken at one-quarter and three-quarter points of the batch volume and tested for slump, the difference between the two slumps shall not exceed one half of the average of the two slumps. All equipment shall be in sound mechanical condition and the interior of the drum or pan and mixing blades shall be kept thoroughly clean and free from hardened concrete or mortar by cleaning at frequent intervals as directed by the Engineer, and in every case before the commencement or after a break of mixing operations.

3.1.4.4 Charging Sequence: The Engineer reserves the right to vary the mixing time or to limit the batch size when the charging and mixing operations fail to produce a batch of concrete that conforms to the foregoing requirements in respect of adequacy of mixing. The concrete of a given composition, as discharged from the mixer, shall be uniform in composition and consistency within batches and from batch to batch. The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Water shall be added before, during and following the mixer-charging operations. Excessive over-mixing, requiring addition of water to preserve the required concrete consistency, will not be permitted. No material for a batch of concrete shall be placed in the drum of the mixer until the entire previous batch has been discharged there from. The inside of the drum shall be kept free from hardened concrete.

3.1.4.5 Mixer Performance: Any mixer that at any time does not meet the requirements of this Clause shall be repaired promptly and effectively or shall be replaced.

3.1.4.6 Payment: Separate payment shall not be made for complying with the requirements of this Clause and all costs shall be deemed to be included in the rates bided in the priced Schedule for the various items of concrete construction. Payment for concrete shall be at the contract rates for cubic metres of concrete in place.

3.1.5 Sampling and Testing

3.1.5.1 General: The Contractor will provide such samples of aggregates, cement, water, mixed concrete, and concrete cylinders as the Engineer may require. The Engineer will arrange testing of these in an approved laboratory and will provide all equipment required for testing concrete and materials for concrete in accordance with this Clause.

3.1.5.2 Standards: Unless otherwise approved, sampling and testing of concrete materials, plastic concrete and hardened concrete will be in accordance with the appropriate Standard Test Procedures.

3.1.5.3 Testing Cement: The Contractor in the presence of the Engineer, shall take samples of cement from storage or cement usage point which appears to have deteriorated through age, damage to containers, improper storage or for any other reason and arrange for testing. The Contractor shall provide all facilities, labour and materials, necessary to obtain and test these samples at no cost to the Department. In the event of any sample being found not to comply with the Specification, the whole consignment from which the sample taken shall be rejected and removed from the site immediately not with standing any previous acceptance on the basis of the manufacturer's certificate. The Engineer may require the removal and replacement of any concrete produced with cement not complying with the requirements of the Specification without any extra cost to the department.

3.1.5.4 Sampling and Testing Plastic Concrete: The Contractor in the presence of the Engineer shall sample concrete for testing from the batching and mixing plant, at the time of pouring into the forms or elsewhere where concrete is being handled or placed. Samples shall be obtained at uniform intervals throughout the production or delivery of concrete for a given placement. The contractor shall supply sufficient number of cylinder moulds and slump cones to enable the sampling required by this section. A placement shall be considered as a continuous operation involving the placing of concrete as follows for. In general, the frequency of sampling of a class of concrete in any placement of **in-situ concrete** will be in accordance with the following table:

Frequency of Sampling Concrete

Up to 10 cubic metres	1 sample (= 3 Cylinders)
Up to 20 cubic metres	2 samples
Up to 40 cubic metres	3 samples

For each additional 20 cubic meters or fraction, 1 extra sample shall be taken. In general, four specimen cylinders, two for testing at 7 days and 2 for testing at 28 days, plus as many specimens as required by the Engineer for other testing will be made from any sample. For pre-cast units, a third specimen cylinder shall be taken from every sample for testing prior to removal of the forms. The Contractor shall provide the required quantity of concrete for sampling and testing and shall include the cost of this concrete and any concrete required separately by the Engineer for any other necessary tests, in the rates bided in the priced Schedule for the various items of concrete construction. The Contractor has the right to be present at any sampling or testing conducted by the Engineer but such right shall not operate to restrict in any way the right of the Engineer to take samples or make tests at any time. The number and frequency of the tests on plastic concrete will be in accordance with the above table but in general shall not be less than four tests for each eight hours of concrete production. More frequent testing of plastic concrete shall be directed under certain circumstances, such as but not limited to times when the fine aggregate moisture content is fluctuating. The Contractor shall not be entitled to any additional compensation due to any additional sampling or testing of plastic concrete at any location so directed by the Engineer.

3.1.5.5 Rejection of Plastic Concrete: Plastic concrete shall be liable to rejection if:

- a) The slump at the time of placing, measured to the nearest 5mm, is not within +/- 10mm of the slump specified or the slump directed.
- b) the water/cement ratio is not as specified.

Plastic concrete, which has been rejected, shall be removed from the works with the least possible delay.

3.1.5.6 Testing Cylinders: The compressive strength of the concrete shall be determined by tests on 150mm diameter by 300mm cylinders. Required properties of Hardened concrete:

- a) The test strength of a sample for acceptance will be the average strength of the two cylinders made on a sample and tested at 28 days.
- b) Hardened concrete shall be liable to rejection if:

The average compressive strength for a particular class of concrete is less than the specified 28 days cylinder strength for that class of concrete in accordance with the Clause 3.1.3.3. If the mixing proportion of a particular class of concrete is specified and the compressive strength of that specified mix proportion fails, the proportion shall be revised until the specified strength is reached.

3.1.5.7 Testing Hardened Concrete in Structures: Entire operation shall be with due precaution so that the structural integrity is no way affected and as per approval of Engineer. The contractor will be responsible for any negligence. If approved by the Engineer, on each specific occasion, at the Contractors expense, hardened concrete liable to rejection shall be tested for compressive strength in accordance with ASTM C42. Unless otherwise directed, cores shall be 150mm in diameter. At least 3 specimens shall be cored and tested from the points as directed by the Engineer. If the average compressive strength of the core specimen so obtained is equal to or greater than 85% of the specified 28-day cylinder strength for that section of the work, the concrete represented by the core specimen shall be considered to be structurally satisfactory. If the concrete is considered to be structurally satisfactory the holes left by the removal of the test cores shall be repaired as specified in these

documents or as directed by the Engineer. Unless otherwise directed concrete which fails to meet the requirements of this Clause shall be removed and replaced in an approved manner without any extra cost to the department.

3.1.5.8 Payment: The entire cost of all sampling and testing, including the cost of providing cylinder mould, slump cones and associated equipment, shall be included in the rates bided in the priced schedule for the various items of concrete construction in the works. The entire cost of securing and testing core specimen of hardened concrete and of removing and replacing rejected concrete is borne by the Contractor.

3.1.5.9 Reference: The reference made in this section regarding different tests are those of latest edition of AASHTO, ASHO, ASTM & B.S. standard or any other standards deemed necessary by the Engineer.

3.1.6 Concrete Construction

3.1.6.1 General: All concrete construction shall conform to the requirements of this Clause and the detailed requirements of Clauses 3.1.6.2 to 3.1.6.7 inclusive. All structures shall be built in a workmanlike manner to the lines, grades and dimensions shown on the Drawings or directed.

3.1.6.2 Accessories: The Contractor shall place and attach to each structure all timber, metal or other accessories necessary for its completion, as shown on the Drawings or directed. The cost of such work, for which specific items are not provided in the Schedule, shall be deemed to be included in the rates bided in the priced Schedule for the work to which they are appurtenant.

3.1.6.3 Changes to Dimensions: The dimensions of each structure shown on the Drawings will be subject to such changes as may be found necessary by the Engineer to adapt the structures to the conditions disclosed by the excavation or for any other practical reason.

3.1.6.4 Changes in Colour: Abrupt changes in colour of external concrete surfaces exposed to public view will not be permitted. The Contractor shall ensure, as far as possible, the surfaces shall be of uniform or well-graded colour using a consistent approved mix.

3.1.6.5 Application of Loads: Loads shall not be applied to concrete placed in the Permanent Works without prior approval.

3.1.6.6 Joints

(a) Construction Joints: Construction joints shall be approximately horizontal or vertical unless otherwise shown on the Drawings or directed and shall be given the prescribed shape by the use of forms, where required, or by other approved means that will ensure suitable jointing with subsequent work. Unless shown on the Drawings key ways shall not be required at construction joints. All intersections of construction joints with concrete surfaces, which will be exposed to view, shall be made straight and level or plumb and leak proof by the use of 25mm by 18mm timber or approved inserts in the corner of the formwork.

(b) Contraction Joints: Contraction Joints shall be located and constructed as shown on the Drawings. The joints shall be made by forming the concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. Unless otherwise shown or specified, the surface of the concrete first placed at contraction joints shall be coated with a colourless grease to break the bond before the concrete on the other side of the joint is placed.

3.1.6.7 Payment: The cost of construction and contraction joints shall be included in the rates bided in the priced Schedule for the concrete in which the joints are required.

3.1.7 Formwork

3.1.7.1 General: Forms shall be used to confine the concrete and shape it to the required lines. Unless otherwise approved, forms shall be designed and constructed by the Contractor in accordance with the appropriate Standard and shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete without excessive deflection of any part or surface and shall be

maintained rigidly in position. The contractor shall be solely responsible for the entire operations. Forms shall be of wood, metal or of other approved material. Forms for exposed surfaces shall be lined with metal or plywood, or other approved material. Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Unless otherwise shown on the Drawings, moulding strips shall be placed in the corners of forms to produce bevelled edges on permanently exposed concrete surfaces. Interior angles on such surfaces and edges at formed joints will not require bevelling unless the requirement for bevelling is shown on the Drawings. The Engineer shall be informed in writing before the Contractor strips off any formwork and its supports etc. The Contractor shall remain fully responsible for the safety of structures from which he removes formwork and its supports etc. He should take all precautions taking structural concept of the whole structure in considerations. No plea in the event of any damage shall be accepted.

3.1.7.2 Shop Drawings: The Contractor shall submit, for approval, shop drawings showing details of the formwork and its supports, including adjustments provided and provisions for stripping off and schedule of support removal. The drawings shall be accompanied by design calculations sufficiently detailed to allow easy checking showing the stresses and deflections in the form surfaces, members and supports. A qualified civil engineer shall certify the drawings and calculations and to be checked and approved for construction by the Engineer considering all relevant involvements and safety matters related to the structural concepts in detail of the whole structure. Approval of these drawings by the Engineer shall not relieve the Contractor of any of his responsibilities under the Contract. The drawings shall show the proposed locations of joints in the form lining and positions of any form ties.

3.1.7.3 Forms-Ties: Embedded ties for holding forms shall remain embedded not less than two diameters or twice the minimum dimension of the tie or 10mm, whichever is bigger from the formed faces of the concrete. The ties shall be constructed so that ends or end fasteners can be removed without causing appreciable spalling of the faces of the concrete. Recesses resulting from removal of form-ties shall be repaired in accordance with Clause 3.1.14.

3.1.7.4 Treatment of Forms: Before forms are erected the surfaces of the forms shall be coated with an approved form-oil that shall effectively prevent sticking and shall not stain the concrete surface. The Contractor shall submit, for approval, at least 2 litres of the proposed form-oil at least 10 days before its use. When concrete is to be placed, the surfaces of the forms shall be free from encrustations of mortar, grout, or other foreign material.

3.1.7.5 Removal of Forms: Except as directed or approved, forms shall be removed carefully as soon as the concrete has hardened sufficiently to prevent damage in order to facilitate satisfactory progress with the specified curing and enable the earliest practicable repair to imperfections on the surface of the concrete in accordance with Clause 3.1.14. Concrete curing shall be started immediately after the forms have been removed and curing only temporarily stopped in the actual locations where repairs are being carried out. Forms on upper sloping faces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be performed at once. In order to avoid excessive stresses in the concrete that might result from swelling of the forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the openings shall be constructed so as to facilitate such loosening. Immediately after stripping off, the concrete forms to be reused shall be cleaned, the surface shall be repaired as necessary and oiled with form-oil and shall be carefully stored in its true shape.

3.1.7.6 Payment: The cost of all labour, equipment and materials for forms and their support, handling & maintenance, and for any necessary treatment or coating of forms shall be included in the rates bided in the priced Schedule of concrete item for which the forms are used.

3.1.8 Tolerances for concrete construction

3.1.8.1 General: Allowable deviations from plumb or level and from the alignment, profile, grades and dimensions shown on the Drawings shall be inclusive of surface irregularities as defined in Clause 3.1.8. Deviations from the established lines, grades and dimensions will be permitted to the extent set forth in this Clause, provided that the Engineer may reduce the tolerance set forth in this Clause if such tolerances impair the structural action or operational function of a structure or item. Where tolerances are not stated in the Specification or shown on the Drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provisions of this Clause. Notations on the Drawings or included in this Specification of specific tolerances in connection with any dimensions, shall be considered as supplementary to the tolerances specified in this Clause. The

Contractor shall be responsible for setting and maintaining concrete forms sufficiently within the tolerance limits and shall ensure that the work is completed within the tolerances specified in this Clause. Concrete work that exceeds the tolerance limits specified in this Clause shall be remedied or removed and replaced by and at the expense of the Contractor.

3.1.8.2 In-situ Concrete: Tolerances for reinforced concrete structures shall be in accordance with the requirements as specified below, except where such tolerances are reduced by the Engineer.

(a) Variation from the plumb:		
In the lines and surfaces of columns, piers, walls, railing posts	In 3m	5mm
	In 6m	8mm
	In 12m or more	16mm
(b) Variations from the level or from the grades indicated on the drawings:		
Concrete railings		6mm
In slab and beam soffits	In 3m	5mm
In any bay or 6m max	8mm	
In 12m	or more	16mm
Other		12mm
(c) Variation in plan		12mm
(d) Variation in bridge deck slab thickness		+ 6mm/ - 3mm
(e) Variation in cross-sectional dimensions of columns, beams and in the thickness of slabs (other than in iv) and walls		+ 12mm/ - 5mm
(f) Footings; the following apply to concrete only, not to reinforcing bars:		
Variations in dimensions in plan		+ 12mm/ - 50mm
Misplacement or eccentricity		- 2% of the footing width in the direction of misplacement but not more than 50mm.

3.1.8.3 Reinforcement: Tolerances for reinforcing steel are given below. Provided the number of bars required by the specified spacing is not varied and provided the specified minimum cover to reinforcement is maintained.

(a)	Length of splice	- 25mm
(b)	Variation of protective cover	± 5mm
(c)	Variation in indicated position of reinforcement:	
	• Starter bars	One bar diameter
	• Slabs and walls	0.25 times the indicated spacing
	• Beams and columns	± 5mm
(d)	Dimension of bent bars:	
	• Stirrups and ties	± 5mm
	• Other bars	± 10mm

3.1.8.4 Embedded Metal Work: Tolerances for placing embedded metalwork ± 5mm

3.1.9 Reinforcement

3.1.9.1 General: The Contractor shall furnish and install all steel reinforcing bars hereinafter referred to as reinforcement, required for execution of the works as specified herein, or as shown on the Drawings or directed.

3.1.9.2 Material: High yield deformed bar's shall be used with minimum yield strength of either (i) 276 N/mm² (Grade 40); or 415 N/mm² (Grade 60) as shown on the Drawings. All deformed bars must confirm ASTM-A615 Grade 40 or Grade 60.. At least 15 days before using any reinforcement in the Works, the Contractor shall submit, for approval, representative samples of the proposed reinforcement to the Engineer. The Engineer may test, from time to time throughout the execution of the Works, further samples of the reinforcement to check compliance with the Specification. The Contractor shall not change his source of supply of reinforcement without prior written approval by the Engineer.

3.1.9.3 Drawings: Steel reinforcing bars shall be placed in concrete where shown on the Drawings or directed.

3.1.9.4 Reinforcement Schedules: Reinforcement schedules to be supplied by contractor's site office on standard approved sheets. The contractor shall check these and promptly, advise the Engineer if he finds errors or inconsistencies in these, before starting of the work. The Contractor shall have to bear the responsibility of any mistakes found later on during or after execution of the work.

3.1.9.5 Placing Reinforcement: The Contractor shall be responsible for the accuracy of cutting, bending and placing of the reinforcement. Reinforcement will be inspected for compliance with the requirements as to grade, size, shape, length, and splicing locations, overlapping length, position and amount after it has been placed. Before the reinforcement is placed, the surfaces of the bars and the surfaces of any metal bar supports shall be cleaned of heavy rust, loose mill scale, dirt, grease and other objectionable foreign substances. Heavy flaky rust, which can be removed by firm rubbing with hessian or equivalent treatment, shall be considered objectionable. After being placed, the reinforcing bars shall be maintained in a clean condition until they are completely embedded in the concrete. Reinforcement shall be accurately placed in the position shown on the drawings and shall be securely held by blocking against the forms, by supporting on concrete or approved metal or plastic chairs or by using metal hangers and by wiring together at intersections using annealed wire of diameter not less than 1.2mm with the ends turned in to the main body of concrete. Bars shall be tied at all intersections except where spacing is less than 300 mm in any direction when alternate intersections shall be tied. Reinforcement supports shall be strong enough to withstand the imposed loads without movement of the reinforcement. They shall be positively attached to the reinforcement and of such size and number as to maintain the specified cover. There shall be a clear distance of at least 25 mm between the bars and any adjacent embedded metal work. The contractor shall ensure that there is no disturbance of the reinforcing bars in concrete that has already been placed. Chairs, hangers, spacers and other approved metal, plastic or concrete supports may be furnished and used by the contractor for supporting reinforcing bars. Concrete supports where used shall be made from the same materials and of the same proportions of sand and cement as that of the concrete in which they are to be used. They shall be cast and cured for at least 7 days before use and shall have wire or other approved device cast in to each support for the purpose of attaching them positively to the reinforcement. If metal supports are used, the portion, which extend to the surface of the concrete shall be galvanised or plastic coated and shall be such shape that the concrete will easily envelop them.

3.1.9.6 Joining and Splicing Reinforcement: Joints or splices in reinforcing bars shall generally be made at the positions shown on the Drawings, but the Contractor will be permitted to make joints or splices at positions other than those shown on the Drawings, provided that such positions are approved by the Engineer and that the joints and splices in adjacent bars are staggered as directed by the Engineer. Approval of such additional splices will generally be 4m in vertical bars measured between the midpoints of laps. The number of splices shall be kept to a minimum. Splices at point of maximum tensile stress shall be avoided. Welded splices of mild steel reinforcement shall only be permitted at those locations shown on the Drawings or directed by the Engineer. Only approved and experienced welders shall be permitted to make welded splices. Each welder shall make, for testing and approval purposes, in the presence of the Engineer, and using the equipment and welding materials proposed for use in the works, 3 welded splices using bar sizes and welding positions as directed by the Engineer. A full welded splice shall have bars lapped and welded to developing tension at least 125 per cent of the specified minimum yield strength of the bar. Where splices in reinforcement are required they shall be staggered. All welding of reinforcement for splices shall generally be in accordance with the latest edition of the American Welding Society (AWS) publication "Structural Welding Code Reinforcing Steel".

3.1.9.7 Measurement: Measurement and payment, for furnishing and placing reinforcing bars shall be made only of the calculated weight of the bars placed in the concrete as shown on the Drawings or directed. The calculated weight for reinforcing bars shall be based on the weight per metre given in Table 3.1.9.7 following or such the table as may be approved by the Engineer. No allowance shall be made for splices or laps except where these are shown on the Drawings. No separate payment will be made for welded splices.

Table 3.1.9.7 : Weight of Reinforcing Bars

Nominal dia (mm)	Area (cm ²)	Weight(kg/meter)
6	0.28	0.222
8	0.50	0.395
10	0.78	0.617
12	1.13	0.888
16	2.01	1.578
20	3.14	2.466
22	3.80	2.980
25	4.91	3.855
28	6.16	4.835
32	8.04	6.315

3.1.9.8 Payment: Payment for furnishing and placing reinforcing bars will be made at the applicable rate per tonne bided therefore in the priced Schedule. This rate shall include the cost of furnishing and attaching wire ties and metal, concrete or other supports, of scheduling, furnishing, cutting, bending, cleaning, securing and maintaining in position all reinforcing bars complete and upto the satisfaction of the Engineer.

3.1.10 Preparation for Placing Concrete

3.1.10.1 General: Concrete shall not be placed until all construction of formwork, installation of reinforcement and parts to be embedded, preparation of surfaces, methods and equipment for transporting, handling, placing and finishing concrete, the number of vibrators and method of consolidating the concrete, the method of curing the concrete have been approved for concreting in a nominated section of work. Concrete shall not be placed in water. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed. The Contractor shall notify the Engineer verbally and in writing, at least 48 hours in advance of the Contractors intention to place concrete. The Contractor shall have adequate operable mixers, vibrators, measuring devices, materials and tools approved by the Engineer prior to starting of a concreting operation. In order that the concrete can be properly finished, when the amount of concrete to be placed continuously is such that it cannot be finished before the end of the regular working day, the time of starting the concreting operations shall be subject to the approval of the Engineer. The Contractor shall furnish assurance to the Engineer of an adequate and uniform source of supply of concrete to permit proper placing and shall be finished before the end of the regular working day. The time of starting the concreting operations shall be subject to the approval of the Engineer. The Engineer under certain conditions may permit night work if requested and if the Contractor provides an adequate system of lighting and approved by the Engineer.

3.1.10.2 Cleaning Foundations: Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud, debris, oil, objectionable coatings and loose, semi-detached or unsound fragments of martial. The surfaces of absorptive foundations against which concrete is to be placed shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete.

3.1.10.3 Blinding Concrete: Unless otherwise shown on the Drawings, or approved in each specific case, all foundation surfaces against which concrete is to be placed shall be covered with a layer of blinding concrete approximately 50mm thick. The Class D concrete shall be used for blinding concrete. The blinding concrete shall be spread and shall be worked thoroughly into all irregularities of the surface. Concrete shall not be placed upon blinding concrete, which has become contaminated, by water, debris or other deleterious material. Blinding concrete which has been so contaminated shall be removed from the surface of the foundation, the surface shall be re-cleaned and a fresh layer of blinding concrete deposited on the surface before concrete is placed against the surface as approved by the Engineer.

3.1.10.4 Cleaning Previously Placed Concrete Surfaces: The surfaces of construction joints, as defined in clause 3.1.6.6 shall be clean and damp when covered with fresh concrete or mortar. Cleaning shall consist of the removal of all Latinate, loose or defective concrete, coatings, sand curing compound if used, and other foreign material to the satisfaction of the Engineer. The surfaces of blackouts, against which concrete is to be placed shall be roughened by scabbing. The surfaces of all construction joints, including surfaces of blackouts, shall be washed thoroughly immediately before placing adjoining concrete. All pools of water shall be removed from the surfaces of construction joints before the new

concrete is placed. The surfaces of all contraction joints as defined in Clause 3.1.6.6 shall be cleaned thoroughly of accretions of concrete or other foreign material by scraping, chipping, or by other approved means.

3.1.11 Placing Concrete

3.1.11.1 General: The Contractor shall advise the Engineer when concrete will be placed and concrete shall only be placed in the presence of the Engineer. The Contractor should obtain written approval of each casting from the Engineer before starting of any casting. Whenever practicable, concrete shall be deposited directly in its final position and shall not be dropped, chuted or caused to flow in a manner to permit or cause segregation. Methods and equipment employed in depositing concrete in forms shall be such as it will not result in clusters or groups of coarse aggregate being separated from the mass. The movement of concrete within the forms by use of vibrators will not be permitted. Unless otherwise agreed by the Engineer, concrete shall not be dropped into place from a height exceeding 1.5 metre. The Contractor shall provide approved chutes and baffles to confine and control falling concrete. Open troughs, chutes or pipes shall be made of metal or metal lined and shall be kept clean and free from coatings of hardened concrete. Water used for flushing shall be discharged clear of the structure. In the event of continuous placing being interrupted for any reason, the Contractor shall thoroughly consolidate the concrete at such joints to a reasonably uniform and stable slope while the concrete is plastic and any concrete which is unconsolidated and no longer plastic shall be removed by the Contractor at his own expense. The concrete at the surface of such cold joints shall be cleaned, dampened and grouted when covered with fresh concrete.

3.1.11.2 Concrete placed in Horizontal layers: Except as intercepted by joints, all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which generally shall not exceed 300mm. The Engineer may direct thinner layers where concrete in 300mm layers cannot be placed in accordance with the requirements of the Specification.

3.1.11.3 Consolidation: Concrete shall be consolidated to the maximum practicable density in such a manner that it is free from pockets of coarse aggregate and closes snugly against all surfaces of forms and embedded materials. Whenever practicable, concrete shall be consolidated by approved immersion type vibrators operated in accordance with the manufacture's recommendations. Form vibrators, or impact hammers applied to the forms, shall be used wherever internal vibration is not possible or would be inadequate. In consolidating each layer of concrete, the immersion type vibrator shall be operated in a near vertical position and the vibrating head shall be allowed to penetrate and re-vibrate the concrete in the upper portion of the underlying layer. In the area where newly placed concrete in each layer joins previously placed concrete in the same layer, more than usual vibration shall be performed, the vibrator penetrating deeply at close intervals over the areas of contact of these layers. Layers of concrete shall not be placed until layers previously placed have been vibrated thoroughly as specified. Contact of the vibrating head with surfaces of the forms shall be avoided. Direct vibration of the reinforcement will not be permitted. For every 3 vibrators in use on a concrete placement, the contractor shall provide one additional standby vibrator of similar compacting capacity in good working order. There shall be not less than 2 vibrators of adequate capacity at any site where concrete is being placed.

3.1.12 Finishes and Finishing

3.1.12.1 General: Finishing of concreting surfaces shall be performed by skilled worker. The Contractor shall inform the Engineer when concreting will be finished. Unless the Engineer in each specific case waives inspection, finishing of concreting shall be performed only in the presence of the Engineer. The Engineer will test concrete surfaces where necessary to determine whether surface irregularities are within the specified limits. Surface irregularities are classified as "abrupt" or "gradual". Offsets caused by displaced or misplaced form sheathing or lining or form sections, or by loose knots or otherwise defective form timber will be considered as "abrupt" irregularities, and will be tested by direct measurement. All other irregularities will be considered as "gradual" irregularities, and will be tested by use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be 1.5m for testing of formed surfaces, and 3m for testing unformed surfaces. Grinding and bush hammering will not be required on formed surfaces, but, unless waived by the Engineer in each specific case, grinding will be required for the repair of surface imperfections or for the removal of concrete, which is outside of the specified tolerances.

3.1.12.2 Class of Finish for Formed Concrete: All formed concrete surfaces shall be given Class 1, Ordinary Surface Finish, and in addition, if further finishing required, shall be given a Class 2,

Rubbed Finish. Exposed surfaces of all formed concrete surfaces including pre-cast concrete shall generally be given Class 2, "Rub Finish". Class 2 finish shall be continued not less than 300mm below the level of any subsequent backfilling. When forms lined with metal or plywood are used, the requirement for a Class 2, Rubbed Finish may be waived by the Engineer, except for the surfaces of posts railings on bridges.

(a) Ordinary Surface Finish (Class-1): Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed. On all surfaces, the cavities produced by form edges and other defects shall be repaired in accordance with 3.1.14. The concrete shall then be rubbed if required or cured in accordance with 3.1.13. The resulting surfaces shall be true and uniform. Surface irregularities shall not exceed 10mm. All surfaces which cannot be repaired to the satisfaction of the Engineer shall be "rubbed" as specified for class 2, rubbed finish.

(b) Rubbed Finish (Class-2): After removal of forms, rubbing of concrete shall start as soon as its condition will permit. Immediately before starting, this work the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall have elapsed before the wetting down to allow the material used in any concrete repairs, in accordance with 3.1.14 to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on the faces. The mortar shall be composed of cement and fine aggregate mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and excessive surface irregularities have been removed, all voids filled and a uniform surface has been obtained. Surface irregularities shall not exceed 5mm. The paste produced by this rubbing shall be left in place at this time. After all concrete above the surface being treated has been cast the final finish shall be obtained by rubbing with fine carborundum stone and water. The rubbing shall continue until the entire surface is of a smooth texture and uniform colour. After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder and objectionable marks.

3.1.12.3 Sprinkling with cement or plastering: Sprinkling of the surfaces with dry cement or any other material during finishing operations for drying of the concrete, to facilitate trawling or for any other purpose will not be permitted. Plastering concrete surfaces, which are damaged or otherwise unacceptable, will not be permitted.

3.1.13 Curing of Concrete

3.1.13.1 General: All concrete shall be cured using water, in accordance with this Clause. Curing of concrete shall start immediately after the forms are removed and the necessary finishing has been done, except where the formwork is maintained in position in a wet condition. The surfaces of construction joints shall be moistened by covering with water-saturated material or by other approved means as soon as the concrete has hardened sufficiently to prevent damage by water. The surfaces shall be kept completely and continuously moist, before and during form removal, by water applied on these surfaces. Water used in curing shall meet the requirements of the Specification for water used in concrete, but with the additional requirement that the water shall not contain any chemicals or other substances that will cause staining of concrete surfaces.

3.1.13.2 Water Curing: All unformed surfaces shall be protected with two thickness of wet burlap which have been spot stitched, wet jute cotton mats or by other approved effective means, as soon as the concrete has been hardened sufficiently to prevent damage by water. These surfaces shall be kept completely and continuously moist, prior to and during form removal. This procedure shall be followed by the specified water curing or membrane curing. Concrete to be water cured shall be cured for at least 7 days immediately following placement of the concrete, or until covered with fresh concrete, by keeping all surfaces continuously, not periodically, wet. Water curing shall be accomplished by one of the following methods or any other method approved and directed by the Engineer.

- a) maintaining the formwork in position in a wet condition
- b) ponding of water on the surface
- c) covering with hessian, jute felt cotton mats, cotton mats burlap or similar approved material maintained in wet condition
- d) covering with at least 25mm thickness of sand maintained in a damp condition

3.1.14 Repair of Concrete

3.1.14.1 General: Repair of concrete shall be performed by skilled workers. The Contractor shall inform the Engineer when concrete will be repaired. Unless the Engineer, in each specific case, waives inspection repair of concrete shall be performed only in the presence of the Engineer. The Contractor shall correct all imperfections on the concrete surfaces as necessary to produce surfaces that conform to Clause 3.1.12. For formed concrete, where the forms are removed within 3 days and repair of imperfections completed within 24 hours after removal of forms, or for unformed concrete where repairs are completed within 24 hours after the placing of the concrete, repairs shall be dry-pack, mortar or concrete repairs. Otherwise repairs shall be epoxy resin repairs. Concrete that is damaged from any cause and concrete that is honeycombed, fractured or otherwise defective, and concrete which is rejected because of excessive surface depressions, shall be removed and built up with dry-pack, mortar, or concrete, as hereinafter specified, to bring the surface to the prescribed lines and grades. Where bulges and abrupt irregularities protrude outside the limits specified in Clause 3.1.12.2 on which Class 2, Rubbed Finish is required, the protrusions shall be reduced by brush hammering and grinding so that the surface tolerances are within the specified limits. After the dressing, the irregularities shall not exceed the limits specified in Clause 3.1.12.2.

3.1.14.2 Dry-Pack: Dry-pack shall be used for filling holes having a depth greater than the least surface dimension; for narrow slots cut for repair of cracks; and for tie-rod fastener recesses as specified. Dry-pack shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section. Dry-pack shall be composed of a mix of 1 part of cement, by volume, to 2.5 parts, by volume, of fine aggregate passing a 1.18mm sieve, together with enough water to produce a mortar which will just stick together when moulded into a ball by a light pressure of the hands and will not exude water, but will leave the hands damp. Dry-pack shall be placed and packed into under-cut holes in layers each having a thickness of approximately 10mm. Packing shall be carried out with a hardwood stick struck with a hammer to compress the dry-pack thoroughly into contact with the surfaces of the hole.

3.1.14.3 Concrete: Concrete-filling shall be used for holes extending entirely through concrete sections, for holes which are greater in area than 0.10 square metre and deeper than 80mm, and for holes in reinforced concrete which are greater in area than 0.05 square metre and which extend beyond the reinforcement that is nearest the surface. Concrete used for repairs shall be of the same class as the concrete in the location at which the repair is being made.

3.1.14.4 Staining of Concrete: For exposed concrete surfaces care shall be taken that accumulation of foreign materials or staining due to any cause does not occur on the finished surface. Any accumulation or staining shall be cleaned off by the Contractor using an approved method.

3.1.14.5 Plugging Form-Tie Holes: In formed concrete, surface holes remaining after dismantling form shall be cleaned out and neatly plugged with dry-pack as previously specified. The dry-pack shall be colour matched with surrounding concrete.

3.1.14.6 Materials Used in Repairs: All materials used in the repair of concrete shall conform to the requirements of this Specification and approved by the Engineer. All fillings shall be bonded tightly to the surface of the holes and shall be sound and free from shrinkage cracks and dummy areas after the fillings have been cured and have dried.

3.1.14.7 Payment: All materials, labour and equipment required for the repair of concrete or removal of stains shall be provided at the expense the Contractor.

3.2 Concrete Piles

3.2.1 Pre-cast Concrete Driven Piles

3.2.1.1 General: This work shall consist of pre-cast reinforced concrete piling furnished and driven in accordance with these specifications and in conformity with the requirements shown on the drawings or stated elsewhere in the contract documents. The type and sizes of piling to be used shall be as indicated on the drawings. Pre-cast concrete driven piles have been used for the design but the Engineer shall consider and may give approval for the use of alternative types of piling. The contractor in submitting an alternative type of pile shall provide design data, the specification to which he proposes to

work, piling experience records and calculations supporting the pile design and any variations in the substructure design.

3.2.1.2 Concrete: Pre-cast concrete piles shall be constructed in accordance with the details shown on the drawings, of concrete class, proportioned, mixed and placed in accordance with the provisions of Section 3.1. All cement used shall be type 1 and concrete shall contain not less than 350 kg of cement per cum. The cross sectional dimension of the pile shall be not less than those specified and shall not exceed them by more than 1 cm. Any face of a pile shall not deviate by more than 6mm from a straight edge of 3m long laid on the face, and the centre of any cross section of the pile shall not deviate by more than 1/1000 of the length of the pile from the straight line connecting the centre of the end faces of the pile.

3.2.1.3 Formwork: The formwork for square pre-cast concrete piles shall comply with the general requirement for concrete formwork as described in section 3.1.7. The head of each square pile shall be square to the longitudinal axis. The corners of the head and the corners of the pile shaft for a distance of 30mm from the head shall be chamfered 25mm X 25mm.

3.2.1.4 Reinforcement: Reinforcement shall be in accordance with the provisions set out in section 3.1.9, and positioned as shown on the drawings.

3.2.1.5 Casting of Piles: Square piles shall be cast in a horizontal position. Special care shall be taken to place the concrete so as to produce a pile free from any air pockets, honeycombing or other defect, and so as to produce a satisfactory bond with the reinforcement. Concrete shall be placed continuously in one uninterrupted pour for each pile and shall be compacted by vibrating or by other means satisfactory to the Engineer. The forms shall be slightly overfilled, the surplus concrete screened off, and the top surface finished to a uniform, even texture similar to that produced by the forms.

3.2.1.6 Curing and Removal of Formwork: Curing of the concrete shall be commenced prior to the formation of surface shrinkage cracks but only after the concrete has hardened sufficiently to prevent damage. Curing shall conform to the requirements of section 3.1.13. Under good weather curing conditions, side forms may be removed at any time not less than 24 hours after placing the concrete but the entire pile shall remain supported for at least seven days and shall not be subject to any handling stresses until the concrete has set for at least 21 days or for a longer period, as determined by the Engineer, in cold weather.

3.2.1.7 Finishing: Piles shall pre-cast a true, smooth, even surface free from any surface blemishes and true to the dimensions shown on the drawings, within the tolerance limits.

3.2.1.8 Marking of Piles: After a pile has been cast, the date of casting reference number, length shall be clearly inscribed on the outer surface of the pile. In addition, each pile shall be marked at intervals of 250mm along the top 3m of its length before being driven.

3.2.1.9 Handling and Storage of Piles: The method and sequence of lifting handling, transporting and sorting piles shall be such that the piles are not damaged. The lifting point of each size of pile shall be proposed by the contractor with supporting calculations for approval of the Engineer which verifies, the pile shall not be damaged during lifting, handling transporting and storing. During transporting and storing, piles shall be adequately supported under the lifting points of the pile. The storage of piles shall be carried out in such a manner that older piles can be withdrawn for driving without disturbing newer piles. Concrete piles shall at no time be subjected to loading, including its own weight, which will induce a compressive stress in it exceeding 0.33 of its strength, whichever is the lesser. For this purpose the assessment of the strength of the concrete and of the stresses produced by the loads shall be subject to acceptance by the Engineer. All piles within a stack shall be grouped by the same length. Packing of uniform thickness shall be provided between piles at the lifting points.

3.2.1.10 Spliced Piles: The Drawing do not detail any splices in piles. The Contractor may adopt spliced piles provided details of the splicing method and drawings are submitted to the Engineer for approval prior to the manufacture of piles.

3.2.1.11 Strength of Piles: Piles shall not be driven until the concrete has achieved the specified 28 day strength.

3.2.1.12 Leaders and Trestles: At all stages during driving and unit incorporation in the superstructure the pile shall be adequately supported and restrained by means of leaders, or other

guide arrangements to maintain position and alignment and to prevent buckling. These arrangements shall be such that damage to the pile does not occur. Leaders shall be of sufficient length to make the use of followers unnecessary.

3.2.1.13 Driving equipment: Before starting any piling operation, the contractor shall submit to the Engineer full details of the pile driving equipment and the method he intends to use in carrying out the work. For special types of piling, driving head mandrel, or other device in accordance with requirements shall be provided so that piles may be driven without injury. Piles shall be driven with steam hammers, diesel hammer, or gravity hammer. When diesel hammers are used, they shall be calibrated by load tests if necessary. The driving equipment shall be of a type, which assures that the energy needed to penetrate the pile to the required depth is transmitted to the pile head without damaging the pile. When gravity hammers are used for driving concrete piles, the drop of the hammer shall not exceed 1.0 m and the hammer shall have a weight of not less than 80% of the weight of the pile and the driving head. The fall shall be regulated so as to prevent injury to the pile. The minimum energy developed by other types of hammers shall be the same as specified for gravity hammers.

3.2.1.14 Driving Procedure and Re-drive Checks: Each pile shall be driven continuously until the specified or approved set and/or depth has been reached, except that the Engineer may permit the suspension of driving if he is satisfied that the rate of penetration prior to the cessation of driving shall be substantially re-established on its resumption or if he is satisfied that the suspension of driving is beyond the control of the Contractor. A follower (long dolly) shall not be used. The Contractor shall inform the Engineer without delay if an unexpected change in driving characteristics is noted. A detailed record of the driving resistance over the full length of the nearest available pile shall be taken if required. At the start of work and in a new area or section, sets shall be taken at intervals during the last 3m of the driving to establish the behaviour of the piles. The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check driving resistances. A set shall be taken only in the presence of the Engineer unless otherwise approved. Re-drive checks, if required, shall be carried out to an approved procedure.

3.2.1.15 Final Set: The final set of each pile shall be recorded either as the penetration in millimetres per 10 blows or as the number of blows required to produce a penetration of 250mm. When a final set is being measured, the following requirements shall be met.

- (a) The exposed part of the pile shall be in good condition without damage or distortion.
- (b) The dolly and packing, if any, shall be in sound condition.
- (c) The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angles to the pile and hammer axis.
- (d) The hammer shall be in good condition and operating correctly.
- (e) The temporary compression of the pile shall be recorded if required.
- (f) The Engineer will provide the limit of the Final set.

3.2.1.16 Driving Sequence and Risen Piles: Piles shall be driven in an approved sequence to minimise the detrimental effects of heave and lateral displacement of ground. When required, levels and measurements shall be taken to determine the movement of the ground or any pile resulting from the driving process. When a pile has risen as a result of adjacent piles being driven, the Contractor shall submit to the Engineer his proposals for correcting this and avoid it in subsequent work.

3.2.1.17 Jetting: Water jetting shall not be allowed. Continuous vibratory percussive methods shall be used to drive a pile to both its design depth as well as set where the upper strata afford high resistance to driving.

3.2.1.18 Length of Piles: The lengths of the piles shown on the Drawings are based on information, which has been obtained from a site investigation prior to the driving of test piles. Before pile lengths are finally selected, the Contractor shall construct to the lengths shown on the Drawings such test piles as may be found necessary and these piles shall be driven in the positions specified by the Engineer who shall be notified in advance of driving. The Contractor shall furnish the Engineer daily a detailed record of the driving of test piles throughout the full depth of driving. After attaining the approved set, driving shall be continued until the Engineer directs that it shall cease. Driving of test piles beyond the point at which the approved set is obtained shall be called for to demonstrate and confirm driving resistance continues to increase. The Contractor at his own expense can increase the lengths to provide for fresh heading and for such lengths as may be necessary to suit his method of operation.

3.2.1.19 Repair of Damaged Pile Heads: When repairing the head of a pile, the head shall be cut off square at sound concrete, and all loose particles shall be removed by wire brushing, followed by washing with water. If pile is to be subjected to further driving, the head shall be replaced with concrete of an approved grade. If the driving of a pile has been accepted but sound concrete of the pile is below the cut-off level, the pile shall be made good to the cut-off level with concrete of a grade not inferior to that of the concrete of the pile. Repaired piles shall not be driven until the added concrete has reached the specified characteristic strength of the concrete of the pile.

3.2.1.20 Cut-off and Extension: Any method for lengthening shall be such that joints are capable of taking safely the stresses during driving and under load.

3.2.1.21 Damage to Adjacent Structures: If during the execution of the work damage is, or likely to be, caused to mains, services or adjacent structures, the Contractor shall submit to the Engineer his proposals for repair or avoidance of such damage.

3.2.1.22 Records: The following data is required:

- (a) Pile location,
- (b) Pile reference number,
- (c) Pile type,
- (d) Nominal cross-sectional dimensions or diameter,
- (e) Length of performed pile,
- (f) Date and time of driving or re-driving,
- (g) Ground level at commencement of installation of pile,
- (h) Working level,
- (i) Pile toe level,
- (j) Type, weight, drop and mechanical condition of hammer and equivalent information for other equipment,
- (k) Number and type of packing used and type and condition of dolly used during driving the pile,
- (l) Set of pile in mm per 10 blows or number of blows per 250mm of penetration,
- (m) If required, the sets taken at intervals during the last 3m of driving,
- (n) If required, temporary compression of ground and pile from time of a marked increase in driving resistance until pile reaches its final level,
- (o) All information regarding obstructions delays and other interruptions to the sequence of work and
- (p) Deviation in vertical and horizontal alignment.

3.2.1.23 Tolerance

- (a) **Setting Out:** Setting out shall be carried out from the main grid lines of the proposed structure. Immediately before installation of the pile, the pile position shall be marked with suitable identifiable pins or markers.
- (b) **Position:** For a pile at cut off or above ground level the maximum permitted deviation of the pile centre from the centre point shown on the setting out drawing shall be 75mm in any direction. An additional tolerance for a pile head cut off below ground level shall be permitted in accordance with paragraphs **3.2.1.23(c)** and **3.2.1.23(d)**. In the case of deviation greater than the allowable tolerance, remedial measures shall be carried out as instructed by the Engineer, in writing. Such remedial measures shall be at the Contractors expense.
- (c) **Verticality:** For vertical piles, the maximum permitted deviation of the finished pile from the vertical shall be 2%.
- (d) **Rake:** For raking piles, the piling rig shall be set and maintained to attain the required rake. The maximum permitted deviation of the finished pile from the specified rake shall be 1 in 25.

3.3 Cast-in-situ Concrete Pile

3.3.1 Scope of work: This work shall consist of boring and constructing cast-in-situ reinforced concrete pile for bridge or hydraulic structure foundation in accordance with the specifications, lines,

levels, dimensions and cross-sections as shown on the drawings providing all labour, materials, equipment including boring equipment and incidentals necessary to complete the work or as per direction of the engineer.

3.3.2 Concrete: The concrete for cast-in-situ reinforced concrete pile shall be manufactured as per Section 3.1 with the minimum proportion of 1:1.5:3 having minimum concrete strength 21 N/mm² at 28 days.

3.3.3 Tremie pipe: The concrete shall be placed by using a tremie pipe. The tremie pipe shall be sufficiently long to reach the bottom level of pile and gradually withdrawn as the placing of concrete proceeds. A tremie shall consist of a steel tube having a diameter of not less than 150mm, sufficiently long enough to reach the bed of water keeping its one end above the water level, constructed in sections having flanged couplings fitted with gaskets. The tube shall be fitted with a hopper at its upper end for pouring concrete inside the tube. The tremies shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow shall be continuous until the work is completed.

3.3.4 Opening bucket: Depositing of concrete by the opening bucket method shall conform to the following specification. The top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged, shall be withdrawn slowly until well above the concrete.

3.3.5 Casing pipe: Temporary steel casing pipe of required diameter shall be used at least for the upper 3m. From ground level during drilling to stabilize the hole. Permanent steel casing pipe if provided in the schedule of items of work, shall be of the required diameter, length and thickness and shall be lowered upto the designed depth immediately after the drilling of holes are completed. At the option of the contractor the permanent casing pipe, may be lowered simultaneously with the progress of drilling and the use of temporary casing pipe may be eliminated. Casing pipes may be transported to site at suitable lengths of pieces and shall be welded as per specification to fabricate the designed length. The pipe shall be of an approved material having sufficient strength and rigidly to prevent distortion by soil pressure or for drilling of adjacent piles and free from pits or any other deformity and the inside of the pipe shall be free from paint, grease or any deleterious substance that may affect the concrete.

3.3.6 Reinforcement: M.S. bars used as reinforcement for cast-in-situ concrete piles shall meet the requirement of Section 3.1.9 Reinforcing steel for structures. All turns of spirals shall be tack welded at 3 places and lapping of vertical reinforcements shall be welded as per specification. Binding with G.I. wire shall not be allowed where welding is specified.

3.3.7 Welding: All welding electrodes shall conform to AWS standards and the electrodes shall be rods of size and classification number as recommended by their manufacturers. Skilled and experienced welder shall perform welding of reinforcing bars and the connections shall be made in accordance with AWS.

3.3.8 Method of construction

3.3.8.1 Preparation: Before starting drilling operation the contractor shall plan the sequence and stages of operation for different piles and establish levels, grades and alignment of all piles with reference to bench marks (BM) previously established at site. The contractor shall have all casing pipes and reinforcing bars fabricated as per design and ready for lowering after the completion of drilling. All necessary equipment such as pump, welding set etc. and materials for concrete work including tremie pipe shall be made available before the start of drilling operation.

3.3.8.2 Drilling: the engineer shall approve the drilling method and equipment to be used. The contractor shall prepare suitable cofferdam/artificial island/staging or any other approved means, if required, for the drilling operation and concreting the piles and piers in water. Bentonite slurry, if required, shall be used to stabilize the hole.

3.3.8.3 Pile cluster: Where there are more than 4 (four) piles in a cluster, the centre pile shall be installed first. All piles in a cluster shall be of the same depth.

3.3.8.4 Tolerance for drilling holes: Bores shall be accurately drilled in the locations shown in the contract drawing. All piles shall be drilled with a lateral tolerance of not more than 75mm from the point specified. Pile that deviates more than 75mm in lateral location or pile whose slope deviates from the vertical by more than 2 (two) percent shall be rejected. Additional piles shall then be furnished and installed by the contractor in such locations as the engineer may direct. All costs of such additional piles required to suit changed pile locations shall be borne by the contractor

3.3.8.5 Obstruction during drilling: When obstructions make it extremely difficult to drill certain holes in the location shown and up to the proper bearing strata the contractor shall take all usual methods to install piles as required including jetting, cutting, drilling or other feasible means. If in the judgment of the Engineer, the contractor is unable to complete properly any pile by resorting to such methods the Engineer may order an additional hole(s) drilled at another selected location at the contractor's expense.

3.3.8.6 Depth of hole: the engineer shall check the depth of hole by lowering suitable drop to determine the length of pile. Immediately after approval of the bore the steel casing pipe shall be installed upto the design depth, if provided in the schedule of items of works, and then the reinforcement cage shall be lowered.

3.3.9 Placing of concrete: The concrete shall be placed by means of tremie pipe and the down end of the pipe shall be extended upto the bottom end of the hole and shall be kept below the surface of the concrete already placed during the process of concreting. The tremie operation shall be as per Section 3.3.3. The temporary casing shall be pulled together with concrete placement but at least 600mm of pipe shall be inside of the tremie concrete. A minimum of 75 mm concrete cover shall be ensured at the bottom end of the reinforcement by fixing pre-cast concrete block. Exact field records of concrete volume poured shall be kept and compared with computed volume of design length of pile. The volume of concrete placed shall in no case be less than the computed theoretical volume. Stoppage of concrete pouring shall be made only to remove all the mud-mixed contaminated concrete from the hole when directed by the engineer and no extra payment shall be made for the contaminated concrete.

3.3.10 Measurement and payment: The cast-in-situ bored pile of the required size shall be paid as per length of pile cast measured in linear metre from the bottom of the pile to the bottom of the pier/pile cap and paid at the contract unit price shown in the schedule of items of works and shall be the full compensation for providing all materials, labour, equipment including drilling equipment and incidentals necessary to complete the work, except for the concrete reinforcing steel which shall be paid separately. Permanent steel casing pipe, cofferdam / crossing / ring dam / artificial island / staging in water shall be paid separately if shown in the schedule of items of works. No payment shall be made for temporary casing pipe or bentonite slurry used for stabilizing the drilled hole or for defective piles.

3.4 Pile Test Loading

3.4.1 Definitions:

- (a) **Allowable Load:** The load which may be safely applied to a pile after taken into account its ultimate bearing capacity, negative friction, pile spacing, overall bearing capacity of the ground below and allowable settlement.
- (b) **Compression Pile:** A pile, which is designed to resist an axial force, such as would cause it to penetrate further into the ground.
- (c) **Kentledge:** The dead weight used in a loading test.
- (d) **Maintained Load Test:** A loading test in which each increment of load is held constant either for a defined period of time or unit rate of movement (settlement or uplift) falls to a specified value.
- (e) **Test pile:** A pile installed before the commencement of the main piling works or a specific part of the work for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimensions and bearing capacity. Test piles may be utilised as working pile, subject to the Engineer's approval.
- (f) **Proof Load:** A load applied to a selected pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed 200% of the working load on

a pile except in circumstances where special provisions are provided for the testing of pre-cast piles driven to a set. In these circumstances 399% is specified.

- (g) **Reaction System:** The arrangement of kentledge, pile or rafts that provides a resistance against which the pile is tested.
- (h) **Tension Pile:** A pile, which is designed to resist an axial forces such as would cause it to be extracted from the ground.
- (i) **Test Pile:** Any pile to which a test loading is, or is to be applied.
- (j) **Ultimate Bearing Capacity:** The load at which the resistance of the soil becomes fully mobilised.
- (k) **Working Load:** The load, which the pile is designed to carry.
- (l) **Working Pile:** One of the piles forming the foundation of a structure.
- (m) **Supervision:** All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained for using the same.

3.4.2 Safety Precautions

3.4.2.1 General: When preparing for, conducting and dismantling a pile test the contractor shall carry out the requirement of the various regulations and other statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

3.4.2.2 Kentledge: Where kentledge is used the contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structure in such a manner that there will not be differential settlement, bending or defection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bounded, used or otherwise held together to prevent it falling apart, or becoming unstable because of deflection of the supports. The weight of kentledge shall be greater than the maximum test load and if this is estimated from the density and volume of the constituent materials an adequate factor of safety against error shall be allowed.

3.4.2.3 Tension Piles and Ground Anchors: Where tension piles or ground anchors are used, the contractor shall ensure the load is correctly transmitted to all the tie rods or bolts. The extension of rods by welding shall not be permitted unless it is known that there will not be reduction in strength by welding. The bond stress of the rods in tension shall not exceed normal permissible bond stresses for the type of steel and grade of concrete used.

3.4.2.4 Testing equipment: In all cases the contractor shall ensure that where hydraulic jack and load measuring devices are mounted on the pile head the whole system shall be stable up to the maximum load to be applied. Means shall be provided to enable dial gauges to be read from a position safe and clear of the kentledge stack or test frame. In conditions, where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure and so on might constitute a hazard to personnel, the hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum working pressure without leaking. The maximum test load or test pressure should be shown as marked reading on the gauge in use, and all operators should be made aware of this limit.

3.4.3 Preparation of a Working Pile to be tested: If a test is required on a working pile the Contractor shall cut down or otherwise prepare the pile for testing as required by the Engineer in accordance with paragraphs 3.4.

3.4.4 Reaction Systems

3.4.4.1 Compression Tests: Compression tests shall be carried out using kentledge. The kentledge shall be supported on cribwork disposed around the pile head so that its centre of gravity is on the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the

kentledge stack. Kentledge shall not be carried directly on the pile head, except when directed by the Engineer.

3.4.4.2 Spacing: The distance from the edge of the test pile to the nearest part of the crib-supporting stack in contact with the ground shall be not less than 1.3m. The centre to centre spacing of Vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2m, whichever is the greatest.

3.4.4.3 Care of Piles: The method employed in the installation of any reaction piles; anchors or rafts shall be such as to prevent damage to any test pile or working pile.

3.4.4.4 Loading Arrangement: The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

3.4.4.5 Equipment for Applying Load: The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The total capacity of the jacks shall be at least 2 (two) times more than the required maximum load. The jack or jacks shall be arranged in conduction with the reaction system to deliver an axial load to the test pile. The complete system shall be capable of transferring the maximum load required for the test.

4.4.4.6 Measurement of Load: Suitable approved measuring devices for determining the load on the pile shall be supplied by the Contractor. Certificates of calibration shall be supplied to the Engineer.

4.4.4.7 Adjustability of Loading Equipment: The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of a maintained loading test.

4.4.4.8 Measuring Movement of Pile Heads: In a maintained load test, movement of the pile head shall be measured by dial gauge or any other levelling method by referring to an external datum. Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made within an accuracy of 0.5mm. A seal attached to the pile or pile cap may be used instead of a levelling staff. At least two datum points shall be established on permanent objects or other well-founded structures, or deep datum points shall be installed. Each datum point shall be situated so that only one setting up of the level is needed. No datum point shall be affected by the test loading or other operations on the site.

3.4.4.9 Protection of Testing Equipment: Throughout the test period all equipment for measuring load and movement shall be protected from the weather. In addition to construction equipment, persons who are not involved in the testing process shall keep a sufficient distance from the test to avoid disturbance to the measurement apparatus.

3.4.4.10 Notice of Test: The Contractor shall give the Engineer at least 24 hours' advance notice of the commencement of the test.

3.4.4.11 Records: During the progress of a test, the testing equipment and all records of the test as required in paragraph 3.4.4.13 shall be available for inspection by the Engineer.

3.4.4.12 Test Procedure: The maximum load, which shall be applied in a proof test, is shown on the Drawings. The loading and unloading shall be carried out in stages as shown in Table 3.4.4.12 or as required by the Engineer. Following each application of an increment of load the load shall be held for not less than the period shown in Table 3.4.4.12 or until the rate of settlement is less than 0.25mm/h and thus slowing down. The rate of settlement shall be calculated from slope of the curve obtained by plotting values of settlement versus time and drawing a smooth curve through the points. Each stage of unloading shall proceed after the expiry of the period shown in Table 3.4.4.12. For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load and at approximately 15 minute intervals for 1 hour, at 30 minute intervals between 1 hour and 4 hours, and 1 hour intervals between 4 hours and 12 hours after the application of the increment of load. The Engineer may require that the full loading, be maintained on the pile for periods longer than as shown below:

Load as % of Working Load	Minimum Time of Holding Load
50	1 h
100	1 h
125	1 h
150	1 h
125	10 min
100	10 min
50	10 min
0	1 h
150	6 h
200	1 h
250	6 h
275	1 h
300	24 h-Proof Load
275	10 min
250	10 min
225	10 min
200	10 min
150	10 min
100	10 min
50	10 min
0	1 h

3.4.4.13 Presentation of Results: Results shall be submitted as (a) a summary in writing to the Engineer, unless otherwise directed within 24 hours of the completion of the test, which shall give for proof test by maintained load for each stage of loading, the period for which the load was held, the load and the maximum settlement or uplift recorded. (b) The completed schedule of recorded data within seven days of the completion of the test.

3.5 Existing concrete structures

3.5.1 Description: This work shall consist of the construction of small extensions; reconstruction of localised defective concrete; rehabilitation of existing concrete facing; reinforcing, anchoring, tying and nominal stressing together concrete elements; ground anchors; and sealing and treatment of structural cracks in various types of members, all in accordance with these specifications and the lines, levels, grades, dimension and locations shown on the Drawings and as required by the Engineer.

3.5.2 Concrete: Concrete shall comply with the requirements of section 3.1 of these specifications.

3.5.3 Reinforcement: Reinforcement shall comply with the requirements of section 3.1.9 of these specifications.

3.5.4 Cement Grout and Mortar: Cement grout and mortar shall be composed of fine aggregate as specified in section 3.1.1.2 mixed with cement as specified in section 3.1.1.3 of these specifications in proportions as defined, together with sufficient water to make a homogeneous workable mix. Exact proportions shall be specified on the Drawings.

3.5.5 Resin repair mortar: Epoxy resins, unsaturated reactive polyester resins or unsaturated acrylic resins specified on the drawings and detailed in the bill of quantities shall conform to the requirements of the manufacturer's recommendations or any other suitable alternatives, subject to the approval of the Engineer, where it can be demonstrated that the proposed alternatives are at least equivalent to the materials proposed.

3.5.6 Construction Methods:

3.5.6.1 General: The Contractor shall in due time and as soon as possible present and discuss his construction proposals/methods and work programmes for nominal extensions to existing concrete structures; for implementing repairs to existing structural cracks in concrete structures; for implementing repairs to existing concrete surfaces and for the rehabilitation of existing defective concrete. The details of works shall cover the requirements specified on the drawings and as directed by the Engineer at each location. The scope of new works shall be as confirmed by the Engineer. The precise extent of all concreted extensions or repairs shall be jointly surveyed by the contractor and Engineer at the commencement of the works and the locations of all extensions, repairs or strengthening shall be recorded and carefully marked in paint on each structure to permanently identify the works to be implemented. In locations where existing concrete sections are to be extended or joined, the existing

concrete shall be carefully broken back at the locations where sections are to be joined as directed by the Engineer. The breaking will be done to ensure that damage to existing concrete is the absolute minimum. Sufficient concrete shall be removed to expose reinforcement of the existing section where appropriate. Sufficient reinforcement shall be exposed to enable additional reinforcement to be lapped to the existing steel. The reinforcement shall be carefully cleaned and all loose concrete shall be removed. The existing concrete shall be cleaned of all dust and construction joint shall be prepared accordingly on the exposed face to ensure a good feature be obtained between the new work and the existing concrete section. Concrete and reinforcement for the construction of the new section shall conform in all respect to sections 3.1 and 3.1.9 respectively. Defective concrete on the front face of substructure walls such as piers, abutments etc. particularly adjacent to the water line; and in beams, slabs and other superstructure; on the web faces of main beams and other superstructures shall be carefully removed in a sequence and in accordance with the strict instructions of the Engineer. Such works shall be permanently supervised by a technical representative of the Engineer and the Contractor shall also ensure that technical staff is permanently available on the site to receive specific instructions. The existing structural integrity of existing members shall not be impaired during this operation and the Contractor shall be fully responsible for ensuring strict compliance with the procedures. Defective concrete on main structural members shall be carefully and cleanly removed by manual methods using hammers and chisels to expose the main and secondary reinforcement. This reinforcement shall be carefully cleaned using wire brushes unless the Engineer gives alternative instructions. The concrete shall also be carefully broken and the surface shall be cleaned of all dust and loose material. The removed defective concrete shall be replaced by a method proposed by the Contractor that shall be subject to the approval of the Engineer. In this respect, the Contractor shall propose and clearly demonstrate that the method he proposes to adopt, is capable of giving a guaranteed facing of concrete that would be equivalent in all respects to the workmanship standards which would be acceptable in new works. Depending on the extent of the repair works, sprayed concrete or gunite shall be allowed provided acceptable procedures are proposed. Traditional formwork methods with "letter boxes" shall also be allowed for large volume repairs. Strategic structural cracks in highly stressed structural members such as shear cracks at scarf joints or shear cracks in beam webs shall be sealed by resin repair mortars. The contractor shall ensure temporary access to effectively implement critical repairs. The final decision of the resin repair shall be made on completion of the inspection immediately prior to undertaking the sealing operation. Initially, cracks shall be cleaned of all dust and debris in accordance with the manufacturer's recommendations, once the resin to be adopted has been identified. Depending on the method to be adopted, nipples shall be inserted along the cracks or vacuum impregnation procedures shall be applied to enable grout to be effectively injected into the structural cracks. The effectiveness of crack repair shall be assessed on the basis of the quantity of resin injected into the existing cracks. The testing of the effectiveness of crack sealing repairs is covered by these specifications. Structural concrete members that exhibit cracking and relative movement may be anchored or tied in accordance with the Engineers instructions. Wing walls and abutments shall be tied and anchored at the locations and to the details shown on the Drawings and as specified in the bill of quantities. Prior to commencing any of the work, the Contractor shall obtain the approval of the methods to be adopted for all temporary arrangements from the Engineer. This shall cover the provision of all temporary stages; the proposed drilling methods; proposed safety measures; proposed anchoring methods and subsequent testing for ground anchors to ensure that tie bars are capable of carrying twice the working load; proposed stressing methods and ultimate grouting of anchor bars. The contractor shall take instructions from the Engineer on the precise requirements for the provision, installation and anchoring of all tie bars incorporated in the works.

3.5.6.2 Workmanship: Repair to existing concrete shall be carried out as shown on the drawings or as may be required, by skilled and experienced personnel well versed in this type of work. The contractor shall clearly demonstrate that his workforce proposed to be employed on concrete repair works has a capability to execute this type of work to a satisfactory standard. Such demonstration may be in the form of test repair works not directly associated with the works.

3.5.7 Measurement: Concrete Extensions and Repairs shall be measured in either cubic metres or square metres depending on the type of work ordered, placed and accepted. In computing quantities, the dimensions of concrete extensions where appropriately shown on the Drawings for new work and extensions shall be used as the basis for measurement. Remedial repairs of defective concrete face work and replacement of defective concrete shall be measured by the area of square metres ordered, marked up and accepted. The sealing of cracks with resin repair mortars shall be measured by the weight of resin used in the injection process of cracks ordered to be repaired, marked up and accepted. The filling of cracks with cement mortar shall be measured by the cumulative length of cracks ordered to be repaired, marked up and accepted. The provision of tie bars and ground anchors including either fixing or drilling, installation, grouting in stages and stressing shall be measured by the weight of bar

ordered, installed and accepted. No incidental works necessary to perform the repair works shall be measured in the basis of payment. The Contractor shall include in the payment items for all necessary temporary works to undertake and complete in every operation.

3.5.8 Payment: The work measured as provided above shall be paid for at the contact unit prices per cubic metre of concrete or square metre of concrete re-facing. Resins used in cracks shall be paid for at the contract unit prices per kg. of material used. Anchors and tie bars shall be paid for at the contract unit prices per tonne of bar used. Concrete cracks filled with cement mortar shall be paid for at the contract unit prices per unit length of crack repaired. The Contractor's rates shall be fully inclusive of all cost of all labour and materials to complete the works in a professional manner.

Pay items shall be:	<u>Unit</u>
Modifications to existing concrete as detailed on the Drawings and as specified in the bill of quantities for reinforced concrete extensions	Cubic metre
Concrete surface repair works (substructures)	Square metre
Concrete surface repair works (superstructures)	Square metre
Resin Repair Mortars	Kg
Cement Mortar in Cracks	Linear Metre
Anchors and Tie Bars	Tonnes

3.6 Brickwork

3.6.1 Description: This work shall consist of the construction, reconstruction, rehabilitation, face work repairs and repainting of brickwork structures, in accordance with these specifications and the lines, levels, grades, dimensions and locations shown on the drawings and as directed by the Engineer.

3.6.2 Materials

3.6.2.1 Bricks: First class bricks shall be made from good brick earth free from saline deposits, and shall be sand moulded. They shall be thoroughly burnt by coal without being vitrified, of uniform and good colour, shall be regular and uniform in size, shape and texture with sharp square edges and parallel faces. They must be homogeneous in texture and emit a clear metallic ringing sound when struck one against the other. They shall be free from flaws, cracks, chips, stones, nodules of lime or canker and other blemishes. A first class brick shall not absorb more than 1/6th of its weight of water after being soaked for one hour, and shall show no sign of efflorescence on drying. Second class bricks shall be as well burnt as first class or may be slightly overburnt but not vitrified, and must give a clear ringing sound when struck one against another. Slight irregularities in size, shape or colour are acceptable provided irregular or uneven courses do not result there from. Second class bricks may have slight chips or flaws but must be free from lime or canker nodules. They shall not absorb more than 1/4 of their weight of water after one hour's immersion and shall be free from saline deposits. Bricks not meeting the above requirements shall not be used in brickwork under any circumstances. Jhama bricks are those, which are so overburnt as to become vitrified or distorted, so as to be unsuitable for brickwork. Jhama bricks may be broken and used for aggregate in roadwork provided the vitrified mass has not become porous or spongy as a result of overburning and the aggregate satisfies the requirements of these specifications. Jhama bricks, which, although vitrified, are not distorted and porous, may be incorporated in certain parts of the works at the discretion of the Engineer. Perforated bricks should be of uniform size and colour with sharp edges, square and parallel faces and having standard number of perforation. They must be standard commercial products of approved manufacturers and shall be approved by the Engineer. Machine made pressed bricks shall be of the size shown on the drawings and shall be standard commercial products of approved manufacturers. The Engineer prior to use in the works shall approve the use of machine made pressed bricks. First class bricks should have the following dimensions after burning: 250mm x 120mm x 70mm. Picked jhama bricks may have dimensions slightly below those for other brick but not less than 235mm x 110mm x 70mm. The unit weight of first class bricks shall not be less than 1100 kg/m³ and the unit weight of jhama bricks shall not be less than 1200kg/m³. The crushing strength of bricks shall be tested

in accordance with STP 7.9. The average crushing strength of first and second-class bricks shall not be less than 17 N/mm². The average crushing strength of jhama bricks shall not be less than 20 N/mm². In all other respects bricks shall comply with Bangladesh standard BDS 208.

3.6.2.2 Cement: Cement shall be as specified in section 3.1.1.3.

3.6.2.3 Fine Aggregate: Fine aggregate shall be as specified in section 3.1.1.2. The fineness modulus of sand shall not be less than 1.50.

3.6.2.4 Water: Water shall be as specified in section 3.1.1.4.

3.6.2.5 Reinforcement : Steel and anchorage shall be as specified in section 3.1.9.

3.6.2.6 Mortar: Cement mortar shall consist of a mixture of one part by weight of cement to two parts by weight of sand. The cement and sand shall be mixed dry and in the specified proportion until the colour of the mixture is uniform. Approved water shall then be added sparingly, only the minimum quantity necessary being used to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer. The mixing shall be done on a clean board or platform with tied joints, to avoid leakage. At the close of each day's work the mixing trough and pans shall be thoroughly cleaned. Cement mortar shall be mixed in such quantities as can be used in the work within 30 minutes. Mortar, which has taken initial set, shall not be used nor shall it be remixed with fresh mortar and such mortar shall be discarded and removed from the working site.

3.6.3 Construction Methods: General: The contractor shall in due time and as soon as possible present and discuss his construction proposals and work programme for building new brickwork structures; brickwork extensions to existing structures; brickwork repairs to defective bricks and rehabilitation of existing structures; and re-pointing of defective joints in existing brickwork. The details of works shall cover the requirements specified on the drawings and as directed by the Engineer at each location. The scope of new works shall be as indicated on the drawings and as confirmed by the Engineer. The precise extent of all brickwork extensions, repairs to defective brickwork, rehabilitation of brickwork and repainting of mortar joints shall be jointly surveyed by the contractor and the Engineer at the commencement of the works and the locations of all repairs shall be recorded and carefully marked in by paint on each structure to permanently identify the works to be implemented. Excavations for new brickwork extensions such as wing walls shall be conducted to the requirements of section 2.7 of these specifications. Blinding concrete shall be provided in accordance with the requirements of section 3.1.10.3 Brickwork shall be constructed in accordance with the requirements specified herein under to the line and levels provided on the drawings and as directed by the Engineer. Extensions to existing brickwork shall be achieved by the careful removal of existing skin courses as directed by the Engineer to the lines and levels specified and marked by paint. The old brickwork and joints shall be carefully prepared and cleaned to enable new brickwork to be constructed on and adjacent to the old courses. Defective brickwork in the front faces of abutment walls, particularly adjacent to the water line, and in brick arches shall be carefully removed in a sequence as instructed by the Engineer. The existing stability of walls and arches shall not be impaired during this operation and the contractor shall be fully responsible for providing temporary supports to guarantee the full structural integrity of the walls, arches etc at all times to be retained. This may require the temporary provision of struts and beams to existing arch rings, spandrel walls and retaining walls. All defective brick works shall be removed on an incremental basis if this is deemed desirable and new brickwork shall be carefully constructed to guarantee that the structural integrity of the element is returned to its original condition. Weak and defective mortar in existing brickwork shall be carefully removed from the joints to a depth instructed by the Engineer. The extent of mortar to be removed from existing joints shall also be instructed by the Engineer and shall be marked by paint on existing brickwork faces. All joints shall be carefully cleaned prior to re-pointing with a cement mortar. The composition of the mortar shall be as directed by the Engineer and shall take into account the existing strength of joints that are not to be repaired. Existing joints shall be re-pointed in a workmanlike manner to ensure full depth penetrations attained and the finish is trimmed off and flush with the face of the brickwork. Cracks in existing brickwork shall be treated similar to joints. Defective material shall be carefully removed and the crack shall be filled with a cement mortar. Tie bars and pattress plates shall be incorporated in accordance with the instructions of the Engineer where existing brickwork can be effectively anchored to other structural features. Tie bars and pattress plates shall be painted in accordance with the requirements of this specification. The tie bars and pattress plates shall be placed and positioned before brickwork extensions are commenced. This would be specifically appropriate for the strengthening and tying of brick spandrel walls to existing brick arches that are to be either elevated or extended. The anchors to the tie bars should be nominally

tightened prior to the construction of the brickwork and subsequently nominally stressed after completion of the structural work and compaction of filling.

3.6.4 Workmanship: Brickwork shall be built plumbed, curved or battered as shown on the drawings or as may be required, by skilled masons and workmen properly supervised. Brick shall be cleaned and if necessary, they shall scrubbed. Brick shall be soaked in water for at least three hours before use. Where new work joins previous work the latter shall be well cleaned and thoroughly watered. All face work bricks shall be specially selected regarding size, shape and edges. Unless otherwise specified bricks shall be laid in English Bond, with frogs upward. All horizontal joints shall be parallel and level. Vertical joints in alternate course shall come directly over one another. Joint thickness shall be 6mm and shall in no case exceed 8mm. The height of four courses including 4 bed joints shall raise 300mm. Walls shall always be carried up regularly along their entire length throughout the structure unless otherwise directed by the Engineer. The brickwork shall be cured for at least seven days. Fixtures such as clamps, pipe brackets etc. shall be provided in the brickwork during execution.

3.6.5 Measurement: Brickwork shall be measured by the number of cubic metres of brickwork that is ordered, placed and accepted. In computing quantities, the dimensions of brickwork shown on the drawings for new work and extensions shall be used as the basis for measurement. Remedial repairs of defective brick and replacement of defective brickwork shall also be measured by the number of cubic metres ordered as indicated on the drawings, marked up and accepted. No measurements shall be taken on the defective brickwork that is necessary to be removed. The re-pointing of existing brickwork joints shall be measured by the number of square metres of re-pointing that is ordered, marked up and accepted. No measurements shall be taken on the amount of defective mortar that is necessary to be removed. No measurements shall be taken of any temporary requirements.

3.6.6 Payment: The work measured as provided above shall be paid for at the contract unit prices per cubic metre of brickwork or square metre of re-pointing. The contractor's rates shall include for all temporary measures to retain structural adequacy of an existing structure, all preparatory work in breaking out defective brickwork and removal of the same for mixing mortar, for placing brickwork on/against prepared surfaces to the lines, levels as indicated on the drawing or as instructed by the Engineer. The contractor's rates shall be fully inclusive of all costs, labour and materials in providing brickwork with sound mortar joints that shall satisfy the structural criteria of the elements of the whole.

Pay items shall be:

Unit

New and Extended Brickwork

Cubic Metre

Replacement of defective existing Brickwork

Cubic Metre

Re-pointing of existing brickwork joints

Square Metre

Steel Anchor Bars

Tonnes

3.7 Inserts and Fittings in Structures

3.7.1 Description: This work consists of furnishing and embedding of inserts, fittings and other incidental parts into hydraulic structure works necessary to provide for further supports for utility pipes and cables and the like. The type, size and location shall be indicated on the Drawing or instructed by the Engineer.

3.7.2 Materials: Unless otherwise indicated on the Drawings, the inserts shall be made of steel conforming to AASHTO Standard Specification M183 (ASTM A36). Material to be as indicated on the Drawing or as approved by the Engineer.

3.7.3 Construction Methods: The inserts and fittings shall be embedded at the locations indicated on the Drawings or as instructed by the Engineer. During casting of concrete in structures, the inserts and fittings shall be kept in the correct position by means approved by the Engineer. The inserts and fittings shall be plugged or pressed against the formwork in such a way that no mortar form the concrete

may enter the thread of the inserts or fittings. After removal of the formwork, the Contractor shall clean the surface of the insert and fittings to the approval of the Engineer.

3.7.4 Measurement and Payment: Embodiment of inserts and fittings for utility pipes and cables shall not be measured as such but paid for at the lump sum price. Such payment shall constitute compensation for all working drawings, materials installation including labour, equipment, tools and incidentals necessary to complete the work.

Pay item shall be:	<u>Unit</u>
Embodiment of inserts and Fittings	Lump sum

3.8 Protective Works

3.8.1 Brick Mattressing/Boulder Mattressing: The Contractor shall supply all materials in accordance with the Specification and Drawings. The mattress shall be secured by anchors made from the specified material, driven to the depth and set at the centres shown on the Drawings or as directed by the Engineer. The location of the anchors shall be marked on the prepared underlying surface with dry powdered lime or similar approved marking substance in accordance with the Drawings or as directed by the Engineer. On inspection and approval of the locations by the Engineer, the anchors shall be driven to the specified depth before placing the wire netting and bricks/boulders. The wire netting mattress base sheet shall be spread and fixed in position to the previously driven anchors. Successive wire netting sheets shall be lapped by 150 mm. The wire netting shall be tied top and bottom by 2 ply 12 SWG galvanized wire at 600 mm intervals in both directions and firmly tied to the anchors. The mattress shall be filled as follows:

(a) **Brick Mattress:** Two layers of bricks shall be placed on the wire netting base as shown on the Drawings. The first layer shall be laid up the slope and the second layer shall be laid across the slope; both layers shall be laid in a staggered formation. On completion of the two brick layers, a second layer of wire netting with 150 mm laps shall be laid on top.

(b) **Boulder Mattress:** Boulders of specified size shall be placed to fill the mattress so as to have a minimum percentage of voids.

3.8.2 Boulders: Boulders shall conform to the sizes/weights and grading shown on the Drawings. The material shall not be polluted, and shall be free from objectionable quantities of dirt, sand, dust and elongated or flaky stones. The boulders shall be free from cracks and veins which could lead to breakage during loading, unloading and dumping. The specific gravity of the boulders shall be between 2.4 and 2.7. The weighted average loss of materials in the sodium sulphate soundness test shall not be more than 10% by weight in accordance with ASTM C88. Water absorption of stone material shall be 2% maximum. The percentage of wear as determined by the Los Angeles Test shall not be more than 40 as per ASTM C535. The aggregate impact value shall not exceed the 30%.

3.8.3 Brick Masonry Blocks : Bricks as specified in Clause 3.6.2.1. Water for mixing mortar shall conform to the requirements as specified under concrete Clause 3.1.1.4, Sand for cement mortar shall be non-saline, hard, dense and free from deleterious materials. Sand shall be screened through a No.16 sieve and have a minimum fineness modules of 1.5. Masonry blocks shall be cast in a casting yard using a 1:4 (cement : sand) ratio or as specified on the Drawings and delivered to the site after proper curing and placed to proper line and grade as shown on the Drawings. All blocks shall be cured for not less than seven days by a method approved by the Engineer.

3.8.4 Precast Concrete Cubic Blocks for Revetment: Precast concrete blocks shall be made to the dimensions shown on the Drawings and to the specified tolerances. The blocks shall comply with the percentages of the different block as shown on the Drawings. The Contractor shall prepare a sizewise schedule of all blocks required for the Engineer's approval before execution of the work. Precast concrete blocks (cc blocks) shall be made from concrete class accordance with Section 3.1 and cast in moulds formed from steel sheet. The moulds shall be sufficiently tight fitting to prevent grout losses and sufficiently rigid to withstand the effects of placing and vibratory the concrete without distorting and capable of releasing the hardened concrete blocks without causing damages to the blocks. Each block shall be marked with a consecutive number and the date of casting; marking shall either be engraved on the block whilst the concrete is still "green" or painted on the block with a water proof paint immediately after stripping formwork. The Contractor shall maintain a register of the number, date of casting, date and location of placing of each block and shall make the register available at all times for inspection by the Engineer. Blocks shall not be stockpiled until they have been cured in accordance with Clause 3.1.13 hereof. They shall not be placed in the Works until at least fourteen days after casting have elapsed. Blocks, which are damaged during transport, stockpiling or handling shall be rejected and removed from the site. Blocks for use in launching

aprons shall be stockpiled in different sizes and in the percentages shown on the Drawings to the satisfaction of the Engineer. Prior to the commencement of placing the blocks, the Contractor's proposal to ensure that the different block sizes are well distributed shall have been approved by the Engineer. If required, the effectiveness of the Contractor's proposal shall be demonstrated to the Engineer.

3.8.5 Filter Materials: Filter materials shall be as specified on the Drawings and either be (a) khoa filter (crushed brick), (b) inverted filter comprising of a fine filter and coarse filter and (c) geotextile filter.

3.8.5.1 Khoa Filter: Khoa filter material shall be made from first class bricks or picked jhama bricks. The khoa filter shall comply with the grading shown on the Drawings.

3.8.5.2 Inverted Filter Materials: The fine filter shall comprise of sand and comply with the grading shown on the Drawings. Coarse filter material shall be made from either first class or picked jhama bricks or gravel (shingle) or broken stone of hard durable rock. The stone delivered to the works shall be rejected if not perfectly clean and if it contains soft, clayey, shaley or weathered stone. The stone may be broken in a stone crusher of approved type or manually. Any dust or fine material below 5 mm in size made in the stone crusher is to be removed by screening and the stone shall be thoroughly washed by an approved method. Filter materials shall pass a 35 mm sieve and be retained on a No.4 sieve or be well graded in accordance with the gradings shown on the Drawings.

3.8.6 Foundation Preparation: The foundation for the filter materials shall be thoroughly compacted and graded to the elevations shown on the Drawings prior to the placement. The filter material shall be placed in a uniform layer of the thickness shown on the drawing or as directed by the Engineer.

3.8.7 Turfing on Embankment Slopes: The crest and slope of the embankment shall be shaped to slopes and levels, fully compacted then fine dressed with approved top soil in a layer of not less than 50 mm thick before being covered by Durba grass turf or a similar approved turf from a source approved by the Engineer. The turf should be cut in 75 mm thick 250x250mm squares and be placed close together in a staggered pattern with 100% coverage. The turf shall be set firmly into the top soil dressing and watered immediately after placing, then daily until the grass is well established and new growth is clearly visible. After placing it shall be fertilized by a suitable commercial fertilizer. All newly covered areas shall be watered until the grass grows fully. Areas that do not grow or wash out shall be repaired and re-fixed with fresh turf at the Contractor's expense.

3.8.8 Brick Channel Protection: All bricks furnished for pitching shall be first class bricks. The bricks shall be placed to the lines and grades shown on the Drawings or as directed by the Engineer. All brick pitching shall be underlain by filter material as specified on the Drawings.

3.8.9 Concrete Channel Protection: Concrete channel protection shall consist of paving the channel slope with either cement concrete or reinforced cement concrete as specified in the Drawing. Prior to the construction of the concrete channel protection, the channel bank shall be prepared in accordance with Part-2 of this specification to the satisfaction of the Engineer. Concrete work shall be undertaken in accordance with Part-3 of this specification. Any expansion joints and weep holes shall be constructed as specified on the Drawings to the satisfaction of Engineer.

3.8.10 Bank Revetment

3.8.10.1 Construction Sequence: The revetment works shall commence from the most upstream part of the eroded bank, based on a chainage to be furnished by the Engineer. The alignment of the starting point of the revetment slope may be adjusted, subject to the approval of the Engineer, to minimise the amount of fill without compromising the stability of the existing embankment. The river bed at each section of the revetment shall first be built up to design level the launching apron placed and then the sloping revetment constructed from the toe upwards.

3.8.10.2 Preparation of Toe Foundation: The toe foundation shall be either excavated or built up to the lines and levels shown on the drawing. Excavation shall be undertaken. Where necessary, the river bed and bank slopes below low water level, shall be built up by placing or dumping earth filled gunny bags in layers, working from the bank into the rivers. The river bank slopes above water shall be built-up with compacted earth and earthfill gunny bags if required. Regular soundings or levels shall be taken to ensure that either the excavation is being undertaken to the design line and levels or gunny bags are being closely packed to the correct lines and levels.

3.8.10.3 Revetment Material: The revetment material shall either be boulders, brick blocks, cc blocks, brick mattressing or boulder mattressing.

3.8.10.4 Placing Blocks Below Low Water Level: Below LWL blocks shall be laid by controlled dumping. On the sloping revetment and in the apron blocks are to be placed to the profiles shown on the Drawings with a nominal voids ratio of 40 percent. In any area of 20 m x 20 m; the number of blocks placed shall not be less than that shown on the Drawings. The nominal thickness shall be achieved over at least 50% of the area and nowhere shall the coverage be less than 80% of that shown on the Drawings. Revetment material is to be randomly placed to form the launching loose apron and placed in the proportions shown on the Drawings from conveniently located stockpiles of individual size.

3.8.10.5 Filling Embankment/River Bank Slope: The eroded embankment/river bank above water level shall be cleared and stripped then trimmed back to stable sections. Care shall be taken to form the gully bag extremity into a neat and dense slope to the line and levels shown on the Drawings.

3.8.10.6 C.C Block Bank Revetment: The inverted filter layers and revetment material placement shall start from the toe and progress up the slope of the embankment. The fine filter layers shall be placed and lightly tamped into place, followed by the coarse filter layer, which shall be sufficiently compacted to support the overlaying material. The inverted filter shall not advance more than 1m up the slope before being covered by the specified overlaying material to assist placement and prevent damage to the filter layer. Above LWL the overlaying material shall be laid on the filter in rows parallel to the direction of the current. The blocks in each row shall be staggered half a block width from those in the row below. Adjacent blocks in the same row shall be laid with a gap between them of the minimum dimensions given below:

Block Size	Gap (mm)
0.60 m and less	10
Larger than 0.6m	20

The bricks and blocks shall be laid in manner so as not to damage or displace the underlying filter. Any damage caused to the filter during placing of the blocks shall be repaired by the Contractor at his own cost and to the satisfaction of the Engineer. The outer face of the revetment above LWL shall have a smooth and even appearance. The outer surface of the completed revetment shall have a smooth appearance with minimal unevenness.

3.8.11 Repairs to Bank Revetments

3.8.11.1 Selection of Reconstruction lengths: Prior to the commencement of the Works, the Engineer shall confirm in writing the actual lengths of revetment that are to be reconstructed. Sequence of Construction. The Contractor shall clearly indicate on his construction programme his intended sequence of construction, taking full account of the need to protect the works during construction. Consideration should be given to progressing the works as follows:

- (a) removal and stockpiling of existing revetment materials;
- (b) investigating and making good adjacent revetment;
- (c) preparing, backfilling, compacting and trimming the earth embankment;
- (d) construction of launching apron;
- (e) construction of the slope revetment, commencing from the toe and working up the slope;

3.8.11.2 Removal of the Existing Revetment Material : The existing revetment material shall be removed from the agreed reconstruction lengths and the earth embankment cleared of all debris. The c.c. blocks and any boulders shall be stockpiled and sorted in locations approved by the Engineer .

3.8.11.3 Construction of Bank Revetment: The construction of the bank revetment shall be undertaken as described in Clause 3.8.10.

3.8.12 Slope and Streambed Protection: This work shall consist of the provision of brick mattressing and supporting brick guide wall. The brick mattressing shall be anchored and encased by wire mesh on the embankment slope, bridge approaches, side and water front slopes at the locations shown on the Drawings and in accordance with these Specifications and in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or as directed by the Engineer. The guide wall shall consist of a brick wall on a mass concrete base to protect the slopes of embankment, bridge approach, side slope and structure-water fronts and channel bed at locations shown on the Drawings and in accordance with these Specification and in conformity with the lines, grades sizes and dimensions shown on the Drawings or as directed by the Engineer.

3.8.12.1 Materials: (a) Bricks: Bricks for slope and streambed protection shall be First or Second Class Bricks in accordance with Clause 3.6.2.1. Samples of Bricks to be used shall be submitted to and approved by the Engineer before any brick is placed.

(b) Sand: Sand to be used for the brick mattressing shall be of minimum F M of 0.8 and shall otherwise conform to the requirements for fine aggregate set out in Clause 3.1.1.2.

(c) Wire Mesh: The wire mesh to be used for anchoring and encasing the brick matters sing shall be made of 12 BWG Galvanised Ironware and the mesh shall be not be more than 100mm square.

(d) Concrete: Mass concrete shall be in accordance with Clause 3.1 of this Specification and as shown on the Drawings.

3.8.12.2 Construction Methods: Side slope surface on which the brick mattressing shall be placed shall be properly trimmed and compacted. Finishing stakes are to be set according to the Drawings and shall have been inspected and approved by the Engineer. After compaction, the wire mesh shall be laid and staked with 75mmx75mmx600mm wooden pegs at intervals shown on the Drawings or approved by the Engineer. The first layer of the double flat brick mattressing shall be laid closely packed. Sides, interstices and the underside of the bricks shall be tightly packed with sand. The brick mattress shall then be covered and encased by another layer of wire mesh anchored and staked securely with the wooden pegs.

3.8.12.3 Guide Wall: Excavation for foundations, sand filling, mass concrete and brickwork shall be in accordance with Section 3.1 and 3.6 of these Specifications as appropriate.

3.8.12.4 Measurement: The quantity of brick mattressing to be measured shall be the number of square metres along the slope completed and accepted as shown on the Drawings. No separate measurement shall be made for excavation and slope trimming. The quantity of guide wall to be measured shall be the number of linear metres completed and accepted as shown on the Drawings.

3.8.12.5 Payment: The work measured as approved above, shall be paid for at the Contract unit prices for such work and shall be full compensation for furnishing and placing all materials and for all labour, equipment, tools and incidentals necessary to complete the work prescribed in this Section and including all excavation and slope trimming.

Pay items shall be:	<u>Unit</u>
Brick Mattressing	Square Metre
Guide Wall	Linear Metre

3.8.13 Geotextile

3.8.13.1 General: Geotextiles shall be clearly and uniformly marked on the upper face. The geotextiles to be incorporated within the works shall comply with the appropriate codes and standards including the following:

ASTM D4491	Standard test methods for water permeability of geotextile by permittivity.
DIN 53936(pt1)	Determination of the water permeability coefficient (k) normal to the geotextile plane with constant head.
ISO 9073-1	Determination of mass per unit area for non woven textiles.
ISO 9073-2	Determination of thickness of non-woven textiles.
ISO 9073-3	Determination of tensile strength and elongation of non-woven textiles.

3.8.13.2 Transport, Storage and Handling of Geotextile: All geotextiles shall be transported, handled and stored in full accordance with the manufacture's instructions. They shall be wrapped in back polyethypene sheeting to prevent UV exposure until immediately before use in the Works. If the wrapping is damaged during handling it shall be repaired immediately by the Contractor using additional black polyethylene sheering. Unused portions shall be re-wrapped promptly. Geotextile fabrics arriving on site in containers shall be unpacked and stored under covers, well sheltered from rain and direct sunlight, until required for use in the Works. Sufficient ventilation under the shelter shall be provided so as to minimise the effects of high temperature thermo-oxidation. Torn or punctured geotextile fabric shall not be permitted in the Permanent Works. Geogextiles are to be covered with suitable materials within one week of being laid. When laying the covering material it shall not be dropped in the dry from a height grater than 2m. Stock piles of materials are not be set on top of laid geotextiles unless the geotextile has been designed for such loads. No construction

equipment is to work on the geotextiles without at least 300 mm of suitable material overlying the geotextile.

3.8.13.3 Geotextile fabric Layer: Geotextile fabric used for the filter layer below the slope protection shall be a non-woven geotextile of the staple or continuous fibre type or similar material approved by the Engineer. The fabric shall be not less than 6mm thick with a tensile strength not less than 12 kN/m² and weigh not less than 0.8 kg/m². O_{90} 3.0×10^{-3} m/s. The Contractor shall undertake the necessary grading and permeability tests of the embankment soils to determine the required filter cloth characteristics.

3.8.13.4 Geotextile Bags: Geotextile bags shall be manufactured from short staple non-woven geotextile weighing not less than 0.8kg/m², and with O_{90} not greater than 0.07mm or similar material approved by the Engineer. Geotextile bags shall be manufactured to the dimensions and capacity specified on the Drawings and filled with sand which complies with the requirements of Clause 1800 hereof. Each bag shall be double stitched along all edges except for the opening at the top of each bag which shall be wide enough to allow the filling of the bag. The minimum tensile strength of the seam shall be not less than 90% of the tensile strength of the geotextile. The top of each bag shall have a flap which shall be closed tightly after filling the then double stitched. The bags shall be stored under cover, well sheltered from direct sunlight and to prevent the ingress of dust or mud. They shall be protected from damage by insects or rodents.

3.8.13.5 Thread for Stitching geotextile bags: Thread specified by the geotextile manufacturer and of the same chemical composition as the geotextile shall be used for stitching the bags. The use of jute, cotton or nylon threads available in local markets shall not be permitted.

3.8.13.6 Measurement: The quality of geotextile protection to be measured shall be the number of square Meters along the slope of completed and accepted as shown on the drawing or instructed by the Engineer. Separate measurement should be made for excavating or filling and slope trimming, and for placing the geotextile bags. The number of bags placed per square meter shall be as specified on the drawing or as per direction of the Engineer. Dimension of the geotextile and the amount of geotextile cloth and thread to be used for manufacturing one bag should be specified as the drawing.

3.8.13.7 Payment: The work measured as per the above shall be paid at the contract unit prices for such work and shall be full compensation for supply and placing all materials, and for labour, equipment tools and incidental necessary to complete the work.

Pay item shall be	unit
Slope protection with geotextile bags (Class 1, 2 or 3)	Square meter
Unit Price for	
Class 1, 2 or 3 for slope protection should be calculated based on number of layers on bags required to cover 1 square meter of protective area.	

3.9 Reinforced Concrete Pipe Culverts/Sluices

3.9.1 Description: This work shall consist of concrete pipe culverts/sluices furnished and installed at such locations as are shown on the Drawings or as directed by the Engineer in accordance with these Specifications and in accordance with the classes, lines, levels, grades and dimensions shown on the Drawings. The work shall include the furnishing and construction of such joints and such connections to other pipes and other items as may be required to complete the structure as shown on the Drawings. The work shall also include connection of existing drains, which have been interrupted by the road construction, to the new drainage system as directed by the Engineer.

3.9.2 Materials

3.9.2.1 Reinforced Concrete Pipe: Reinforced concrete pipes for culverts shall be of the tongue and groove type and shall be constructed fully in accordance with the Drawings and Sections 3.1 and 3.1.9 of these Specifications.

3.9.2.2 Mortar: Mortar shall be in accordance with the requirements of paragraph 2.6.2.6.

3.9.2.3 Reinforcement: Steel reinforcement shall be in accordance with Section 3.1.9 of these Specifications, except where modified by the Drawings.

3.9.2.4 Bricks: Bricks shall be in accordance with Section 3.6.3.1 of these Specifications.

3.9.3 Construction Methods

3.9.3.1 General: Pipes shall be laid on an improved foundation of minimum 150 mm concrete base under existing or new embankment fill. The dimensions and concrete specification, and steel reinforcement if any, shall be as per drawing or as instructed by the Engineer.

3.9.3.2 Excavation: The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the concrete base material under and around the pipe. Before laying, the ground shall be trimmed true to line and grade, as directed by the Engineer, over sufficient width to permit satisfactory construction of the concrete base. Special care shall be taken to remove any hard or deleterious material from the foundation area. When soft, spongy or unstable soil is encountered, such soil shall be removed from under the foundation for a width and to a depth as directed by the Engineer and replaced with sand or other suitable selected material properly compacted to provide adequate support for the pipe laid on concrete base (foundation). The prepared surface shall provide a firm foundation of uniform density, throughout the length of the culvert. Excavated materials shall not be deposited in the drainage channel and if such materials are suitable, may be incorporated in the works as common fill.

3.9.3.3 Bedding: Bedding or base foundation for pipe culverts shall be constructed by filling concrete in a trench cut in the natural ground or embankment to a depth as shown on the Drawings. The pipe culverts shall be in base concrete to a thickness as shown on the Drawings accurately shaped by a template to fit the lower part of the pipe culvert exterior.

3.9.3.4 Installation: All concrete culvert pipes shall be laid with reinforced and mortared joints. The pipes shall be laid carefully and in straight line. Before succeeding sections of pipe are laid, the lower half of the groove of the proceeding section shall be plastered on the inside with cement mortar of sufficient thickness to bring the inner surface of the abutting pipe flush and even. At the same time the upper half of the succeeding pipe shall be similarly plastered with mortar. After the pipe is laid, the remainder of the joint shall be filled with similar mortar, and sufficient additional mortar shall be used to form a bead around the joint. The inside of the joint shall be wiped and finished smooth. The mortar on the outside shall be protected for two days or until the Engineer permits backfilling to proceed.

3.9.3.5 Backfilling: Backfilling shall be carried out with material as indicated on the Drawings. It shall be placed in uniform layers not exceeding 150mm in un-compacted depth and compacted as embankment fill by layer at the depths concerned below sub-grade. Special care shall be taken to compact the material under the haunches of the pipe and to ensure that the backfill shall be brought up evenly on both sides of the pipe. Sand used for backfill shall conform to the requirements for backfill by sand to structures in section 2.8 and embankment fill shall conform to the requirements of section 2.4 of these specifications.

3.9.4 Measurement: Culvert pipe shall be measured as the number of linear metres of pipe from end to end of each pipe structure, complete and accepted in place. Excavation, concrete base backfill and tamped fill as well as cutting of holes for connection pipes shall be measured and priced as separate item. Headwalls shall be measured and paid for in accordance with section 3.6.5: 3.6.6

3.9.5 Payment: Concrete culvert pipe measured as provided above shall be paid for at the contract unit price per linear metre for the particular size of pipe. The price shall be full compensation for furnishing, hauling and installing the pipe, jointing, excavation, dewatering, pumping and bailing, concrete and RCC work, backfilling, compaction and for all labour, tools, equipment and incidentals necessary to complete the accepted structure.

3.10 Steel Sheet Piling Work

3.10.1 Piling Equipment and Workmanship: Not less than 14 days before any piling work is commenced the Contractor shall submit to the Engineer for approval full details of his proposed piling plant and detailed method for carrying out the work. Where applicable, such details shall include a full description of the piling frame, hammer, helmet and packing, methods of handling, pitching and supporting the piles before and during driving, the proposed driving procedure and such further

information as the Engineer may require. The piling frame shall be of sturdy construction supported on an adjustable base, securely guyed and with ample toggle connections to leaders so that the pile is firmly held at all times. The type and weight of hammer shall be to the approval of the Engineer and the weight of the hammer shall be at least half that of the pile; in general, a heavy hammer with a short drop should be used in preference to a light hammer with a longer drop. The Contractor shall not commence any piling until the plant and methods which he proposes to use have been approved by the Engineer but such approval shall not relieve the Contractor from any of his obligations and responsibilities under the Contract. If for any reason the Contractor wishes to make any change in the plant and methods of working which have been approved by the Engineer, he shall not make any such change without having first obtained the Engineer's approval thereof.

3.10.2 Records: The Contractor shall keep complete records of all data as required by the Engineer covering the fabrication, driving and installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after installation of the piles.

3.10.3 Setting Out: The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the satisfaction of the Engineer and shall set out with a suitable identifiable pin or marker the position of pile line. The main setting out for piles is to be completed prior to commencement of piling. Secondary or individual pile setting out is to be completed and agreed not less than 8 hours prior to commencing work on the piles concerned and adequate notice for checking shall be given by the Contractor. Notwithstanding such checking and agreement, the Contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions, and alignment of the piles.

3.10.4 Tolerances: Piles shall be driven accurately vertical and the permitted deviation of the pile centre from the centre line shown on the Drawings or setting out plan shall not exceed 50 mm measured at the working level of the piling rig, or other level agreed by the Engineer. The maximum permitted deviation of the finished pile shall be 1 in 75 from the vertical.

3.10.5 Steel Sheet Piles: Steel sheet piles shall be roughly of U-shape with joints of piles when driven located on the neutral axis of the piling work. Length of steel sheet piles shall be in terms of whole numbers of metres for standard lengths and shall be measured in divisions of 500 mm. There shall be one handling hole of diameter 25 mm to 60 mm, the centre of which is to be located 100 mm to 300 mm from one end. Steel sheet piling shall either be supplied by LGED or an alternative specified in the Particular Specifications. Steel sheet piles shall not show harmful defects under use. It shall be straight and out end surfaces shall be flat for all practical purposes. It shall be adequately engaged with adjacent piles during driving provided that they can be disengages for extracting. Joints of steel sheet pile shall be watertight provided their structure does not obstruct driving and extraction. Steel sheet piles shall be hot rolled from structural carbon steel and shall have the following properties:

(a) Chemical Properties:	Phosphorous	:0.055% (max)
	Sulphur	:0.055% (max)
(b) Mechanical Properties:	Tensile strength	: 410 N/mm ² (min)
	Yield strength	: 270 N/mm ² (min)
	Elongation	: 17% (min)
(c) Width:	400-600 mm	
(d) Depth:	75 - 160 mm	
(e) Thickness:	7.5 - 8.5 mm	

3.10.6 Pitching and Driving Steel Sheet Piles: All sheet piles shall be driven in presence of the Engineers' authorized representative and no pile driving will be allowed at night without prior permission from the Engineer. Piles shall be accurately pitched and driven in the position and to the lines shown on the Drawings within the specified tolerances. The lengths of piles shall be as shown on the Drawings or such other lengths as the Engineer may direct. Piles shall be driven in a sequence approved by the Engineer. The steel sheet piling shall be assembled against the guides so that each pile is rigidly supported and plumb at both edges and side. All temporary guide structures shall be removed by the Contractor. At all stages during driving, piles shall be adequately supported and restrained without damage to the piles or any coatings or preservative treatment, by means of leaders, trestles, temporary supports or other guide arrangements to maintain position and alignment. Handling, slinging and pitching of piles shall be by methods approved by the Engineer. Piles deflected from the proper lines shall, where ordered by the Engineer, be withdrawn and re-pitched until the proper line is obtained. No forcible method of correction of the position or line of any pile will be permitted. Any holes from which piles are withdrawn shall be packed with approved non-plastic material before re-driving. The cost of withdrawing, re-pitching, re-driving to the previous level and filling with non-plastic materials shall be borne by the Contractor. Piles ruptured in the interlock or

otherwise damaged in driving shall be pulled and new pile should be driven. If at any time the forward edge of the piling wall is found to be out of plumb, the piling already assembled shall be driven to the forward edge plumb before additional piling is assembled or driven. The maximum permissible taper in a single pile shall be 20 mm per metre of length. Splicing of piles during driving will not be allowed except where specifically approved by the Engineer. Where welding of piles is approved by the Engineer for field conditions, welding shall be done in accordance with the direction of the Engineer. No pile (or pair of piles) shall be driven to less than one half or more than two thirds of the specified depth before the next pile (or pair of piles) has been driven to one half of the specified depth. Corner joints and special piles shall be fabricated in accordance with the Drawing.

3.10.7 Treatment of Steel Sheet Pile Tops: The top 300 mm length of steel sheet piles, to be embedded in concrete as shown on the Drawing, shall be given two coats of bituminous paint to form a non-bonding contact with the concrete. A 50 mm gap, filled with impregnated hessian cloth or an approved filler, shall be maintained above the piles. The filler, used in accordance with the manufactures instructions, shall be kept in position with clips etc. or as approved by the Engineer. The main length of the steel sheet piles should not be painted.

3.11 Gates and Hoists

3.11.1 General: (a) The work covered by this Section shall include the manufacturing, painting, packing, transportation to site, installation, site testing and remedying of defects of gates and hoisting systems for the various hydraulic structures. A detailed description of work to be undertaken is included in the Drawings and BOQ and technical specifications of particular structures.

(b) The work shall include anchor bolts, plates, angles, channel and others as per Technical Specifications, Drawings and BOQ. The services not expressly called for in the Specifications or shown on the Drawings and BOQ but which are necessary for completion and proper operation shall be supplied and installed by the Contractor at no increase in cost to the Contract.

3.11.2 Instructions on Installation, Equipment, etc.: The Contractor shall provide operation and maintenance instructions/training to local LGED staff for the gates and hoists including equipment instrumentation, etc. to be supplied and installed under the Contract. The cost of this training shall be included in the rates for supplying and installing.

3.11.3 Manufacturing: (a) Manufacturing shall be done using the approved Drawings in terms of dimensions, materials and specifications. Clarifications/explanations of the drawings, materials and specifications, if required, shall be obtained from the Engineer.

(b) Manufacturing of gates and hoisting systems shall be done at qualified workshops having experience in manufacturing and installing gates of similar hydraulic structures.

3.11.4 Inspection during Manufacture: The Engineer or his representative may at any time inspect manufacturing of the gates and hoists to check quality and specification of materials, dimensions and workmanship. For this, the Contractor shall inform name, address and location of the manufacturing workshop to the Engineer as soon as the manufacturing commences.

3.11.5 Materials: (a) Material will mean all ferrous and non-ferrous materials whether treated or machined, used to complete manufacture and installation of gates, stop logs and their lifting devices.

(b) Most of the materials of different components have been specified in the Drawings. If the Contractor wants to add any material in addition to those specified, he must obtain prior approval of the Engineer.

(c) At any stage of manufacture, if any inferior material contradictory to standards or specification is discovered in any component or accessories irrespective of whether it is in a major or minor component, the component shall be rebuilt with parts of appropriate materials and all costs related to such revision of works will have to be borne by the Contractor. Payment to the Contractor will remain suspended until the required corrections are made and certified by the Engineer or his representative.

3.11.6 Bushing: Wheel bearing of fixed wheel gates shall be provided with self lubricating bearings in accordance to the Drawings. All other bearings and bushings shall be provided with grease ways and proper grease fittings for preventive maintenance.

3.11.7 Rubber Seals: (a) Rubber seals shall be moulded solid sections of the type and dimensions indicated in the Drawings. The material shall be a compound of natural rubber or a copolymer of butadiene or styrene or a blend of both and shall contain reinforcing carbon black, zinc oxide, accelerators, antioxidants, vulcanizing agents and plasticizer. The physical characteristics shall meet the following specification:

Tensile strength	20 N/mm'
Elongation at break	45%
300% modules	6 N/mm2
Durameter hardness (shore type A)	60-70

Water absorption (max)	5% by weight
Compression set	30%
Tensile strength after Oxygen bomb aging ASTM D572	80% of Tensile strength
Tensile strength of vulcanized joints	10 N/mm ²

- (b) The seals shall be moulded in one piece for each straight length of manufacture, without inclusion of voids or canvas reinforcement.
- (c) The seals shall be made continuous right round the gate and shall be spliced at the corners by shop vulcanizing to provide a single continuous seal. The tensile strength of all shop splices shall not be less than 50% of the tensile strength of unspliced material.

3.11.8 Miscellaneous Materials: (a) Wire rope for stoplog hoists shall be made from improved plough steel, galvanized, fibre cored and of the extra pliable type with 6/37 strand construction. Standard wire rope fittings shall be used.

- (b) All fixing bolts and nuts shall be galvanized. All pins shall be of stainless steel.

3.11.9 Fabrication: (a) Components supplied shall be in good condition and marked as per the fabrication drawings for easy checking.

- (b) Before being assembled, all the components shall be in good condition. If twisted or bent or damaged in any way they must be repaired, according to the Drawings and as per instruction of Engineer, before assembly.
- (c) All tolerances and allowances for metal fits shall conform to the appropriate approved standard Journals and sliding surfaces shall be polished and finished with sufficient smoothness and accuracy to ensure proper operation when assembled.
- (d) Cutting shall be by machine, by sawing or by oxy-acetylene torch. Oxygen cut edges must have all gouges removed by grinding. All outside corners shall be clean and with a radius of the right dimension.
- (e) Pin holes shall be bored to gauge, smooth and straight, and at right angles to the axis of the member. Boring shall be done after the member is securely fastened in position.
- (f) Machining shall be by methods which result in a good final surface.

3.11.10 Embedded Metalwork: (a) Metalwork components to be cast into the structures shall be fabricated as per the Drawings. Unless indicated on the Drawings, the embedded metal components shall not be painted but prepared in accordance with specifications and then firmly secured in position as per drawing and satisfaction of the engineer prior to concreting.

- (b) The Contractor shall plan concreting work so as to avoid risk of knocking or damaging the components set and positioned for embedment.
- (c) Exposed surfaces of embedded metals after casting of concrete work shall be painted according appropriately.
- (d) Welding during positioning of parts shall be done carefully, so that, vertical and horizontal levels of the exposed surfaces may not be disturbed due to heat, generated at the time of welding.
- (e) Rubbing surfaces shall be cleaned before installation of gates or stoplogs.

3.11.11 Tolerances: Tolerances for sealing surfaces, guides etc, shall be selected to prevent over stressing of the gate parts and to effect watertight seal. Tolerances for machined and fitted parts shall comply with the requirements of the specifications or standards. All tolerances and means of adjustment shall be subject to the Engineer's approval.

3.11.12 Tests: (a) Tests will include the assembly of components in the manufacturing shop as well as on site.

- (b) All tests performed at shop or at site shall be witnessed by the Engineer or his representative and results recorded. If any defects are discovered, they shall be remedied and the tests repeated until satisfactory results are obtained.
- (c) Tests at Manufactures shop shall be done as below:

Gates/Stoplogs

Gates/stoplogs, including seals, guides, and fixed wheels, where applicable, shall be assembled at the manufacturer's shop. While assembled, the gates and stoplogs shall be checked for dimensions, tolerance and accuracy of alignment. Any errors or misalignment discovered shall be promptly corrected. The seals shall be fitted to their supports during shop assembly. Sealing frames, track frames, side guide frames, lintel beams and sill beams etc, shall be checked whether satisfactorily manufactured or not. All dimensions of guides that correspond to the gate and stoplog dimensions shall be checked and any error and misalignment shall be corrected. Parts shall be clearly match-marked before disassembly for transportation.

Guide Frames

Appropriate sections of the stoplog guide frames shall be assembled and fixed in the shop to see that the guiding, bearing and sealing surfaces lie in a true plane for their entire length.

Hoists

The hoists shall be shop assembled and tested for smooth performance at normal operating speed and at no load. All lubrication, grease and oil required for the performance of tests shall be furnished by the manufacturer. If any defect is discovered it must be corrected and the entire test repeated.

(d) Installation and Tests at Site shall be done as below:

Guide Frames

Guide frames shall be assembled in the blockouts and firmly secured in the location shown on the Drawings. Concrete shall not be commenced unless the correct positioning of the frame has been achieved by adjustment of bolts and nuts and approved by the Engineer.

Gates/Stoplogs

The gates and stoplogs complete with seals, guides and fixed wheels, wherever applicable, shall be assembled so as to attain a tight and water proof sealing at the base, top and sides. The lifting and lowering of gates and stoplogs should be achieved from the deck without undue resistance. Except where water sealing is required, all metal to metal contact surfaces must be lubricated by the manufacturer during test operations. Any defects observed shall be corrected promptly and the test repeated. Any damage to the gate or components during installation and testing shall be repaired, replaced, as required, by the Contractor at no extra cost.

Flap Gates

Care shall be exercised in setting and adjusting pivots and sealing surfaces to assure that the gates hang properly, swing freely and seal uniformly around the entire perimeter. The gate frames shall be adjusted simultaneously with the gate pivot adjustments. The gates and components shall be handled carefully to prevent damage to sealing surfaces and racking, bending and/or otherwise preventing them from operating as required. Following installation and placement of second stage concrete, the gates shall be operated manually to demonstrate satisfactory installation and operation.

Slide Gates

Care shall be exercised during the installation of embedded metalwork and gate guides to obtain proper alignment and insure that the appropriate components are plumb. The frames and wedges shall be adjusted as required to assure that the gates will slide freely and seat uniformly. Care shall also be exercised to prevent warping, racking, bending or other damage to the gate or components. Following installation and placement of second stage concrete, the gates shall be operated manually to demonstrate satisfactory installation and operation.

Stop logs

The Contractor shall handle and store the stoplogs safely and securely from the time they are delivered to site until the time they are accepted by the Engineer. The installation of the stop logs shall be performed in a workmanlike manner, and care shall be exercised to insure that the stop logs seat uniformly to the satisfaction of the Engineer.

3.11.13 Hoists: Before assembly and installation, all bearing surfaces, journals, grease and oil grooves shall be carefully cleaned and lubricated with approved oil and grease.

Flap Gate Hoist

The Contractor shall install gate hoists as shown on the Drawings. Approved manufacturer's installation instruction shall be strictly observed. Prior to acceptance the hoist shall be lubricated and operated through a complete cycle of opening and closing of the gate to demonstrate satisfactory installation and operation under design load.

Slide Gate Hoist, Stems and Guides

The Contractor shall install hoists on each slide gate as well as stems and stem guides as shown on the Drawings. Approved manufacturer's installation shall be strictly observed. Prior to acceptance, the hoist shall be lubricated and operated through a complete cycle of opening and closing of the slide gate to demonstrate satisfactory installation and operation under design load.

Slide Gate Lifting Beams & Pulleys

Pulleys for lifting vertical gates shall fit properly on the flange of the hoisting I-beam and must ply freely over it.

3.11.14 Painting: All exposed metal surfaces of the items described in the preceding paragraphs shall be painted in accordance with the specifications Drawings and BOQ.

3.11.15 Measurement and Payment: Payment for supplying and installing the gates and components including hoists shall be on a lump sum basis for each set in accordance with the BOQ. Payment for each complete set shall be made when they have been tested to the satisfaction of the Engineer and taken over by the project staff with satisfaction.

3.12 Rubber Dam Bags

Description

The work covered by this Section includes materials and fixing of rubber bags required for rubber dams.

Dam Bag

Material

The Rubber Dam Bag shall be made of high strength polyamide fabric in required number of plies adhered with the inner, outer and intermediate rubber layers of specified thickness and strength.

Tensile Strength of Rubber Bag

The tensile strength of the main Rubber Bag shall be minimum 650 Kn per meter strip in warp direction and $\frac{2}{3}$ rd of the warp strength in weft direction. The corresponding strengths after ageing in air at 100°C for 4 days shall not be less than 80% of the strength before ageing. The corresponding strengths shall also not be less than 80% after immersion in water at 70°C for 4 days.

Tensile strength of side closure sheet shall not be less than half of the tensile strength of the main bag.

Adhesion Strength

The adhesion strength between the fabric and rubber layers (inner, outer or intermediate) shall not be less than 6 KN per meter strap. The corresponding strength after immersion in water at 70°C for 4 days shall not be less than $\frac{2}{3}$ rd of the strength before immersion.

Thickness and fabric plies

The rubber bag shall be made with number of fabric plies and rubber layers appropriate for the specified tensile strength subject to minimum 3-ply fabric and 13mm total thickness.

Rubber Layer

Material

Material of the rubber layers (inner, outer and intermediate) shall be best quality synthetic rubber (neoprene) of specified strength, elasticity and other technical properties.

Tensile Strength

Tensile strength of the synthetic rubber (neoprene) in layers (inner, outer and intermediate) shall be not less than 12 MPa. The tensile strength shall not reduce by more than 20% after ageing in air at 100°C for 4 days.

Elongation

Elongation of the synthetic rubber (neoprene) in layers shall not be less than 400% at the specified tensile strength. The corresponding elongation after ageing in air at 100°C for 4 days shall not be less than 300%.

Surface Cracking

Surface of rubber layer (inner and outer) shall not show any crack at 20% elongation after Ozone Test with 10000 pphm air at 20°C,

Other Properties:

The Rubber Layer shall further have the following properties:

- Unit weight : 1.33 E0.22 gm/cm³
- Shore-A Durometer Hardness : 60 E 5
- Abrasions Resistance : 0.8 cm³/1.61 km (maximum)
- Brittleness Temperation : (-) 30oC

Test Standard

All strengths and properties and testing procedures mentioned above are according to ASTM Standards or equivalent.

Size and Shape of Rubber Dam

The size of the Rubber Dam given by the Length of the Dam between abutments and Height of Dam above concrete base floor/ crest shall be as per approved drawing. Civil construction of the structure shall maintain accurate dimensions between abutments and the Rubber Bag shall be fabricated with exact measurement so that no mismatch occurs during installation of the Dam Bag. The contractor shall maintain required communication with the Dam Bag manufacture/ supplier to avoid any such mismatch.

The Rubber Dam shall be of pillow shape between vertical abutments. The design parameters for the Dam Bag shall be as given on the Drawings and will include the following:

- i. Dam Height = H m (max)
- ii. Internal Pressure Head = 1.30 times Dam Height, H
- iii. Distance between Anchor Lines = S m

The contractor shall confirm concurrence of the Dam Bag supplier with the anchorage line dimension or obtain the Engineer's approval of the dimension given by the Dam Bag supplier before civil works construction and Dam Bag fabrication.

Anchor System

The Rubber Bag along with the base cover sheet shall be anchored to the concrete base floor by using mild steel pads and platens and anchor bolts and nuts as per drawings and specifications.

Second stage casting block-outs shall be kept along the anchor lines as per alignments and dimensions along with dowel bars from first stage concrete as shown in the Drawings. The anchor bolts shall then be set in position in the second stage blocks to line and level as per drawings and welded to supporting chairs and dowel bars. The anchor bars shall be set and fixed in position with adequate support and welding so that they are not displaced from line and level during placing and vibrating the second stage concrete.

Second stage concrete shall be of richer mix as per drawing and specification. It is preferred that an approved high early-strength admixture is used in the second stage concrete and a minimum 2-week period of continuous curing of the concrete is done before fixing the Rubber Bag. The curing period is important because heavy concentrated loads are usually applied on the anchor bolts during fixing the Rubber Bag.

Holes in the Rubber Bag and base cover sheet shall be made true to positions and measurements after laying the Rubber Bag in position opposite to the anchor bolts to avoid any miss-punch in the Dam body.

The Dam Bag and the base cover sheet shall be anchored to the concrete base floor using pad-platens and anchor bolts-nuts (double nuts each bolt) using levelling sheets, cushioning foam sheets and so on as required to make the anchorage sound and leak proof.

All nuts of all anchor bolts shall be check-tightened after Test Inflation of Dam Bag and re-working of the anchorage, if needed, is done. The exposed portions of the bolts and nuts shall be coated with grease, covered with caps or good quality polythene sheet and the whole anchorage trench shall be filled covering the anchor bolts with lean concrete as per drawing to protect the bolts-nuts from rust/ chemical corrosion from contact with water.

Test Inflation

After anchoring is complete, the Dam shall be test inflated in presence of the Engineer in-Charge to at least one meter height and maintained inflated for 24 hours to check for possible leakage through the anchorages or from any other joints of the Dam Bag, and also to check functioning of the inflation/ deflation pipe lines and valves. The defects, if any found, must be rectified as per specification and instruction of the Engineer in charge.

PART 4: BURIED IRRIGATION PIPE SYSTEMS

4.1 Description

This section is concerned with works for command area development, CAD, subprojects that are not covered in previous sections. In particular it covers:

- i. uPVC buried pipes
- ii. Reinforced concrete buried pipes
- iii. Conveyance system associated structures
- iv. Pump House and Pumping Platforms
- v. Pumps and Electrification

4.2 uPVC Buried Pipelines

4.2.1 Introduction

This section covers the conveyance pipe system works including: (i) pipe sizes, wall thickness and material specification; (ii) pipe storage and handling; (iii) pipeline layout and location of structures; (iv) trench construction; (v) pipe placement and jointing; (vi) structure connections; (vii) thrust control; and (viii) pipeline testing and backfill.

4.2.2 PVC Pipes and Fittings Appearance and Sizes

(a) Appearance

When viewed without magnification the internal and external surfaces of the pipes and fittings shall be smooth, clean and free from scoring, cavities and other surface defects. The material shall not contain visible impurities. The ends of the pipes and fittings shall be clean and square to their axes. The colour of the pipes and fittings shall be grey.

(b) Pipe and Fitting Sizes and Wall Thickness

The base material from which the uPVC pipes are produced shall be un-plasticised Polyvinyl Chloride (PVC"u") with additives as necessary for manufacture in accordance with ISO 4065: 1996(E).

All fittings having sockets shall comply with ISO 727-1985 and shall be compatible with the pipes supplied.

Wall thicknesses of uPVC pipes and pipe fittings shall be commensurate with a working pressure rating of 3.25 bar (32 m head). Required wall thickness shall be determined in accordance with ISO 4065: 1996(E), having a SDR value of 81 (equivalent to PN 3.25)

The pipes shall have one end socket and one end spigot (plain). The spigot end shall be chamfered to facilitate insertion into the socket of the adjacent pipeline / fitting. The socket shall be machine made.

The length of the pipes shall be 6.0 m including socket. Pipe diameters and wall thickness are tabulated below for the range of pipes and pipe fittings likely to be used.

uPVC Pipe Diameters and Wall Thicknesses

Nr (m)	External Diameter (mm)		Nominal Wall thickness (mm)		Internal Diameter (mm)	Length
1	160	2.00	156	6.00		
2	180	2.30	175	6.00		
3	200	2.50	195	6.00		
4	225	2.80	219	6.00		
5	250	3.10	244	6.00		
6	280	3.50	273	6.00		
7	315	4.00	307	6.00		
8	355	4.40	346	6.00		
9	400	5.00	390	6.00		
10	450	5.60	439	6.00		
11	500	6.20	488	6.00		

12 560 7.00 546 6.00

uPVC Tee Dimensions and Wall Thicknesses

Nr Dimensions - External Diameter

(mm) Nominal Wall thickness

(mm) Length

(m)

1	Tee 160 x 160 x 160	2.50	1.47
2	Tee 180 x 180 x 180	2.80	1.47
3	Tee 200 x 200 x 200	3.20	1.47
4	Tee 225 x 255 x 255	3.50	1.47
5	Tee 250 x 250 x 250	3.90	1.47
6	Tee 280 x 280 x 280	4.40	1.47
7	Tee 315 x 315 x 315	4.90	1.47
8	Tee 355 x 355 x 355	5.60	1.98
9	Tee 400 x 400 x 400	6.30	2.29
10	Tee 450 x 450 x 450	7.00	2.67
11	Tee 500 x 500 x 500	7.80	2.67

uPVC Bend Dimensions and Wall Thicknesses

Nr Dimensions - External Diameter

(mm) Nominal Wall thickness

(mm) Length

(m)

1	Bend 160	2.50	1.52
2	Bend 180	2.80	1.52
3	Bend 200	3.20	1.52
4	Bend 225	3.50	1.52
5	Bend 250	3.90	1.52
6	Bend 280	4.40	1.52
7	Bend 315	4.90	1.52
8	Bend 355	5.60	1.52
9	Bend 400	6.30	1.98
10	Bend 450	7.00	1.98
11	Bend 500	7.80	1.98

PVC End Caps Dimensions and Wall Thicknesses

Nr Dimensions - External Diameter (mm) Nominal Wall thickness (mm) Length (m)

1	End cap 160	2.00	0.56
2	End cap 180	2.30	0.56
3	End cap 200	2.50	0.56
4	End cap 220	2.80	0.56
5	End cap 250	3.10	0.56
6	End cap 280	3.50	0.56
7	End cap 315	4.00	1.42
8	End cap 355	4.40	1.42
9	End cap 400	5.00	1.42
10	End cap 450	5.60	1.42
11	End cap 500	6.20	1.42

4.2.3 Pipe Testing and Marking

(a) Pipe Testing

The following tests shall be conducted for uPVC pipes on representative samples of each diameter of pipe required. Testing shall be carried out in any reputable laboratory as required by the Engineer.

Dimensions: The thickness of the pipes and pipe fittings shall not be less than the nominal thicknesses tabulated, and shall not exceed the nominal thickness by more than 15%.

Short Term Hydrostatic Test: For a temperature of 200C and a test pressure of 9.5 bar the pipes shall not fail within a period of 1.0 hrs.

Heat Reversion Test: The longitudinal reversion value in accordance with the test requirements of ISO 2505 shall not be greater than 5%.

Impact Strength: Impact strength at 200C shall satisfy ISO 3127.

Resistance to Acetone: A short length of pipe shall be immersed in acetone vertically to a depth of at least 25 mm at room temperature for 2 hours shall not show any attack on the surface of the test piece. Fattening and / or swelling of the pipe shall not be deemed to constitute failure.

Specific Gravity: The specific gravity of the pipe material shall be within 1.35 to 1.45.

(b) Pipe Marking

Pipes shall be permanently marked at intervals no greater than 2.0 m. The marking shall include the following information:

- Manufacturers name or trademark
- Nominal outside diameter
- Pipe material (uPVC)
- Standard (ISO 4065: SDR 81)
- Date (and time) of manufacture
- LGED
- Not for sale

(c) Fitting Marking

The marking of fittings shall include the following information:

- Manufacturers name or trademark
- Sizes
- Fitting material (uPVC)
- Standard (ISO 727)
- Date (and time) of manufacture
- LGED
- Not for sale

4.2.4 Pipe Handling and Storage

(a) Receiving Pipes and Fittings

All pipes and pipe fittings received on Site shall be visually inspected for damage which may have occurred during transit. Ends shall be checked for any cracks or splits or other damage. The pipes shall also be checked for any severe deformation which could later cause jointing problems.

Any damaged pipes and fittings should be returned to the place of manufacture / procurement and will not be accepted in the permanent works.

(b) Handling

The pipes and fittings should be handled with reasonable care. They are relatively light and must not be thrown around and / or dropped from any height.

Pipes and fittings should not be dragged / pushed / dropped from a truck bed. Loose pipes may be rolled down on a timber support but care must be taken that they do not fall on each other or on any hard or uneven surface.

(c) Storage

Pipes should be stored on level ground which is dry and free from sharp objects. Different pipe sizes should be stored separately.

The pipes and fittings shall be protected from the sun.

Pipes should be continuously supported along its length. If this is not possible the spacing of supports should not exceed 1.0 m.

Pipes shall not be stacked to a height in excess of 2m, or 6 layers, whichever is the lesser.

4.2.5 Pipeline Layout and Location of Structures

The contractor shall confirm the pipeline layout and lengths of each size of pipe required under the contract by setting out the pipeline alignments prior to trench excavation, marking locations for all pipe bends and structures, particularly irrigation riser outlets, with marker flags. The marker flags shall be at least 1.6m in height.

The locations of riser outlets shall be discussed and confirmed by the outlet farmers represented by the the Organizing or Management Committee of the WMCA, all as directed by the Engineer-in-Charge.

4.2.6 Trench Construction

The trench shall be excavated to a depth to ensure cover to the top (crown) of the pipe of typically 1.0 m, and at least 0.8 m. The trench grade (longitudinal slope) shall be as shown on the drawings or as otherwise directed by the Engineer-in-Charge, so as to provide uniform slopes between pipeline structures.

The trench below the top of the pipe shall be only wide enough to permit the pipe to be easily placed and joined, and to allow for initial backfill material to be uniformly placed under the haunches and along the side of the pipe. The usual trench width shall be $D + 0.3$ m where D is the pipe outside diameter.

Where stable conditions exist trench side slopes shall be vertical subject to safety considerations. Where necessary for side slope stability, trenches may be excavated with sloping sides. Where working conditions and / or right-of-way restricts width, the sides of the trench shall be shored using timber boards braced across the trench.

The trench bottom shall be uniform so that the pipe is fully supported without "bridging". Clods, stones and uneven spots that can damage the pipe or cause non-uniform support shall be removed. A small layer of bedding material (sand) may be spread over the bottom of the trench to facilitate uniform support to the pipe.

Where rocks, stones or uneven material are encountered, the trench bottom shall be cut 100 mm below the required grade, and backfilled with bedding material (sand).

Excavated material shall be placed along one side the trench, allowing easy access from the other side for placement of pipes prior to laying.

The excavated trenches shall be fenced / marked off as directed by the Engineer-in-Charge to prevent people / animals falling into the trench.

Where ground water is encountered it shall be kept below the formation level of the pipes to be joined by pumping, side drainage trench construction, placement of sand in the trench bottom and any other measures as directed by the Engineer-in-Charge.

4.2.7 Pipe Placement and Joining

Small holes shall be excavated for the socket ends of the pipes to permit the pipe body to be uniformly supported along its whole length. Pipe laying may start from any structure location and shall proceed in a downstream direction.

Pipes shall be carefully placed in the excavated trench for joining after removal of all foreign matter or dirt. Prior to joining the connecting surfaces of the spigot and socket shall be cleaned with a rag or brush.

The pipe socket (bell end) should be aligned downstream. Ensure that the rubber gasket (ie “O” ring) is placed correctly in the socket and that lubricant is applied to the spigot of the adjacent downstream pipe. The spigot should be smoothly chamfered – if necessary any minor irregularities may be filed off.

The two pipes should be carefully aligned and the spigot of the downstream pipe inserted into the socket (bell end) of the upstream pipe applying firm pressure, either by hand or using a “bar and block” assembly. A small twisting motion may be useful for smaller pipe diameters. Care should be taken to avoid over entry of the spigot into the socket.

Pipes shall be cut by a method which provides a clean square profile with splitting of damage to the pipe wall. Cut spigot ends shall be chamfered.

4.2.8 Structure Connections

Minor settlement of rigid structures will not usually cause shear breakage of the uPVC pipe, and the uPVC pipes may be placed directly into the smaller concrete structures, but not the header tank. As uPVC pipe will not bond with concrete a water seal is provided by two “O” ring rubber gaskets placed 100 mm apart in the wall of the structure.

To minimize differential settlement initial pipe backfill within 1 m of the structure shall comprise sand. Further to accommodate any differential settlement, rubber “O” ring pipe joints shall be provided to in the pipeline about 1 m from the structure.

For major structures, and in particular the header tank, the uPVC pipes shall connect to steel pipes with flange connections. The steel pipes will be set into the walls of the concrete structures.

4.2.9 Thrust Control

Thrust control (joint restraint) is required to prevent pipe movement and damage at the following locations: (i) changes in pipe direction (eg tees, bends, elbows, etc); (ii) change in pipe size; (iii) dead ends (end caps). Thrust control shall comprise Class D concrete placed between the pipe and the (vertical) side of the excavated trench to resist movement.

4.2.10 Initial and Final Backfill

(a) Initial Backfill

Initial backfill shall be by hand and shall comprise soil or sand that is free from stones larger than 15 mm in diameter. At the time of placement the moisture content of the material shall be such good compaction can be achieved. Initial backfill shall not be carried out during wet weather.

Initial backfill shall be placed under and around the pipe and to provide 50 mm cover to the pipe top (crown). Initial backfill shall be compacted firmly to provide adequate lateral support to the pipe and prevent movement. Compaction shall be carried out using a steel plate or other approved rammer at least 12 kg in weight in 100 mm thick compacted layers.

Pipeline testing and commissioning shall be carried out after initial backfilling of the pipeline trench, but before final backfill unless otherwise approved / directed by the Engineer-in-Charge.

Grounds for carrying out final backfill prior to testing may include: (i) a real and identified risk of pipe floatation; (ii) safety hazard – particularly near settlements; (iii) blocking of right of way, etc.

(b) Final Backfill

Final backfill may be by hand or machine.

Final backfill material shall be free from large stones and other debris larger than 75 mm in diameter. The material shall be placed and spread in approximately uniform layers to fully fill the trench. Final backfill shall be placed and compacted by iron rammer in 250 mm thick compacted layers.

(c) Concrete Backfill

To ensure against floatation and / or scour and exposure of the pipeline where it crosses natural drainage lines, the initial backfill material may comprise concrete Class D placed and compacted under and around the pipe and to a depth of 100 mm over the top of the pipe.

Concrete backfill shall also be used where the pipeline crosses under road embankments.

4.3 Reinforced Concrete Buried Pipelines - New/ Repair

4.3.1 Description

This work covers both new/ re-laid reinforced concrete pipelines and repair of existing concrete pipelines to address leaks and/ or other problems.

Materials for the pipes and construction methods shall be as detailed in Section 3.9. However this section includes additional specifications particularly for pipe bedding, jointing and for repair of existing pipelines.

4.3.2 New / Re-laid Reinforced Concrete Pipelines

Where passing under roads, or where directed by the Engineer-in-Charge, pipe bedding shall be as for pipe culverts and shall comprise mass concrete placed in the excavated trench with reinforced and mortared joints, see Section 3.9. Otherwise pipe bedding shall comprise sand/ gravel 100 – 150 mm thick depending on diameter of pipe, see table below.

Leaking joints often occur due to settlement/ movement of the pipe, and where very soft clay is encountered additional measures to prevent movement shall be taken as shown on the drawings and/ or directed by the Engineer-in-Charge. These measures may include for excavation of soft clay and replacement with sand/ gravel.

Pipe laying shall generally proceed in a downstream direction. For spigot and socket pipes, it is recommended that the pipe socket shall be downstream, and jointing shall be by placing the downstream pipe's spigot into the socket.

The procedure for addressing leaks where the pipeline has settled and has to be re-laid shall be as follows:

- i. The settled/ leaking pipeline length shall be removed and the pipe joints cleaned of cement mortar. Badly damaged pipes shall be discarded and replaced with new.
- ii. The trench shall be dewatered of any standing water, and over excavated to remove soft clay/ plastic material. Sand/ gravel bedding shall be placed to the required pipe grade and to prevent future settlement and opening out of joints.

Bedding for New / Re-laid Concrete Pipes

Internal Diameter		
(mm)	Pipe wall thickness	
(mm)	Joint Type	Bedding
300	50	Butt
(Plain)	Sand / gravel bedding 100 mm thick	
350		
400		
450		
500	Sand / gravel bedding 150 mm thick.	
550	75	
600		
650	Spigot & Socket	
700		
750	100	
800		
850		
900 or greater		

Pipe joints shall be sealed using cement mortar solutions (Option A) or using a sealant (Option B), as shown on the drawings or directed by the Engineer in Charge.

(a) Joint Sealing with Cement Mortar - Option A

Smaller pipes are likely near the end of the pipeline under lower pressures, typically 1-4 m, and these are likely to comprise plain-ended pipes with butt joints. For butt joints the following procedure shall be adopted:

- i. 1:1 cement mortar to be placed in any gap between adjacent pipes.
- ii. A jute / hessian 150 mm wide bandage impregnated with cement slurry shall be wound around the joint.
- iii. 1:2 cement mortar outer surround to be placed over bandage.
- iv. Concrete 1:2:3 to be placed under and around joint as directed.

Larger pipes are likely near the beginning of the pipeline and may be under greater pressures, typically 3-6 m. These pipes shall comprise spigot and socket pipes for which the following procedure shall be adopted:

- i. If shown on the drawings or ordered by the Engineer-in-Charge reinforced concrete plinths shall be cast for each joint to help prevent movement of the pipes. These plinths shall be cast at least 24 hours before pipe laying.
- ii. For pipes to be connected, 1:2 cement mortar shall be placed in the socket and over the top of the adjacent pipe spigot, and the spigot inserted squeezing out excess mortar.
- iii. After connecting two adjacent pipes, the pipe joint shall be further packed with cement soaked jute rope.
- iv. Concrete 1:2:3 shall be placed under and around joint.

Appropriate lifting equipment shall be used to move the pipes and then hold the pipes securely in position during jointing and until the cement – mortared joints have set.

(b) Joint Sealing with Flexible Sealant - Option B

In soft ground conditions where minor pipe movement may occur after laying, a joint sealer should be used that can accommodate some movement. In these situations the gap between adjacent pipes should be sealed using an approved flexible sealer with good adhesion to concrete, such as Butyl Mastic, or a 2-part Polysulphide sealant. A primer may be required. The sealant and primer shall be applied as per the manufacturer's instructions. The sealant shall be squeezed between adjacent pipes or placed from the inside. Cement mortar and concrete shall be placed under and around the outside of the pipe as detailed above.

4.3.3 Repair of Existing Reinforced Concrete Pipelines

The procedure to identify and repair leaks in existing buried reinforced concrete pipelines shall be as follows:

- i. To locate leaks the outlet alfalfa valves shall be closed except for those at or near the end of the pipelines and one or more pumps shall be used to fill the concrete pipelines.
- ii. The leaks shall be marked using marker flags, and then the pumps shall be switched off and the pipeline drained.
- iii. Inspection of leaks in the larger (750 mm or more) pipelines may be carried out in-situ with access by removal of pipes at intervals of about 50 m and/ or by digging to expose the pipe wherever significant leaks were observed. Internal inspection is particularly recommended where numerous small leaks are observed.
- iv. Where pipe subsidence is observed and cracks are large, the pipes are to be removed and re-laid as described in Section 4.3.2 above.

- v. Where leaks are minor, subsidence is not severe and cracks not large, repair may be carried out in-situ working from inside the pipe for larger (700 mm diameter or more) pipes, and from outside for smaller pipes.
- vi. In firm soils where pipe settlement and significant joint movement is not observed, rigid cement/ mortar joint sealing methods shall be used. Otherwise an approved flexible joint sealer shall be used.

The procedure to seal leaks in existing pipes without removal and relaying of the pipe is described in the table below.

Joint Sealing of Leaks in Existing Pipes without Removal

Internal Diameter

(mm) Pipe wall thickness

(mm) Joint Type Joint Sealing

300 50 Butt (Plain) For small pipes repair can only be done from the outside.

Remove material to expose leak. Repair using cement soaked jute rope squeezed into the crack with a cement slurry jute / hessian sacking bandage wrapped around the joint. Bandage to be covered with 1:2 mortar outer surround. Concrete 1:2:4 may be placed under and around joint after repair as directed. After 7 days (min) test for any leakage before backfilling.

350

400

450

500

550 75

600

650 Spigot & Socket

700

750 100 For larger pipes repair from inside by first cleaning out the joint to remove any loose material and to form a joint at least 15 mm deep and 5 mm wide. Then: (i) Option A: Pack the joint with cement soaked jute rope and smooth over with 1:2 cement mortar. Alternatively (ii) Option B fill the joint with an approved flexible sealer with good adhesion to concrete, such as Butyl Mastic, or a 2-part polysulphide sealant. A primer may be required.

800

850

900 or greater

4.4 Pipeline Testing and Commissioning

The pipeline shall be tested for leakage and to ensure that design flows are supplied to all outlets along the pipeline before final backfilling. As part of the commissioning process, in addition to checking of flows at each outlet, water levels in the standpipes shall be measured and adequacy of freeboard confirmed at the design flows.

The reasons for any instances of inadequate freeboard shall be reported to the concerned authorities and the cause determined, such as foreign material left in the pipeline, inaccurate measurement of pipe length, wrong pipe diameter used and so on. Following identification of the causes remedial measures/ actions shall be taken as ordered by the Engineer-in-Charge.

If for reasons of safety and / or cropping necessity, (parts) of the pipeline are fully backfilled prior to testing and system commissioning then the Contractor shall re-excavate selected parts of the pipeline, and any areas where surface wetness is observed, to expose the joints and check for any leakage as ordered by the Engineer-in-Charge.

Any leaks or damaged pipes / pipe seals shall be repaired and the pipeline retested.

4.5 Conveyance System Associated Structures

Works for pipeline system structures such as the header tank, control structures, riser outlets, standpipe air-vents, standpipe escapes and washouts comprise earthworks, concrete, brick masonry works and so on and are covered in Section 3.

4.6 Pump House and Pumping Platforms

Pump house and/ or one more pumping platforms shall be constructed at the pumping location as shown on the drawings and ordered by the Engineer-in-Charge.

The pump house may be designed for permanent housing of the pumps and associated pipework and fixtures, in which case it shall be sized accordingly and the floor of the pump station selected so that pump suction head is not more than 5 m or as shown on the drawings. The pump house shall generally comprise plastered brick masonry walls, reinforced concrete floor and steel sheet roofing.

Where the pump house cannot be located so that suction head is within acceptable limits, then it may be designed to store pumping equipment and to mount electrical installations as required. In this case one or more pumping platforms may be provided closer to the water source for safe mounting of the pumps during the irrigation season.

Access steps shall be provided to the pumping platform(s) as shown on the Drawing or directed by the Engineer-in-Charge. Typically they will comprise reinforced concrete walkway supported on concrete or steel-sheet piles, possibly with bank protection.

Materials and workmanship for pump houses and pumping platforms shall confirm with the relevant parts of this Specification.

4.7 Pumping Plant, Pipework and Electrical Connection

4.7.1 General

This section provides a general description of the: (i) Pumping plant; (ii) Pipework and associated fittings; and (iii) Electric power connection that may be provided to CAD subprojects. All such works are to be done in accordance with the drawings and as per the guidelines and instruction of the manufacturer/ supplier.

The exact number and model of pumps, diesel engines / electric motors, and associated steel pipe work, valves and fittings to be provided shall be as detailed in the Bills of Quantities. However to allow for varying irrigation demand at least two pump sets shall be provided, and generally 3-6 depending on scheme size.

4.7.2 Pumping Plant

Pumping plant comprises the pumps themselves together with diesel engine or electric motor usually all mounted on a steel skid frame.

(a) Pumps

The peak efficiency for any pump occurs for a certain single head and discharge and efficiency falls off rapidly if the pump is required to pump at different heads. Pumps selected shall operate at efficiencies of 70-83% under site conditions.

Details of the range of pumps that would meet operating requirements for LGED CAD subprojects are tabulated below .

Pump Model and Operating Head

(b) Power Requirements

For the range of pumps tabulated above the pumping power requirements for the most efficient operating points (about 80% efficiency) are given below.

Pump Model, Most Efficient Operating Point and Power Required

(c) Diesel Motors

For a diesel motor (engine), its Break Horse Power, BHP (power output) must at least equal the power required by the pump. In practice the following considerations are taken into account:

- i. Fuel efficiency – engine fuel efficiency drops when operated at maximum power and speed (rpm), and also a very low power and speed, with optimum fuel efficiency occurring at medium power and speed. The pump curves given above are for an operating speed of 1450 – 1500 rpm. Typically diesel engines may operate at speeds from 1000 to 2400 rpm, and a speed of about 1500 is likely give maximum fuel efficiency. Therefore if the pump power requirement is calculated to be 26 HP, then adopting a diesel engine with a 10-20% higher power output, ie about 30 BHP, is likely enable high fuel efficiency.
- ii. Service life: engines for pumping water are likely to be operated continuously for long periods, and service life is increased by operating them at about 80% peak power and speeds.
- iii. As a rule of thumb, the power delivered by the engine, its break horse power, BHP, should be 10-20% higher than the pumping power requirement. Adopting 15% gives diesel engine BHP requirements for the range of pumps being considered, see below.

Diesel Engine Output Power Requirements

The energy efficiency of internal combustion engines is typically 15-35%, as most of the energy of the fuel is wasted as heat.

The diesel engine of the required rated power shall be provided complete with a self-starter and battery, all mounted on a steel Base-frame. The base-frame shall have lug-holes to allow for bolting to a concrete plinth. The pump set and steel frame shall be painted with anti-corrosion paint.

(d) Electric Motors

While the power of diesel engines usually refers to their output power, the power for an electric motor typically refers to its rated input power, which is the power it can safely take without burn-out.

The rated input power for an electric motor is typically given by:

$$\text{Pumping power requirement} / \text{motor efficiency}$$

The efficiency of electric motors is typically 75-80%, much higher than for internal combustion engines. Most of the wasted energy is in the form of heat.

The motor power ratings required for the range of pumps considered is tabulated below for 80% motor efficiencies.

Electric Motor Input Power Requirements

The electric motors shall have the following: (i) AC 3-phase, 50 Hz, 380 +5% Voltage squirrel cage; (ii) Starter enclosed within metal box and ensuring adequate protection to motor against overload and with 3-phase volt and amp meter and neon indicators; (iii) Capacitor Bank to keep power factor on 0.95 and installed inside Starter Box; and (iv) a steel Base-frame which shall have lug-holes to allow for bolting to a concrete plinth. The pump set and steel frame shall be painted with anti-corrosion paint.

Each motor shall have a Switch Fuse Unit with indicator lamp (see below).

4.7.3 Pipework, Control Valves and Associated Fittings

Mild steel galvanized / painted steel suction and delivery pipes shall be provide for each of the pumps sets (pump & motor) provided by LGED/ Project complete with bolted flange/ welded connections, bends and arrangement to facilitate pump priming. The pipelines shall be of sufficient length to allow water to be pumped during the lean season from the river / khal to the header tank / discharge box. The diameter of the steel pipes shall not be less than the pump size.

Unless otherwise directed by the Engineer-in-Charge gate (sluice) valves shall be provided in each of the delivery pipelines leading from the pump to the header tank. These shall be fixed with bolted flange connections to allow for replacement as necessary.

Mild steel perforated foot valves shall be galvanized or painted with anticorrosion paint and shall be fitted to the end of the suction pipes.

4.7.4 Electric Power Connection

If electric power lines, typically 11 kV, with sufficient capacity are located near to the pumping point then electric pumps may be adopted, otherwise diesel.

Electric power supply, connection and associated equipment and fittings shall be provided as advised by the concerned authority, the Rural Electricity Board (REB) or the Power Development Board (PDB).

Where electric pumps are adopted a complete electrical installation shall be provided for operation of the pumping plant. This shall include the following:

- Transformer(s); Lightning Arrestors; Dropout fuse cut-off; Earthing wire; PFC/ PFI, all mounted on standard approved electric company poles located near to the pumping location; and
- Energy meter; main switch; distribution board/ box with switches for all pumps/ circuits and with mini-current circuit breakers, all mounted to the wall of the pump house or where directed by the Engineer-in-Charge.
- Overhead electric cable power connection complete with supporting poles.

Since night time operation is envisaged 65 Watt tubular fluorescent lights or similar approved shall be provided to the pump house as shown in the drawings or directed by the Engineer-in-Charge.

The electrical equipment shall conform to the standards of the competent authority, REB or PDB, and have water proofed construction and protective covers. For each installation: (i) the REB will usually require 3 No single phase transformers hung from a single pole which together provide 11/0.41 kV; while (ii) the PD will usually require a single 3-phase transformer supported on a platform between two adjacent poles to provide 11/0.41 kV.

All cables shall be adequately supported and present a neat appearance. Cables shall be fixed using proper cable cleats or saddles.

The Contractor shall test and commission the electrical equipment along with the pumping plant whether sourced under this contract or some other arrangement all in accordance with requirements of the Power Development Board and as directed by the Engineer-in-Charge.

PART 5: SMALL BUILDINGS (CI Sheet Roofing)

5.1 Description

The works in this section are for small buildings that may be required at subprojects, including WMCA office and pump house buildings.

WMCA office works include: (i) the office with adjacent twin toilets; (ii) rainwater water harvesting to the tank on the toilet building; (iii) electrification works; and (iv) basic office furniture. Ancillary works such as: (i) tubewell, hand pump and plinth; (ii) site fill and access arrangements (culvert crossing and so on); and (iii) fencing shall be provided as required for each site, included in the BoQs or directed by the Engineer-in-Charge.

The orientation and exact layout of each WMCA office shall be prepared and approved after receipt of a copy of the registered deed of land in favour of the WMCA. The required office floor level and exact fill amount for each site will be determined at this time.

5.2 Materials

5.2.1 Earthwork, Brick Masonry and Concrete Work

Earthwork, brick masonry and concrete materials and workmanship shall be in accordance with the relevant sections of these Specifications in Section 2 and 3.

5.2.2 Structural Steel

All steels used in doors, windows, roof trusses and security grills shall be shall conform to the American or British Standard Specifications. The sections, sizes and profiles shall be as per the requirements for a specific work as shown on the Drawings. Mild steel with a yield strength of not less than 250 MPa (N/mm²) shall be used unless otherwise shown or directed by the Engineer.

5.2.3 Timber

All timbers for temporary or permanent works shall be of best quality, sound, straight and well seasoned. They shall be free from sap, defects, radial cracks, cup-shakes, large/loose/dead knots, or other imperfections and shall show a clean surface with cut.

Timber shall be stored in stacks at least 200mm above the ground level.

The stacks of the timbers shall be protected from hot dry wind, direct sun and rain. Weights may be placed on top of the stacks to prevent wrapping of timber. Nails, metal straps, etc. attached to used timber shall be removed before stacking.

All timbers shall be subject to inspection at Site piece by piece and shall be to the approval of the Engineer who may reject such timber as is considered by him to be under-specified.

All joiner's works shall be wrought and finished with a clean, even and smooth face. Thickness shall be given to include 2mm for each wrought face in soft- wood and 1.5mm for hard wood.

5.2.4 Glass

All glass shall be obtained from an approved manufacturer and be free from blemishes of all kinds and descriptions, whether surface or internal.

Flat glass shall be provided where specified or directed in the following grades:

- 24 oz. flat drawn clear sheet glass.
- 32 oz. clear sheet glass.
- 6mm thick 'Georgian' rough cast wired glass.
- 6mm thick polished glass.

All glass sheets shall be kept dry and stored in a covered place. Glass sheets shall be lifted and stored upright on their long edges. They shall be supported at two points at about 300mm from each end by fillets of wood.

Workmen handling glass sheets, remnants and waste glass pieces and fibre-glass shall be provided with gloves, jelly and other suitable hand protections.

5.2.5 Pipes

(a) M.S. pipe

M.S. Pipe shall be made from low carbon steel conforming to the requirements of ASTM A-53 and physical requirements as specified therein.

(b) uPVC pipe

The base material from which the uPVC pipes are produced shall be un-plasticised Polyvinyl Chloride (PVC"u") with additives as necessary for manufacture in accordance with ISO 4065: 1996(E).

All fittings having sockets shall comply with ISO 727-1985 and shall be compatible with the pipes supplied.

When viewed without magnification the internal and external surfaces of the pipes and fittings shall be smooth, clean and free from scoring, cavities and other surface defects. The material shall not contain visible impurities. The ends of the pipes and fittings shall be clean and square to their axes.

(c) Storage and handling of pipe

All pipes and pipe fittings received on Site shall be visually inspected for damage which may have occurred during transit. Any damaged pipes and fittings should be returned to the place of manufacture / procurement and will not be accepted in the permanent works.

Pipes shall be stored in stacks with stoppers provided at the bottom layer to keep the pipe stack stable. The stack, particularly of smaller diameter pipes, shall be in a pyramid shape. Pipes shall not be stacked more than 1.5m height.

PVC pipes shall be stored in a shaded area.

5.2.6 Gunny bags

Gunny bags used in the permanent works shall be new, 50/75 kg capacity bags similar to those normally used. The Contractor shall submit sample bags to the Engineer for his approval.

5.2.7 Paints and protective materials

(a) White lead paint

White lead paint shall be made from pure white lead in accordance with BS 239, mixed with fine boiled linseed oil, turpentine, dryers and pigments and strained free from skins and all extraneous matter before being pigments. If so used, the quantity shall not exceed 8% of the paint mixed ready for the brush. No other ingredient except the colouring matter will be allowed and the colour shall be produced by using the least required amount of colouring matter. The proportions of the ingredients for the various coats shall be subject to the approval of the Engineer.

(b) Red lead paint

Red lead paint shall be made from non-setting red lead in accordance with BS 217, thoroughly ground and well and freely mixed with approximately 15% of boiled linseed oil to give a paint with good covering power, bobby and adhesion. It shall be determined by tests to be made by the Contractor to the satisfaction of the Engineer. The Engineer may select samples of the paint for analysis after a sufficient quantity of the work about to be painted has been mixed.

(c) Linseed oil putty

Putty for stopping and glazing shall consist of whiting/chalk powder thoroughly ground with linseed oil to form a smooth paste, and shall conform BS 544.

(d) Varnishes/wood polish

The material is required to be clear and transparent and when applied shall on drying, give a glossy coating free from fun and specks. The composition of the varnish shall conform to the requirements of BS 274.

(e) White wash

White wash shall be made from pure flat lime brought to the work in an unslaked condition. Water shall be added to this lime in a tub until the mixture is of the consistency of cream and shall be allowed to rest for a period of 48 hours. The mixture shall then be strained through an approved cloth strainer and 4 kg of gum boiled with 12 kg of rice and a suitable quantity of blue shall be added per cubic meter of the mixture.

(f) Colour wash

Colour wash, where not of an approved proprietary brand, shall be made from pure selected fat lime as described above for white wash, to which shall be added and intimately mixed the necessary pigment to produce the tint specified. The pigment shall be to the approval of the Engineer.

(g) Oil bound distemper

Oil bound distemper shall comply with BS 1053 Type-1 and shall be obtained from an approved manufacturer.

(h) Emulsion paints

Robbialac/ Berger/ Elite Emulsion Paints shall preferably be used but the Engineer may allow any other brands of equivalent standard subject to the production of appropriate test certificates and guarantees.

(i) Creosote

The Creosote is a paint used for preservation of timber. It shall be pure tar distillate of the best quality as obtained and sold under the trade name "SOLIGNUM". The 'SOLIGNUM' shall be clear so as not to mar the timber. Other brands equivalent to 'SOLIGNUM' may also be used, if only approved by the Engineer.

(j) Storage and handling of paint, varnishes, etc.

Paints, varnishes, lacquers and thinners shall be kept in properly sealed or closed containers. The containers shall be kept in a well ventilated location, free from excessive heat, smoke, sparks or flames. The floor of the paint store shall have at least 100 mm thick loose sand on it.

Temporary electrical wiring and fittings shall not be installed in a paint store. When electrical lights, switches or electrical equipment are necessary to be stored or used in the same room, the room shall be designed in a way to reduce explosion risks.

Buckets containing sand shall be kept ready for use. A five-kilogram dry powder fire extinguisher conforming to accepted standards shall be kept at an easily accessible position close to the paint store.

5.3 Pointing, Plastering and Tiling

Brick masonry surfaces shall be finished by "Jointing" or "Pointing" or "Plastering". A plaster finish may also be given to concrete only as directed / approved by the Engineer.

5.3.1 Jointing and pointing brick masonry

In general brick masonry surfaces which shall remain exposed shall be pointed or plastered and those which shall be buried underground shall be jointed.

In jointing, the face joints of the mortar shall be worked out while still green to give a finished surface flushed with the face of the brick masonry works. The faces of brick masonry works shall be cleaned to remove any splash of mortar during the course of raising the brick masonry.

For pointing, the joints shall be squarely raked out to a depth of 15mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be

thoroughly washed with water, cleaned and wetted. The mortar shall be filled and pressed into the raked out joints before giving the required finish.

If the type of pointing is not mentioned on the Drawings or BOQ, flush pointing shall be used unless otherwise directed by the Engineer.

For groove pointing, after the mortar has been filled and pressed into the joints and finished with the edges of the bricks, it shall be grooved along the centre with a half round tool of such width as may be specified by the Engineer. Such works shall only be carried out within the period that the mortar remains green. The excess mortar shall then be cut off from the edges of the lines and the surfaces of the masonry shall also be cleaned of all mortar.

5.3.2 12mm thick cement - sand plaster on brick masonry wall

(a) Description

This item of work shall consist of making 12mm thick cement plaster on brick masonry wall surfaces and at any other appropriate locations in cement mortar.

(b) Materials

Cement used in the works shall be ordinary Portland cement.

Sand used for plastering work will normally have a Fineness Modulus (F.M.) of 1.2 or as directed by the Engineer, and a specific gravity of not less than 2.6.

(c) Construction methods

(i) Preparation of mortar

Cement mortar for plaster works on brick masonry walls shall consist by volume of one part Ordinary Portland cement and four or six parts screened sand as directed by the Engineer or detailed on the drawings of bills of quantities. Requisite quantity of water shall be added and the components mixed and thoroughly incorporated together to give a workability, appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding mixing water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform. Cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture. Water shall then be added sparingly, only to the minimum as would be necessary to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after water is added. The adding of additional water to and re-tempering (cement mortar that stiffened because of evaporation of water), shall be permitted only within 30 minutes from the time of adding water at the time of initial mixing.

Mortar that has taken initial set shall not be used in the work with or without addition of fresh materials.

(ii) Preparation of surface

Before application of plaster, all joints in brick masonry walls shall be adequately raked out whilst the mortar is still green and not later than 48 hours after the time of laying. The brickwork should be brushed down with stiff wire brush so as to remove all loose dust from the joints. Surfaces to be rendered shall also be scrubbed clean of all loose materials and be made free from all dust, grease, etc. and be well wetted with water and kept dampen for 24 hours before applying plaster (the walls should not be soaked but only damped evenly).

(iii) Application of plaster

Plaster shall consist of two coats when applied over brick masonry i.e. under and finish. The under and finish coats shall be applied without an interval.

The undercoat shall have a minimum thickness of 6mm and shall be levelled with straight edge and scratched for key. The finish coat shall be trowelled over with care and levelled with a straight edge to obtain a flat smooth surface. All edges and corners, unless otherwise shown on the Drawings, shall be rounded or chamfered as directed by the Engineer. All moulds shall be neat, clean and true to template.

Plaster shall be floated and trowelled to a true and plumb surface and tested frequently during the progress of the work with a straight edge sufficiently long. There shall be no overlaps or construction joints in single unbroken surface unless the area is over 28 square meters or prior permission is taken from the Engineer for a deviation. Plaster shall be stopped only at corners, construction or expansion joints.

If any crack appears in the plaster or any part sound hollow when tapped, or found to be soft or otherwise defective after the plaster has dried, the defects shall be mended by cutting out and re-plastering at the Contractor's own cost. Such works should not leave any visible impression on the places mended.

The methods and equipment used for transporting and placing mortar shall be such, as not to damage or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar shall be kept clean and free from set mortar, dirt or other deleterious foreign substances.

The plaster shall not be applied during rain sufficiently heavy or prolonged to wash the mortar. Mortar already applied, but becomes diluted by rain, shall be removed and replaced at the expenses of the Contractor before continuing any further works.

(d) Protection and curing

All plasters shall be kept moist throughout the progress of work and protected for a minimum 10 days immediately following completion against harmful effects of weather by suitable covering. During hot weather, all finished or partly completed works shall be covered or wetted in such a manner as will prevent rapid drying of the plaster.

On completion of works, all visible surfaces shall be free from damage or debris and shall look clean. All cares shall be taken so that the plaster surfaces are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

(e) Measurement and payment

The amount of completed and accepted work shall be measured and paid at the contract unit price per square meter of plaster which price shall include for furnishing all materials including their transportation and storage, mixing of mortar, plastering surfaces and corners, rounding and/or chamfering preparing, cleaning and watering the surfaces to be plastered, watering and protecting the plaster after completion, providing scaffolding and its erection and removal, all other works and all incidentals necessary to complete the Work.

5.3.3 6 mm thick cement - sand plaster on R.C.C surfaces

(a) Description

This item of work shall consist of making 6mm thick cement plaster on R.C.C surfaces and at any other appropriate locations in cement mortar.

(b) Materials

Cement used in the works shall be ordinary Portland cement.

Sand used for plastering work will normally have a Fineness Modulus (F.M.) of 1.2 or as directed by the Engineer, and a specific gravity of not less than 2.6.

(c) Construction methods

(i) Preparation of mortar

Cement mortar for plaster works on brick masonry walls shall consist by volume of one part Ordinary Portland cement and two, three or four parts screened sand as directed by the Engineer or detailed on the drawings or bills of quantities. Requisite quantity of water shall be added and the components mixed and thoroughly incorporated together to give a workability appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tempering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding mixing water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform, Cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture. Water shall then be added sparingly, only the minimum necessary to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after water is added. The adding of additional water to and re-tempering shall be permitted only within 30 minutes from the time of adding water at the time of initial mixing.

Mortar that has taken initial set shall not be used in the work with or without addition of fresh materials.

(ii) Preparation of surface

Before application of plaster, smooth concrete surfaces shall be roughened to provide key. The surfaces shall be scrubbed clean of all loose materials and soaked with water and kept dampen for 2 hours before plastering. A neat cement coat shall be applied on all concrete surfaces before application of plaster.

(iii) Application of plaster

Plaster shall consist of a grout application and a finish coat, when applied direct to concrete surface. The grout application and finish coat shall be applied without an interval.

All edges and corners, unless otherwise shown on the Plans, shall be rounded or chamfered as directed by the Engineer. All moulds shall be neat, clean and true to template.

Plaster shall be floated and trowelled to a true surface and tested frequently during the progress of the work with a straight edge sufficiently long. There shall be no overlaps or construction joints in single unbroken surface unless the area is over 28 square meters or prior permission is taken from the Engineer for a deviation. Plaster shall be stopped only at corners, construction or expansion joints.

If any crack appears in the plaster or any part sound hollow when tapped or found to be soft or otherwise defective after the plaster has dried, the defect shall be mended by cutting out and re-plastering at the Contractor's own costs.

The methods and equipment used for transporting and placing mortar shall be such, as not to damage or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar shall be kept clean and free from set mortar, dirt or other deleterious foreign substances.

The plaster shall not be applied during rain sufficiently heavy or prolonged to wash the mortar when the works are carried out under open sky. Mortar already applied, but which becomes diluted by rain, shall be removed and replaced before continuing the work at the expenses of the Contractor.

(d) Protection and curing

All plaster shall be kept moist throughout the progress of work and protected for a minimum 10 days immediately following completion against harmful effects of weather by suitable covering when the location is exposed under the open sky. During hot weather, all finished or partly completed works shall be covered or wetted in such a manner as will prevent rapid drying of the plaster.

On completion of works, all visible surfaces shall be free from damage or debris and shall look clean. All cares shall be taken that the plaster surfaces are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

(e) Measurement and payment

The amount of completed and accepted work shall be measured and paid at the contract unit price per square meter of plaster which price shall include for furnishing all materials including their transportation and storage, mixing of mortar, plastering surfaces and corners, rounding and/or chamfering preparing, cleaning and watering the surfaces to be plastered, watering and protecting the plaster after completion, providing scaffolding and its erection and removal, all other works and all incidentals necessary to complete the Work.

5.3.4 Glazed wall tiles

(a) Description

Works covered under this item shall consist of supplying, fitting and fixing approved glazed ceramic tiles laid on walls or any other places.

(b) Materials

Glazed ceramic tiles, unless otherwise specified, shall be of the standard size of 150mm x 150mm x 6mm or as approved by the Engineer, white or coloured, free from blemishes and dimensional defects and conforming to the standards of Federal Specification SS-T-308p.

Mortar for installation shall consist of 1 part cement and 3 parts sand (FM 1.2). Cement used in the works shall be ordinary Portland cement. Sand will normally have a Fineness Modulus (F.M.) of 1.2 or as directed by the Engineer, and a specific gravity of not less than 2.6.

All grout for tile joints shall be prepared with white cement, coloured cement and with inert pigments as specified / directed by the Engineer.

(c) Construction methods

The Contractor shall submit three sets of samples of all types of tiles to the Engineer for his approval before procuring the materials.

The tiles are to be fitted and fixed on wall on a base of 20mm thick cement mortar prepared with 1 part ordinary Portland cement and 3 parts sand of FM 1.2. The mortar bed shall be cut through horizontally and vertically every 425mm to 600mm.

If the surface needs levelling, a scratch coat of plaster shall be applied, levelled and scratched for key and be allowed to dry out for 12 hours before installing tiles.

The setting mortar shall be applied evenly and a neat cement paste to a thickness of about 2mm shall be trowelled to the back of the tiles and the tiles to be set firmly tapped into place to ensure full contact. The joints shall be in required pattern and shall not exceed 2mm in width.

The tiles shall be soaked in water for at least 6 hours before setting. Installation shall be controlled by strings, pages, spacers, levels or other suitable methods that will ensure correct layout and uniform leveled joints.

The joints shall be grouted with white cement, cleaned and damp-cured for at least 3 days.

(d) Measurement and payment

The amount of completed and accepted work shall be measured and paid at the contract unit price per square meter of tiled surface which price shall include for furnishing all materials, equipment and labour, including transport, storage and handling of materials, cleaning, preparing and laying bed and cutting and laying the tiles, grouting, curing and all other works and all incidentals as would be necessary to fully complete.

5.4 Metal Work

5.4.1 Description

Metal works includes the furnishing and installing of all structural steel for roof structure, security grills, doors and window, the galvanized roofing sheets and miscellaneous metal work such as anchors, bolts and fastenings.

5.4.2 Materials

All materials shall be of new stock and of the best commercial quality for the indicated purpose.

Manufactured steel sections will be accepted where such is the obvious intent of the Drawings.

All anchor bolts and other parts required for securing each item of work to the construction shall be new.

Steel materials: all structural and miscellaneous steel members and components shall comprise standard structural sections, shapes and plates, as indicated on the Drawings. Mild steel grade 250 shall be used unless otherwise shown or directed by the Engineer.

Steel bars shall be made from billet steel and shall conform to ASTM A-616 or approved equivalent.

5.4.3 Fabrication - welding

(a) General

Welders shall be experienced in the type of welding work to be performed. If at any time the welder's performance quality is found not satisfactory, as determined by the Engineer, the welder shall be replaced.

(b) Forms of welding

The principal forms of welding metals are as follows:

- Electric arc welding
- Gas welding

The electric arc welding process is the most important and is most extensively used for mild steels ranging from light articles with a wall or thickness of 16 gauge to heavy fabrications. This is a process whereby the metal of the two members to be welded is fused together through hit generated by an electric arc. Fusion should be complete over the whole area of the joint surface.

Gas welding is done using oxy-acetylene flame and is not adapted to structural steel works, but is generally used for small jobs. The flame produced by burning oxy-acetylene is fed through a blowpipe, which is ignited at its tip. The flame is played on the two pieces to be welded until the metal becomes hot enough to fuse together adding additional metal to the joint as necessary by melting in to it a suitable electrode.

Unless otherwise specified, all welding shall be performed following the Shielded Metal Arc Process with low hydrogen electrodes for manual welding.

(c) Workmanship and visual quality requirements

Each weld shall be uniform in width and size throughout its full length and each layer of welding shall be smooth, free of slag, cracks, pinholes and undercut and shall be completely fused to the adjacent weld beads and base metal. In addition, the cover pass shall be free of coarse ripples, irregular surface, non-uniform bead pattern, high crown, deep ridges or valleys between beads and shall blend smoothly and gradually into the surface of the base metal.

Butt Welds shall be slightly convex, of uniform height and shall have full penetration.

Fillet Welds shall be of specified size with full throat and with each leg of uniform length.

Repair, chipping or grinding of welds shall be done in such a manner as not to gouge, groove, or reduce the base metal thickness.

(d) Welding repairs

All weld defects which are determined unacceptable, shall be removed by chipping, grinding, arc or flame gouging. All repairing shall be done by and at the expenses of the Contractor.

(e) Electrodes

All electrodes shall be purchased in sealed containers and shall be thoroughly dry when used. Electrodes with wet or damaged coatings shall not be used.

The maximum diameter of electrodes for welding area shown in the following table:

Average thickness of plate or section	Maximum gauge or diameter of electrode to be used

Less than 5mm	3.2mm – 10 SWG
5mm to less than 8mm	4mm – 8 SWG
8mm to less than 10mm	5mm – 6 SWG
10mm to less than 16mm	6mm – 4 SWG
16mm to less than 25mm	9mm
25mm and over	9mm

The maximum width of any bead of welding, other than a cover pass, shall not exceed 3 times the diameter of the electrode being used.

(f) Cutting and edge preparation

Members of structural steel and miscellaneous metal works, which are to be joined by welding shall be cut accurately to size. The edges of these members shall be sheared, flame-cut, machined and ground as required to suit the required type of welding and to allow thorough (full) penetration of the weld.

The prepared surfaces shall expose sound metal, free from laminations, surface defects, rust, grease, paint and other foreign matter.

(g) Welding construction

Methods which are essentially required to be followed while welding are as follows:

- Welds should be made in the flat position as far as practicable.
- Freedom of movement of one member should be allowed as far as possible.
- The work should be securely held in position by means of spot welds, service bolts, clamps or jigs before commencing welding so as to prevent any relative movement due to distortion, wind or other causes.
- The parts to be welded must be thoroughly cleaned and proper flux used. Any paint or rust and loose mill scales, etc. should be removed from the surfaces to be welded and surrounding materials for a distance of at least 12mm from the weld. A coating of boiled linseed oil may be permitted.

(h) Defects in welded joints

The usual defects in welded joints are:

- Lack of penetration or fusion of the metal to the bottom of the joint or welded members.
- Laps in the metal of the weld not properly fused together.

Defects are most likely to occur at the root of the weld and in this position they are liable to have the maximum effects in reducing the strength of the weld.

(i) Inspection and testing of welds

The metal in a good weld when cold should show its original colour. If the metal has a rusty or dull red colour or appears crystallized, it is an indication that the heat has become too high and the metal has been burnt. A good weld will show an evenness of ripples or waves and well formed beads with good

fusion along the edges of the welds. There should be no unfilled cavities, small pockets of slags or burnt metal and small air or gas pockets.

A visual inspection of welds shall be carried out. The following defects are unacceptable:

- Dimensional defects such as insufficient throat or leg length, excess convexity, excess or insufficient reinforcement.
- Undercuts, overlap, blowholes, slag inclusion, seams and excess weave.
- Any crack or liner indication.

5.4.4 Installation

(a) General

Installation of metal works and metal fabrication shall be in accordance with the Drawings and any approved Shop Drawings, true and horizontal and perpendicular, as the case may be, plumb, level and square, with angles and edges parallel with related lines of the work.

(b) Anchors, bolts, studs and fasteners

All anchors, bolts and washers, inserts etc. as required for the installation and completion of the work shall be provided at the time schedule for the concrete work. Bolts and anchors shall be present by the use of templates or such other methods as may be required to locate the anchors and anchor bolts accurately.

(c) Base and bearing plates

Bases and plates where shown in the Drawings, shall be set accurately using a high strength, non-shrink grouting mortar to obtain uniform bearing. Grouting mortar shall be mixed and installed in accordance with the manufacturer's specifications and instructions. Surfaces to receive the grout shall be cleaned and moistened thoroughly immediately before the grout is placed. Exposed surfaces of grout shall be water-cured with wet burlap for 7 days.

(d) Doors, windows and metal security grills

Doors, window units and metal security grilles gates shall be properly and correctly installed by expert persons with all hardware and accessories furnished and installed as shown on the Drawings and as required for complete and finished installations. Doors, windows and security grills shall operate freely, properly and smoothly at completion.

Doors, windows and security grills shall be fabricated from mild steel standard size sections, except that door frames (Chowkat) shall comprise timber protected by 18BWG (1.257mm thick) galvanized steel sheet.

5.4.5 Steel sheet roofing

Galvanized corrugated steel sheet roofing shall be new sheets of galvanized iron corrugated sheets 0.46 mm thick unless otherwise shown on the Drawings, bills of quantities or directed by the Engineer. The roofing sheets shall be firmly secured to the purlins or side rails, and be complete with ridge pieces, stop ends, cappings and flashing. The lap between sheets shall be 300 mm or as directed by the Engineer.

Fixing to steel purlins or side rails shall be with galvanized J-hook or U-bolts and nuts with galvanized and suitable resilient washers.

If shown on the drawings and / or as directed by the Engineer a best quality bambu Tarja matting shall be fixed under the galvanized iron sheets.

All the above shall be in accordance with the manufacturers and Engineers instructions and the following British Standard and B.S. Code of Practice or equivalent:

- B.S. 3083 "Hot dip zinc coated corrugated steel sheets for general purposes".
- C.P. 143 Pt 10 "Galvanized Corrugated Steel Sheet".

5.4.6 Painting of metal work

All works shall conform to the details of the Drawings and except for galvanized metal shall be protected with one prime coat of red lead oxide paint and two coats of a synthetic exterior enamel finishing paint for metal as manufactured by "Berger" or approved equivalent.

Both the anti-rust prime coat and the finishing enamel coats shall be approved by the Engineer.

Before applying the anti-rust prime coat, all rusts, loose milled scales, dirt, welding flux, spatter and other foreign materials shall be removed with wire brushes or steel scrapers. All grease and oil shall be removed by solvent recommended by paint manufacturer. Surfaces shall be dry when painted.

Prime coat shall be thoroughly and evenly applied and shall be well worked in to corners and joints taking care to avoid sags and runs. Bolts, which are to remain permanently in the work, shall be dipped in paint to cover the entire bolt.

Prime coat shall be omitted from surfaces to be embedded in concrete or masonry. Prime coat shall also be omitted from surfaces to be welded in the field, except where the primer used can be conclusively shown to have no adverse effect on the weld.

After installation of steel works and metal fabrication, abraded areas, field areas, field bolts and welds to be touched up and spot shall be painted with the same type of corrosion inhibitor primers as were used for shop painting. Field welds shall be thoroughly wire brushed or sanded prior to painting touch up.

All metal surfaces shall then be painted with two coats of the approved synthetic exterior enamel paint.

5.4.7 Measurement and payment

The different items on structural and miscellaneous metalwork, as indicated on the Drawings and specified herein, will be measured by the various units listed in the Bill of Quantities.

PART-6: BUILDINGS

1.0	GENERAL SPECIFICATION	111-170
2.0	SPECIFICATION FOR STRUCTURE OF BUILDING	171-265
3.0	SPECIFICATION FOR MISCELLANEOUS ITEMS OF BUILDING	266-429
4.0	SPECIFICATION FOR ENVIRONMENTAL MITIGATION WORKS	430-449
5.0	SPECIFICATIONS FOR SOCIAL ASPECTS	447-447
6.0	SPECIFICATION FOR SALINITY	448-448

PART-6: BUILDINGS

1 GENERAL SPECIFICATION

1.1 INTRODUCTION

These Specifications shall apply to all such works to be executed involving construction of a building and its allied works under the Contract or otherwise directed by the Engineer. In every case, the Work shall be carried out to the satisfaction of the Engineer and conform to the location, lines, dimensions, cross-sections, etc shown on the Drawings or in the Bill of Quantities (BOQ) or as indicated by the Engineer. The quality of materials, processing of materials as may be needed at the site, salient features of the construction work and quality of finished works shall comply with the requirements set forth in the succeeding Sections and Sub-sections. Where the Drawings and Specifications describe a portion of the work in only general terms and not in complete detail, it shall be understood that only the best general practices are to prevail, materials and workmanship of the best quality are to be employed and instructions of the Engineer are to be fully complied with.

Words importing the singular also mean the plural and vice versa where the context so demands. Similarly, words importing the male also mean female or neuter and vice versa where the context so requires. Words have their normal meaning under the English language unless specifically defined.

1.2 DEFINITIONS

The following words and expressions shall have the meaning hereby assigned to them, except where the context otherwise require. However, in the case of any conflict with the stipulations of the Conditions of the Contract, the expressions and meaning of the Conditions of Contract shall prevail.

‘The Engineer’ shall mean the engineer designated or any other engineer appointed from time to time by the Chief Engineer and notified in writing to the Contractor to act as ‘the Engineer’ for the purpose of the Contract.

‘The Contractor’ shall mean any person or corporate body who is pre-qualified under the Project/ enlisted with the LGED and whose Tender to carry out the Work has been accepted by the Employer and the legal successors in title to such person, but not (except with the consent of the Employer) any assignee of such person.

A ‘Sub-Contractor’ shall mean any person or corporate body named in the Contract as a Sub-contractor for a part of the Work or any person or corporate body to whom a part of the Work has been subcontracted with the consent of the Engineer and the legal successors in title to such person or corporate body, but not any assignee of any such person or corporate body.

‘The Contract’ is the contract between the Employer and the Contractor to execute, complete and maintain the Work.

The expression of ‘Work’ or ‘Works’ are what the Contract requires by the Contractor to construct, install and hand over to the Employer, as defined in the Tender Documents. Unless there be something either in the subject or context repugnant to such construction it shall be construed and taken to mean the works by or by virtue of Contract to be executed, whether temporary or permanent and whether original, altered, substituted or additional.

‘Site’ means the places provided by the Employer where the Works are to be executed and any other places as may be specifically designated in the Contract as forming part of the Site.

‘Bid’ means the Contractor’s priced offer to the Employer for the execution and completion of the Work and the remedying of any defects therein in accordance with the provisions of the Contract, as accepted by the Letter of Acceptance.

‘Letter of Acceptance’ means the formal acceptance by the Employer of the Bid.

1.3 LOCATION OF WORKS

The project area for the works are in the districts of

1.4 GENERAL REQUIREMENTS

These Specifications shall be read in conjunction with various other documents forming the Bid Documents, namely Notice Inviting Bids, Instructions to Bidders, Conditions of Contract, Bill of Quantities, Drawings and other related documents. In case of an ambiguity the description of item of works in the Bill of Quantities prevail.

The Specifications in accordance with which the entire works described hereinafter are to be constructed and completed by the Contractor shall comprise the following:

- Part-1 - General Specifications
- Part-2 - Specifications for Structures of Buildings
- Part-3 - Specifications for miscellaneous items of Building Works
- Part-4 - Specifications for Environmental mitigation Works
- Part-5 - Specifications for Social Impact

1.5 DESCRIPTION OF WORKS

The works to be carried out under the Contract are new construction of 2 storied building, market developemntt, tubewell, toilet.

1.6 SCOPE OF WORK

The Work to be carried out under the Contract shall consist of the various items as generally described in the Tender Documents as well as in the BOQ furnished in the Tender Documents.

The Work to be performed shall also include all general works preparatory to the construction of a building and all other related works. The Work shall include works of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the intent and meaning of the Drawings, BOQ and these Specifications and further Drawings and Orders as may be issued by the Engineer from time to time. Whether specifically mentioned or not in the various Sections of this Specification, the Scope of Work shall include compliance by the Contractor with all conditions of the Contract, all materials, apparatus, plant, equipment, tools, fuel, water strutting, timbering, transport, offices, stores, workshop, staff, labour and the provision for proper and sufficient protective works, temporary fencing and lighting, etc. It shall also include safety of workers, first-aid equipment, suitable accommodation for the staff and workmen with adequate sanitary arrangements, the effecting and maintenance of all insurance, the payment of all wages, salaries, fees, royalties, duties or other charges arising from the erection of works and the regular clearance of rubbish, reinstating and clearing the site as may be required on completion of the Work, safety of the public and protection of the Work and the adjoining land.

The Contractor shall ensure that all actions are taken to have a built-in quality assurance in the planning and execution of the Work. The quality assurance shall cover all stages of works such as setting out, selection of materials, selection of construction methods, selection of equipment and plant, deployment of personnel and supervisory staff, quality control testing, etc. The work of built-in quality assurance shall be deemed to be covered in the Scope of Work.

1.7 SUBMITTAL

The submittal by the Contractor shall include construction programme, all Shop Drawings, reports, samples, test results etc. to conform with all applicable provisions of the General Conditions of the Contract and as required under the various Sections of these Specifications. The purpose of the submittal required herein is to assure that items furnished and installed are, in all matters of consequence, equivalent to the specified items and that proper records are maintained of the changes made in the Specifications, Drawings or in materials used or any deviations made in the construction process.

The Contractor shall forward all submittal to the Engineer under a cover letter stating that the submittal have been carefully reviewed by the Contractor and that on-site conditions or dimensions where necessary and correctness have been verified and checked.

The submittal shall be reviewed by the Engineer to verify that the Contractor's obligations are fulfilled as per the turn intention of the Contract. In checking and approving submittal, the Employer does not relieve the Contractor from responsibilities for construction errors or omissions, which may occur, even though executed in accordance with the approved Shop Drawings. Any such errors or omissions, as is discovered later on, should be corrected by the Contractor irrespective of any approval by the Employer at no additional cost to the Employer. This does not apply to modifications approved as specified herein.

The Contractor shall make submittal of construction requirements at least 10 days prior to actual construction of the component to allow time for checking and re-checking, if necessary. Any works fabricated or installed by the Contractor prior to approval of the Shop Drawings or other required submittal shall be done at his own risk.

Construction Programme

Within 7 days of the Formal Work Order being issued, the Contractor shall submit to the Engineer for his approval a Bar Chart/Gantt Chart showing the programme sequence in which works have been proposed to be carried out including the procurement and delivery of equipment and materials.

The Contractor shall, whenever required by the Engineer, also provide in writing a general description of the arrangements and methods, which would be adopted for the execution of the Work.

If at any time it would appear to the Engineer that the actual progress of work does not conform to the approved programme, the Contractor shall be obliged to produce for the approval of the Engineer the reasons for any changes with a revised programme showing the modifications to the previously approved programme necessary to complete the Work on schedule. Submission to and approval by the Engineer of such programmes or furnishing of such particulars shall neither relieve the Contractor from any of his duties and responsibilities under the Contract nor it shall prejudice the 'Liquidated Damages' Clause of the Contract.

Notice of operation

The Contractor shall give full and complete written notice of all the important operations, including setting out, to the Engineer sufficiently in advance (not less than 10 days) to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purposes. The Contractor shall not start any important operation without the written approval of the Engineer.

As-built drawings

Before the expiry of the period of maintenance, the Contractor shall submit the full sets of As-Built Drawings of the completed works to the Employer. The sets shall comprise the negatives of Drawings prepared with high quality reproducible polyester transparent "Mylar" film (or similar material) from which clear copy can be re-produced, three clearly printed Drawings and a CD.

The As-Built Drawing shall clearly show the lines and dimensions of the permanent construction actually made based on the changes to the original design from time to time as ordered by the Engineer or proposed by the Contractor and approved by the Engineer.

The original transparent negatives of the Tender Drawings and the Design Drawings will be lent free of charge to the Contractor on request free of charge for his making further prints or reproducing additional number of negatives of Drawings.

Shop drawings

The Contractor shall prepare the Shop Drawings at his own costs showing clearly all elements of construction that are required to assure proper shop fabrication or job installation of items requiring Shop Drawings shall be clearly shown. All material quality, finishes, construction details as specifically related to the project must be shown on the Shop Drawings.

1.8 TAKING OVER POSSESSION OF SITE

The Contractor shall, upon receiving the Work Order, immediately take possession of the Site and move his men and materials to prepare the Site in order to create conditions for starting the Work as per terms of the Contract, Drawings and Specifications.

1.9 MOBILIZATION

The work of mobilization shall consist of carrying out the following listed actions together with all other requirements of the Contract with regard to commencing the execution of the Work by the Contractor at his own cost.

- (a) Procurement, assembly, repair and make to running condition of all the contractor-owned constructional plant and equipment by the Contractor at any other site as convenient to him.
- (b) Transportation of Contractor-owned constructional plant, equipment and materials from the storage site as mentioned above in (a) to the place of construction.
- (c) Assembling and installation of all items of constructional plant, equipment, etc. required for the execution of the Work.
- (d) Receiving all constructional plant, equipment and materials to be furnished by the Employer, if any, and collect and transport those to the Work site. All materials shall be properly stored, inventoried and protected until used in to the Work and all plant and equipment shall be tested and made ready for use.
- (e) Construction of a suitable Site office building or shed for storage of materials and equipment, workshop, other operational buildings and First-Aid Center attended by competent Medical Assistants.
- (f) Maintenance of all temporary roads, fences and sanitary facilities, keep all areas used by the Contractor clean, neat, well-kept and in good repair and provide proper drainage to protect the area from surface run-off and flooding.
- (g) Provide all the required electric power, water supply and other utility connections to temporary installations at the Site as may be necessary for the execution of the Work.
- (h) Obtain all insurance policies, performance bond and payment guarantees as required under this Contract.
- (i) Payment of all fees, permits, licenses, etc. as may be required covering the execution of the Contract.

1.10 MONITORING PROGRESS

MONTHLY REPORTS

The Contractor shall furnish the Engineer, without cost to the Employer, at regular monthly interval and in a form and number of copies determined by the Engineer, with the following:

- a) Physical progress for the month under report and the estimated progress for the following month.
- b) Completion schedules (target and actual) based on the approved construction programme.
- c) A tabulation of construction equipment listing the major items and pieces of equipment comprising the construction plant as were utilized for performance of the Work during the month under report.
- d) A tabulation of employees countersigned by the Engineer's representative, showing the supervisory staff and the number of several classes of labour employed by the Contractor in the month under report.
- e) Any report which may be specifically requested by the Employer and/or by the Engineer.

Attendance at Site meetings

The Contractor shall attend punctually the progress and other on-site meetings as would be requested by the Engineer.

Receiving visitors

The Contractor shall receive all authorized visitors of the Employer and allow them to visit the Work in the manner as would be requested by the Employer.

1.11 CONTRACTOR'S SITE FACILITIES

The Contractor shall, at his own expenses, be responsible for the provision, maintenance, operation and subsequent removal of the following and all other necessary temporary facilities and services on Site those are required to accomplish the Work in a safe and orderly manner as per provisions of the Contract:

- a) All temporary stores, warehouses and workshops.
- b) All temporary buildings for office accommodation for the Contractor's staff.
- c) Living accommodation for staff.
- d) Adequate number of toilets necessary for all persons engaged for the Work with separate arrangements for women. All sewage from toilets shall be disposed off by means of septic tank and soak pit or by some other acceptable disposal system.
- e) To keep all sanitary facilities clean and their frequent disinfecting.
- f) Fencing, lighting and security.
- g) Cranes or other appropriate ways and means for off-loading plant and equipment, placing in temporary storage and moving from storage to equipment locations.
- h) Site transport for the staff.
- i) Electric power for temporary buildings and tools.
- j) Provisions for adequate supply of water of acceptable quality at the Site for use in the Work.
- k) Raw water from Site Tube-wells and provisions for adequate potable water.

In addition to above, the Contractor shall also make available all other necessary temporary facilities and services on Site those are required to accomplish the Work in a safe and orderly manner as per provisions of the Contract.

The Contractor shall submit for the approval of the Engineer detailed Plans and/or construction Drawings of the temporary buildings, warehouses, workshops and labour camps that he propose to construct or arrange on lease/rent including the proposals for water and power supply and sewerage facilities. These requirements shall be fulfilled by the Contractor within 10 (ten) days from receipt of the Formal Work Order to commence work (Date of commencement of Work). All buildings and facilities shall be of standard and acceptable to the Engineer.

The labour camps shall be at a location approved by the Engineer and conform to all requirements of the local law. It shall be laid and constructed in accordance with a Drawing prepared by the Contractor and approved by the Engineer.

The Contractor shall be responsible for acquiring the land deemed necessary for the Work beyond the Employer's land and for his temporary buildings, warehouses, workshops, staff quarters, labour camps and any temporary access road. The Contractor shall maintain the Site and all working areas in a safe and hygienic condition and in all matters of health and sanitation shall comply with the requirements of the local Medical Officer of Health or other competent Authority.

1.12 MATERIALS, PLANT, EQUIPMENT AND TOOLS

Products

The Contractor at his own expenses shall provide the materials, products, plant and equipment as shown on the Drawings or as specified in the Contract. Necessary haulage and safe storage of materials, supervision of works etc. shall be provided by the Contractor.

Equal products and equivalents

Except as specifically required otherwise, the mention of any proprietary materials by trade name is intended to establish a standard of quality, appearance, size and durability. The products of other manufacturers may be used subject to the conditions as stated below.

Additional costs related to substitutions

Any additional costs, or any losses or damages, arising from the substitution of any materials or methods from those originally specified shall be borne by the Contractor, unless such substitution was made at the written request or direction of the Employer.

Failure of equal products

Where products are accepted, based on representation of the Contractor, as approved equals, those shall be used subject to the same installation and performance standards as required by the original specification. Approval of a request for substitution shall not modify the Contract requirements except as specifically noted. Subsequent failure of "approved equals" shall be considered first. For any evidence of improper installation or product inequality, the installation shall be repaired or corrected as directed by the Engineer at the full costs of the Contractor.

Plant, equipment and tools

The Contractor shall furnish all constructional plant, equipment and tools for the proper execution of the Work at his own expenses and keep those in proper working condition. The Contractor shall supply the Employer a list of major items of the constructional equipment and tools that he proposes to use in execution of the Work.

1.13 SUFFICIENCY OF MEANS EMPLOYED

The Contractor shall take upon himself the full and entire responsibilities for the sufficiency of his supervisory and other personnel, plant or equipment or tools, scaffolding, timbering and generally for all means used for the fulfillment of the Contract. In the event of any of these means proving insufficient, the Contractor shall remain fully and entirely responsible for the sufficiency of these means notwithstanding any previous approval or recommendation that might have been given by the Engineer.

1.14 PROTECTION AND SAFETY

General

The Contractor at all times shall take all necessary measures to the safety of life and property during construction of various parts of a building. International Safety Manuals used in Engineering Construction Project shall be adopted for protection and safety at the construction Site during the period of construction. Nothing stated herein shall be construed to nullify any rules, regulations, safety standards or statutes of the local authority, or those contained in the various Acts of the Government of Bangladesh. The specific rules, regulations and Acts pertaining to the protection of the public or workmen from health and other hazards wherever specified by the local Authority etc. or by the Act/Ordinance of the Government shall take precedence over whatever are specified herein.

Safety of workmen

Helmets conforming to BDS 1265 and BDS 1266 shall be worn by the workmen and other personnel at all times while works are going on.

Safety goggles of accepted standard (BDS 1360) shall be used by individuals engaged in drilling, cutting, welding and all such works which cause hazard to the eye. The welders and gas cutters shall be equipped with proper protective equipment like gloves, safety boots, aprons and hand shields having filter glass of accepted standard and suitable to the eyes of a particular worker.

Site precautions

In absence of boundary walls, construction Site shall be delineated by fences.

Warning signs shall be displayed, where necessary, to indicate hazardous areas like high voltage zone, area of no smoking etc. Hand lamps shall be of low voltage, preferably 24V. All electrically operated hand tools shall be provided with double earthing.

The temporary wells, which shall be provided by the Contractor at the construction Site as a part of the toilet facilities, shall be provided with proper covers.

The toilet facilities shall be located at a corner of the Site so as to avoid any obstruction. Protection from bad weather and falling object and proper privacy shall be provided to the toilet users.

Temporary toilets shall be dismantled, all wells filled up, and the whole area made level, dressed and restored back to proper grade at the end of the project.

The Contractor at all times shall protect the excavation, trenches and building materials from rain water, groundwater, backing up of drains and from water of any origin. He shall provide all pumping arrangements for removal of surplus water, coverings and other materials as required.

All rubbish and debris shall be removed from the Site and disposed off at a safe distance as per direction of the Engineer so as not to create any obstruction to Work or give rise to health hazards.

The Contractor shall take all necessary precautions to ensure against fire during construction. The Contractor must make all necessary arrangements for providing adequate protection against fire hazards at the construction site during the period of execution of the Work.

Timber, coal, paints and similar combustible materials shall be separated from each other. A minimum of two dry chemical powder (DCP) type fire extinguishers shall be provided at both open and covered locations where combustible and inflammable materials are stored.

Inflammable liquids like petrol, thinner etc., shall be stored in conformity with the relevant regulations. Explosives like detonators, gun powder etc. shall be stored in conformity with all fire protection provisions set forth in the Bangladesh National Building Code.

1.15 CARE OF WORKS

Movement of transport and plant

The Contractor shall exercise diligence and care in the movement of all transports and plant within the Work area so as not to cause injury or damage to life or property. The Contractor shall be responsible for restoring any roadway, bridge, culvert etc. damaged by his transports and plant to the satisfaction of the Engineer or the appropriate Authority.

Keeping works free from atmospheric condition

The Contractor shall construct all temporary works and other works and supply and operate pumping plant and ensures all measures as may be found necessary for the construction of the Work under proper atmospheric condition.

Notwithstanding any approval by the Engineer of the arrangements made, the Contractor shall remain responsible for the sufficiency thereof and shall be liable for keeping the works safe at all time regardless of the climatic condition at his own expenses. Any loss of production, additional overheads or additional costs of any kind that may result from inclement climatic conditions shall be at the Contractor's risk.

Materials on and under the Site

All soil, turf, gravel, stone, timber, or other materials obtained in the excavations, clearing of the Site of the Work and soil stripping, shall belong to the Employer and must not be removed from the Site without the written permission of the Engineer. Provided the Engineer directs the Contractor, he may use for the construction of the Work, any timber obtained from trees felled at the Site and any of the materials excavated under the Contract, which the Engineer may determine to be fit for such use.

1.16 SURVEY WORKS

Permanent Bench Mark

Before commencing the work the Contractor shall establish at his own cost, at least 2 (two) permanent Bench Marks (B.M) with permanent pillars at suitable positions as per direction of the Engineer. These B.Ms. shall be incorporated in the Drawings and used for controlling all levels of construction works.

Reference line pillars

The Contractor shall establish permanent Reference Line Pillars (axis pillars, centre line pillars, etc.) at his own cost for all structures before starting of excavation of foundation pits/trenches as per standard practice and or as per direction of the Engineer.

The Contractor shall remain responsible for safeguarding all Survey Monuments, Bench Marks, Beacons, etc. The Contractor, at his own expenses, shall make necessary arrangements to protect the B.M pillars against any disturbances, damages, including their maintenance.

The Engineer will provide the Contractor with the data necessary for setting out of the center line. All dimensions and levels shown on the Drawings or mentioned in the Documents forming part of or issued under the Contract shall be verified by the Contractor on the Site and he shall immediately inform the Engineer of any apparent error or discrepancy, if found by him in such dimensions or levels. The Contractor shall, after or in connection with these staking out of the center line, survey the terrain and shall submit to the Engineer for his approval, a profile as required by the Engineer.

Instruments and equipment for surveys shall be subject to rigorous inspection by both the Contractor and the Engineer and any items found to be defective in the opinion of the Engineer, shall be promptly replaced, repaired or adjusted as per his direction. A qualified Surveyor or Engineer shall supervise all survey works.

The checking of the setting-out of works by the Engineer's staff shall not relieve the Contractor of any of his liabilities or responsibilities under the Contract.

1.17 FABRICATED ITEMS INCORPORATED IN THE WORK

Whenever required by the Specifications to fabricate or manufacture and furnish equipment for incorporation in the permanent works, the Contractor shall submit to the Engineer for his approval the names of the manufacturers or fabricators the Contractor proposes to use and also his detailed Shop Drawings for approval before proceeding with the Work. All such Drawings shall be adequately and properly checked before being submitted to the Engineer for approval and shall be so designated.

Any fabricating or manufacturing undertaken during or before the approval of the Drawings, will be at the Contractor's risk. The Engineer shall have the right reserved to ask the Contractor to make any changes in the Design, which may be found necessary in the opinion of the Engineer, for the equipment or component materials to fully meet the requirements and intent of these Specifications without causing any additional costs to the Employer.

Approval of the Contractor's Drawings shall not relieve the Contractor of any part of his obligation to meet all requirements of these Specifications or of the responsibilities for the correctness of his Drawings. At the time of delivery of the equipment, the Contractor, if requested to do so, shall furnish the Engineer two complete sets of negatives of the final approved Drawings.

1.18 INSPECTION/TESTS AT FABRICATOR'S WORKSHOP

General

All equipment furnished under these Specifications and all works performed thereon will be subject to inspection by the Engineer or his authorized representative. Inspection at the manufacturer's plant, when located only in Bangladesh, may be made with the intention to determine the meeting of requirements of the Specifications in respect of use of equipment and materials.

The Contractor shall notify the Engineer a minimum of 15 (fifteen) days in advance of the date and place of equipment/materials to be available for inspection. No equipment or materials shall arrive at the Site until the Engineer's inspection at the manufacturer's plant or Contractor's storage place

outside the actual Site has been made, the Engineer's approval has been given, final Drawings have been furnished by the Contractor and the Contractor's responsibilities for furnishing equipment and materials meeting the requirements of the Contract Document are fully complied with. All costs of the Engineer's inspection shall be borne by the Contractor.

Tests and inspection record

The record shall identify the Contractor and the Supervision Consultant staff (when applicable) involved, the place, the date and time when the inspection is completed, the sections of the Work and the materials tested or inspected and its state of completion. Reference shall be made to the relevant Working Drawings and the specific aspects or properties, which were checked or measured, shall be recorded.

One copy of each record of inspection shall be submitted to the Engineer and one copy of each record of inspection shall be submitted to the Supervision Consultant (when involved). The Contractor shall maintain records of inspections and tests in an orderly fashion at the Site until the issuance of the Defects Liability Certificate for the whole of the Work, or such earlier time as the Engineer may instruct. The Engineer shall have the rights of access to them at all times.

After the issuance of the Defects Liability Certificate for the whole of the Work, or such earlier time as the Engineer may instruct, the Contractor shall, as instructed by the Engineer, either dispose of the records or deliver them as directed.

Notice of works off-Site

The Contractor shall give adequate written notices to the Engineer on the preparation or manufacture at a place not within the Site of any pre-fabricated units or parts of units or materials to be used in the Work. Such notices shall state the place and time of the preparation or manufacture, quarrying or extraction. The notice be given sufficiently in advance as to enable the Engineer to make arrangements which he may deem necessary for inspection before the start and at any stage of the Work and not only at the time when the units or parts are completed. Off-Site works shall not commence without the prior approval of the Engineer.

Any unit or parts, prepared or manufactured without giving such prior notice to the Engineer, may be rejected, if the Engineer considers that his inspection was necessary during the time of preparation or manufacture. No inspection by the Engineer shall relieve the Contractor of any of his responsibilities, duties and liabilities under the Contract.

Standards

Except where otherwise specified or authorized by the Engineer, all materials and workmanship shall conform to the latest edition of the relevant Standard Specifications of the ASTM or BNBC.

Materials meeting other internationally accepted equivalent or higher Standards may be accepted subject to review by the Engineer. The Contractor shall submit in English language any such alternative Standards proposed by him, for approval by the Engineer.

The Contractor shall provide the Engineer 3 (three) sets of each of the Standards, Codes and References to be used in the Contract within 45 (forty-five) days of the Date of Commencement of the Work. In addition, he shall supply 3 (three) copies of any other Standards or Codes subsequently specified or alternatively proposed to be used by the Engineer, the Supervision Consultant (when involved) and the Site Laboratory. All Standards shall be in English. On completion of the Contract, all copies of Standards, Codes and References, so provided, shall become the properties of the Employer.

Proprietary products

Where a proprietary or brand name or the name of a supplier or manufacturer is indicated on the Drawings or in the Specifications, this would be in respect of items, which have not otherwise being adequately described by ASTM, BNBC or equivalent recognized Standards. Alternative items based on recognized national Standards of the country of origin may be accepted provided that documented proof in the English language is submitted to the Engineer for his approval sufficiently in advance and

showing that the alternative proposal is equal or higher in quality and performance than the specified item.

Materials to be new

All materials used in the permanent works shall be new. No materials, incorporated in the permanent works, shall have previously been used in the temporary works.

Orders for materials

Before orders are placed for any materials of any description to be used in the permanent works, the Contractor shall submit to the Engineer the names and addresses of the manufacturers or suppliers proposed. Following approval by the Engineer, the Contractor shall submit to him copies of all orders placed for such materials.

Samples

In accordance with the provisions of the Contract, the Contractor shall, in the way as directed by the Engineer, supply samples of materials to be incorporated in the Work. The Contractor shall submit the samples required for approval in labeled boxes suitable for storage and with sufficient time for testing. Due allowance shall be kept for the fact that if samples are rejected, further samples and testing will be required. The Engineer shall keep the approved samples with him and will compare the supply with the sample before acceptance. He shall reject any materials not conforming to the character and quality of the approved samples.

Certificates

All manufacturer's certificates of tests, proof sheets, mill sheets etc., showing that the materials have been tested in accordance with the requirements of the relevant ASTM, BNBC or other approved Standard or this Specification, shall be supplied in English language by the Contractor to the Engineer free of charge.

1.19 TOLERANCES

Unless it has been specified in the different Sections otherwise, all works shall be constructed within the tolerances shown in the Table given below.

Type of Structure	Item	Tolerance
Concrete Structures	<u>Tolerances from the specified position (Structure)</u>	
	Maximum departure of plan position of structure or element	25mm
	<u>Tolerances from the specified dimensions (Structure)</u>	
	Maximum departure in thickness or cross sectional dimensions of columns, beams, buttresses, wall footings etc., up to and including 500mm thick (except tunnel and shaft linings)	+6mm -3mm
	Ditto – between 500mm and 1000mm thick	+10mm - 5mm
	Ditto – between 1000mm and 4000mm thick	+10mm -8mm
	Ditto – over 4000mm thick	+25mm -10mm
	<u>Tolerances from specified position (Surface)</u>	
	Maximum departure of vertical, sloping or curved surfaces including joint surfaces	25mm
	Maximum departure of horizontal or near-horizontal surfaces including joint surfaces	20mm
	<u>Tolerance on Straightness or Departure from Specified Curve (Surface)</u>	
	<u>General Surface</u>	
	Maximum deviation in horizontal or vertical directions (gradual)	12mm in 2m

Type of Structure	Item	Tolerance
	Maximum deviation in horizontal or vertical directions (abrupt)	6mm
Formwork	Sectional dimension Plumb Levels (before any deflections has taken place)	+5mm +1 in 1000 of height +3mm
Reinforcement	Length of splice Variation of protective cover Variation in indicated position or reinforcement: ▪ Starter bars ▪ Slabs and Walls ▪ Beams and columns Dimension of bent bars: ▪ Stirrups and ties ▪ Other bars	-25mm +5mm One bar diameter 0.25 times the indicated spacing +5mm +5mm +10mm
R.C.C. Piles	1. Pre-cast driven pile: a) Verticality for vertical pile b) Verticality for raker pile	1 in 50 1 in 25
	c) Deviation from position shown on the plan for vertical and raker piles after driving Concrete piles casting tolerances: a) Maximum departure in thickness or cross sectional dimensions	$\frac{1}{4}$ th of least dimension or 75mm whichever is greater +6mm - 0.00
	b) Deviation of pile face c) Deviation of cross-section centroid from straight line connecting the centroid of the end faces of the pile 2. Bored and Cast-in-situ pile: a) Verticality for vertical pile b) Verticality for raker pile c) Deviation from position shown on the plan for vertical and raker pile shaft	6mm in 3m 10mm 1 in 75 1 in 25 Maximum 75mm in any direction
Timber Piles	Deviation of cross-sectional dimension Deviation of cross-section centroid from straight line joining end face centroid Level of top pile	- 6mm 40mm + 12mm

* In addition to above, other tolerances have also been specified in the different Sections and Sub-sections in the relevant portions.

1.20 RECORDING OF MEASUREMENT

Conditions of the Contract, Technical Specifications and Contract Drawings are to be read in conjunction with the Bill of Quantities (BOQ).

General directions and descriptions of works and materials are not necessarily be repeated nor summarized in the BOQ. References to the relevant Sections of the Contract documents shall be made before entering the Tender's rate.

The quantities given in the BOQ are only approximate and provisional and are given to provide a common basis for tendering. It does neither expressly nor by implication prescribed that the actual volume of work to be performed will exactly correspond therewith.

Any clarification regarding the BOQ and the Method of Measurement shall be adjudged by the Engineer in accordance with this Standard Specification, its Sub-sections, BOQ and other Tender Documents.

The works, executed fully complying the Drawings and instructions of the Engineer, will be measured for payment in accordance with the method adopted in the BOQ and the item therein set forth, notwithstanding any custom to the contrary. The net quantities of the finished works in place will always be taken except where otherwise specified.

No allowance shall be made for waste, laps, cuttings, etc. and no deduction will be made for grout nicks, joggle holes or rounded arises and sinkage or for fitting iron works, etc.

1.21 PAYMENT

Full account shall be taken of all information contained in the Tender Documents and made available during the tender period as affects, inter-alia, working methods, haulage requirements and sequence of operations. Full allowance shall be made for all these provisions in the rates and sums entered against the various items in the BOQ of the Contract.

The specified payment Sections/Sub-sections of the Contract shall apply to any additional or varied works, which may be required to execute under the Contract except where specifically varied therein.

The basis of payment will be the actual quantities of works ordered and carried out, as measured by the Engineer (based on the As-Built Drawing, BOQ or otherwise as directed by the Engineer) and valued at the rates and prices of the Tender, where applicable, or otherwise at such rates and prices as (in case of non-tendered items) the Engineer may fix within the Terms of the Contract.

No payment will be made on account of the anticipated profit for work covered by the Contract, which is not performed. No adjustment will also be made in the unit rates set out in the Bill of Quantities because of an increase or decrease in the actual quantities from the Estimated quantities indicated therein, unless otherwise stated in the Conditions of Contract.

Notwithstanding any limit, which may be implied by the wording of the individual item and or the explanations in this Section, it is to be clearly understood that the Tender price is for the works finished and completed in every respect. Full account of all requirements and obligations have to be taken, whether expressed or implied covered by all parts of the Contract. The Tender price shall, therefore, include all incidental and contingent expenses (including all taxes and VATs) and risks of every kind necessary to construct, complete and maintain the whole of the Work in accordance with the Contract. Full allowance is to be made in the Tender price for all costs involved in the following, inter- alia, which are referred to and/or specified herein:

- ☐ All setting-out and survey works.
- ☐ Temporary access unless separately billed, fencing, guarding, lighting, and all temporary works including their removal on completion.
- ☐ Paying fees and giving notices to the Authorities.
- ☐ Reinstatement of the Site.
- ☐ Safety precautions and all measures to prevent and suppress fire and other hazards.

- ☐ Interference to the works by persons or vehicles being legitimate users of the facilities on or in the vicinity of the Site.
- ☐ Protection and safety of adjacent structures so far as they may be affected by the works or temporary works.
- ☐ Supplying, maintaining and removing the Contractor's own housing for staff and labour, offices, workshop, plant yard, transport, welfare, services in connection therewith and other facilities required by the Contractor on completion of work unless separately billed.
- ☐ Working in the dry condition except where otherwise permitted by the Specification.
- ☐ Supplying, inspection and testing of materials intended for use in the works including the provision and use of equipment.
- ☐ Maintaining public roads and footpaths.
- ☐ Opening quarries and borrow pits including all surveys, site investigations, removal and disposal of overburden, trimming of quarry or borrow pit faces and floors and all measures necessary to render quarries or pits safe and free for draining on completion.
- ☐ Providing and transporting to Site all equipment necessary for the execution of the Work, setting to works, operating (including all fuel and consumable stores), removal from the Site all construction equipment upon completion of the Work, costs of all tests and other requirements in respect of such plant and equipment.
- ☐ The requirements and all incidental costs and expenses involved to provide all necessary skilled and unskilled labours and supervision.
- ☐ Protection of all completed works following operations making good damages to any completed works due to any cause whatsoever, clearing all rubbish as they accumulate and leaving the Site in a tidy condition.
- ☐ All costs associated with the provision and submission of Progress Reports, Records, Photographs, preparation of the necessary Shop and Working Drawings etc. except those provided in the Bill of Quantities.
- ☐ Workmen's compensation and Owner's liability insurance.

Payments under the item for hiring of land (if there be any) in addition to the Employer's land for temporary works shall be made in accordance with the receipts obtained from the land owners within the limitation of quoted rate only if such provision is made in the BOQ of the Contract.

Payment of royalties for fill materials obtained from privately owned land/carried earth shall remain included within the rates of the relevant items of the Contract. The volume of borrowed materials shall be calculated on the basis of pre-work and post-work measurements. Finished sections as per Drawings will be the basis for post-work measurement while the Work is complete as per Specifications.

Payment shall mean gross payable amount on the rates of the BOQ including the Performance Security.

With regard to the Sub-section on 'Contractor's Site Facilities', payment will be made for hiring land for the Contractor's temporary works outside the Employer's property, only if such provisions are kept in the BOQ of the Contract.

The cost of keeping the works free from water will only be paid for, if referred to in the BOQ of the Contract Documents.

No payment shall be made for any tests required under the Specification unless specifically referred to in the BOQ. If the Engineer requires any tests outside the BOQ, the cost of such test shall be agreed with the Engineer before execution and paid for as a supplementary item.

No direct payment shall be made for works required under other Sub-sections. The costs for such works shall be deemed included in the related items of the BOQ.

1.22 CONSTRUCTION MATERIALS

1.22.1 BRICKS

General

Bricks shall be manufactured from clay or shale or a combination of these materials and shall be uniformly burnt throughout. They shall be hard and sound and give a clear metallic ring when struck with a small hammer or another brick and should not break when dropped to the earth from a height of 1.5m with one brick above another in the formation of a 'T'. The surface should be too hard to be scratched with the fingernail.

Bricks shall be stacked on dry firm ground in regular tiers. Each stack shall comprise 50 bricks in length and 10 bricks in height, the bricks being placed on edge. The width of each stack shall be formed with two bricks. Clear distance between adjacent stacks shall be not less than 800mm.

Bricks shall be loaded or un-loaded with care, and shall not be thrown or dumped. They shall be carried from the stack to the Site of placement in small batches as and when necessary.

First class bricks

First Class Bricks shall comply with the following requirements:

Appearance. Sound, hard and well burnt, uniform in size, shape and colour, homogeneous in texture and shall have plane rectangular faces with parallel sides and sharp straight right-angled edges. This shall be of uniform colour (generally deep red or copper), homogeneous in texture and free from cracks, flaws and nodules of free lime. A fractured surface shall show a uniform compact structure free from holes, lumps or grits. Shall emit clear metallic sound when struck. When scratched by steel or nails, there should be no permanent mark on the surface.

Unit Weight 2000 kg/m³

Crushing strength	170 kg/cm ² (average) but not less than 140 kg/cm ² in any individual brick
Maximum water absorption	20% of dry weight
Efflorescence	Nil
Dimensions (± 3mm)	240mm x 115mm x 70mm

Picked jhama bricks

Picked Jhama Bricks shall be over-brunt first class bricks, uniformly vitrified throughout with good shape, hard, slightly black in colour and without cracks or spongy areas.

Water absorption, as a percentage of the dry weight, shall not exceed 15%.

Crushing strength should be on average 210 kg/cm², but not less than 170 kg/cm² in any individual bricks

All other requirements for First Class Bricks shall also apply to Picked Jhama Bricks.

First class machine made bricks

First Class Machine Made Bricks shall be thoroughly burnt and shall have plane rectangular faces with parallel sides and sharp straight right-angled edges. They shall be of uniform colour (generally deep red or copper), homogeneous in texture and free from cracks, flaws and nodules of free lime. A fractured surface shall show a uniform compact structure free from limps and grits of holes.

Other requirements of the First Class Machine Made Bricks shall comply with the following requirements:

Minimum crushing strength	210 kg/cm ² .
Maximum water absorption	10% of dry weight
Efflorescence	Nil
Dimensions (± 5mm)	200mm x 100mm x 50mm

Perforated bricks

Perforated bricks shall meet the following specifications:

Minimum compressive strength on gross area for

Multi-core brick	70 kg/cm ² .
10-hole engineering bricks	210 kg/cm ²
Maximum size of perforation	645 mm ²
Minimum number of perforation	
Along the width of brick	2
Along the length of brick	6
Minimum wall thickness	
Between brick edge and perforation	16 mm
Between adjacent perforation	10 mm
Maximum water absorption	12% of dry weight.
Efflorescence	Nil.
Dimension	241mmx114mm x 70mm.

The perforations may be of any regular shape in cross-section. In case of a rectangular section, the larger dimension shall be parallel to the longer side of brick. Dimension of perforation measured parallel to the plane of the shorter side shall not be more than 16 mm except in case of circular shape of the perforation in which case it may be allowed up to 20mm. Total area of perforation shall not exceed 45% of the total area of corresponding faces of the brick.

In all other respect the perforated bricks shall conform to the specifications of the First Class Machine Made Bricks.

Clinker bricks

Clinker bricks shall meet the following specifications:

Minimum compressive strength	562 kg/cm ²
Minimum modulus of rupture	42 kg/cm ²
Maximum water absorption	12% - 15% of dry weight.
Efflorescence	Nil.
Dimension	203mm x 102mm x 51mm.

Clinker bricks shall be manufactured by dry process and burnt to a higher temperature and shall be uniformly vitrified to a dark copper tone.

Arises shall be square, straight and sharply defined.

1.22.2 AGGREGATES**General**

Aggregates shall be hard, strong, durable, dense and free from injurious amount of adherent coatings, clay, lumps, dust, soft or flaky particles, shell, mica, alkali, organic matter and other deleterious substances. The various sizes of particles of which an aggregate is composed of shall be uniformly distributed throughout the mass.

Testing of aggregates shall be in accordance with BS 812 or ASTM C-136.

Approval of a source of aggregate by the Engineer shall not be construed as constituting the approval of all materials to be taken from that source and the Contractor shall be responsible for the specified quantity and quality of all such materials used in the Work. Aggregates shall not be obtained from sources, which have not been approved by the Engineer.

The Contractor shall provide means of storing aggregates at each point where concrete is made such that

- ☐ aggregates shall be stored on a hard and dry patch of ground covered with a 50mm thick layer of lean concrete
- ☐ each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times
- ☐ contamination of the aggregates by the ground or other foreign materials shall be effectively prevented at all times
- ☐ each heap of aggregate shall be capable of draining freely
- ☐ the aggregates shall be handled so as to avoid segregation

The Contractor shall make available to the Engineer such samples of the aggregate as he may require. Such samples shall be collected at the point of discharge of aggregate to the batching plant/mixer machine. If any such sample does not conform with the Specifications, the aggregate shall promptly be removed from the Site and the Contractor shall carry out such modifications to the supply and storage arrangements as may be necessary to secure compliance with the Specifications.

Coarse aggregate

General

Coarse aggregate shall be obtained from breaking hard durable rock or gravel or Picked Jhama Bricks, which conform to the requirements of AASHTO Standard Specifications M-80. Coarse aggregate shall be clean, free from dust and other deleterious materials. The grading of the coarse aggregate shall be such that when combined with the approved fine aggregate and cement, it shall produce a workable concrete of maximum density.

Aggregate pieces shall be angular in shape and have granular or crystalline or smooth, but not glossy non-powdery surfaces.

Maximum allowable limits of deleterious substances that shall not be exceeded for coarse aggregate are shown in the following table:

Material	Mass Percent
Soft fragments	2.00
Clay lumps	0.25
Material passing the 0.075mm sieve	0.50 for clay 1.50 for fracture dust
Thin or elongated pieces: Flakiness index (STP T 7.13) less than	30.00

The Aggregate Crushing Value (STP T 7.7) shall be less than 30% or the Ten percent Fine Value (STP T 7.8) shall be greater than 150 kn.

Grading for nominal size coarse aggregate shall comply with the following ASTM C-33 standard gradations:

20mm nominal size Coarse Aggregate

Sieve Size (mm)	% Passing by Weight
25	100
19	90-100
12.50	20-55
9.50	0-15
4.75	0-5

40mm nominal size Coarse Aggregate

Sieve Size (mm)	% Passing by Weight
50	100
37.5	95-100
19	35-70
9.5	10-30
4.75	0-5

Coarse aggregate subject to five cycles of the Soundness Test, specified in ASTM C88, shall not show a loss exceeding 10% when magnesium sulphate solution is used except where otherwise approved.

The flakiness and elongation indices of the predominant size fractions in each single sized coarse aggregate, determined in accordance with BS 812, shall not exceed 20% and 35% by weight respectively.

Aggregate for use in concrete which is subject to abrasion and impact shall comply with the Test requirements of BS 812 and the Specification of BS 63 Part 1 and BS 63 Part 2 and BS 882 respectively.

Coarse aggregate shall be tested for drying shrinkage characteristics in accordance with BRS Digest No. 35.

Coarse aggregate shall be stored at Site in such a manner that it is not contaminated by fine aggregate, earth or other foreign matter. Adequate precautions shall be taken to prevent segregation of the coarse aggregate while it is being transported and stacked.

Stone aggregate

The boulders to be used as coarse aggregate in concrete shall be composed of limestone, sandstone, granite, trap rock or rock of similar nature and shall have the following properties:

Compressive strength (minimum)	490 kg/cm ²
Specific gravity	2.4 – 2.7
Unit-weight	2245 – 2566 kg/cum
Porosity	2 – 6%
Water absorption	1.5 – 5% by weight

The boulder shall be of uniform light colour as approved and shall be free from thin lamination, adherent coatings and deleterious substances. The wear loss of coarse aggregate of all types shall not exceed 35% by weight when tested by the Los Angeles Abrasion Test.

The boulders shall be supplied in sizes that can be handled manually by one person. Stock piling shall be such as to permit ready identification of the materials and shall be approved by the Engineer. Site for stockpiles shall be clean prior to storing materials. The stockpiles shall be built up in layers not to exceed 1.22m in height and each layer shall be inspected before the next layer is started. The crushed boulder chips shall be stacked in accordance with the specified sizes in different stacks as directed by the Engineer. Height of each stack should not exceed 33% of the minimum base dimension of the stack.

Brick aggregate

Brick aggregate shall be as far practically as possible of uniform specific gravity. Blown bricks or unevenly burnt bricks shall not be crushed for the purpose of providing aggregates. Best possible first class picked jhama bricks of selected quality only shall be allowed for crushing.

Brick aggregate shall consist of first class Picked Jhama Brick chips graded as stated above under the Sub-section 'General'. All brick aggregates shall be screened and washed at Contractor's own costs and shall consist of clean, well shaped cubical particles, free from splintered or flaky particles, soil, organic matter or any deleterious materials.

Storage of coarse aggregate

Aggregate of different sizes or grades and from different sources of supply shall not be mixed. All aggregate shall be stored separately free from contact with earth and other deleterious matter. The coarse aggregate should be stockpiled in different stacks, according to the sieve sizes.

All precautions shall be taken during transport and stockpiling of coarse aggregate to prevent segregation. Segregated aggregate shall not be used until they have been thoroughly re-mixed and the resulting stack is of uniform and acceptable gradation.

Aggregate shall be stock-piled at least 7 (seven) days prior to their anticipated use to permit the Engineer to sample each stock-pile to determine the acceptability of the material for the intended use.

Fine aggregate

General

Fine aggregates for use in the concrete and masonry work shall be non-saline clean natural sand and have a Specific Gravity not less than 2.6 and conform to the requirements of ASTM C 144. It shall be angular (gritty to touch), hard and durable, free from clay, mica and soft flaky pieces. All sands must be well washed and clean before use.

A well graded sand should be used for cement work as it adds to the density of the mortars and concretes. Sand required for brick work needs to be finer than that for stone work.

Sand which contains 90% of particles of size greater than 0.06mm and less than 0.2mm is fine sand. On the other hand, sand which contains 90% of particles of size greater than 0.6mm and less than 2mm is coarse sand.

Supply methods and stock piling of sand shall be such, as to permit ready identification of the material delivered and shall be approved by the Engineer.

Impurities

Sand shall be clean and free from injurious amount of organic impurities. Deleterious substances shall not exceed the following percentage by weight.

Material passing No. 200 sieve	2.0
Shale, coat, soft or flaky fragments	1.0
Sulphur compounds	0.3
Clay Lumps (wet, on No. 4 sieve)	0.00

Fine aggregate subject to five cycles of the soundness test, specified in ASTM C88 shall not show a loss exceeding 10 mass percent when magnesium sulphate solution is used except where otherwise approved.

Grading

Sand shall be well graded from coarse to fine within the limits given below or shall conform to the specified Fineness Modulus.

Fine aggregate for concrete

Sieve No.	% Passing by Weight
9.5mm	100
4	95-100
16	45-80
50	10-30
100	2-10

Fine aggregate for masonry

Sieve No.	% Passing by Weight
4	100
8	95-100
16	70-100
30	40-75
50	10-35
100	2-15

Sand fill

Sand for sand fill shall consist of hard, dense, durable materials free from injurious amounts of clay lumps, light weight materials or other deleterious substances.

Unless otherwise specified on the Drawings, sand fill with gunny bags shall have Fineness Modulus not less than 0.8.

Sand fill for the Geo-textile bags shall, unless otherwise approved by the Engineer, comply with the following grading:

	mm
d90	0.60 to 0.30
d86	0.50 to 0.25
d60	0.40 to 0.20
d50	0.35 to 0.20
d10	0.20 to 0.05

1.22.3 Cement

Cement used in the works shall be obtained from manufacturers, approved in writing by the Engineer and shall be Ordinary Portland Cement complying with the requirements of ASTM C150 Type 1 or BS 12 or BDS 232 or equivalent standard. Special cements shall conform to the requirements provided in writing by the Engineer.

A certificate showing the place of manufacture and the results of standard tests carried out on the bulk supply from which the cement was extracted must accompany each consignment of cement delivered to the Site.

The Engineer may make any tests, which he considers advisable or necessary to ascertain, if the cement has deteriorated in any manner during transit or storage. Any cement which, in the opinion of the Engineer, is of doubtful quality shall not be used in the Work until it has been re-tested and test result sheets, showing that it complies in all respects with the relevant standard, have been delivered to and accepted by the Engineer.

Cement that becomes lumpy or otherwise deteriorated in transit or storage shall not be used for brick masonry or concrete works. All cement, found unsuitable for use, shall be removed from the Site immediately.

The Engineer shall ask to carry out sampling, inspection and testing of all cement as may consider be necessary. Samples shall be taken as instructed from the Site store or from elsewhere on the Work or from any places where cement is used for incorporation in the Work. The compressive strength and tensile strength of standard cubes and briquettes respectively shall be not less than as follows:

Days	Compressive strength (N/mm ²)	Tensile strength (N/mm ²)
3	12.4	1.0
7	19.3	1.9
28	27.6	2.4

Initial setting time shall be not less than 45 minutes and the final setting time shall be not more than 8 hours. Cement, when tested for fineness, shall have a specific surface of not less than 160m²/kg. Cement when tested for soundness shall not have an expansion of more than 10 mm. The unit weight of cement shall be a minimum of 14.16 KN/m³.

White cement

White Cement shall be made from pure calcite lime stone and have the same physical properties as those of Portland Cement Type 1, ASTM C-150.

Atypical composition of White Cement is as follows:

CaO 65%

SiO ₂	25.5%
Al ₂ O ₃	5.9%
Fe ₂ O ₃	0.6%
MgO	1.1%
SO ₃	0.1%

Rejection of cement

The Engineer may reject any cement as the result of any tests thereof notwithstanding the manufacturer's certificate. The Engineer may also reject cement, which has deteriorated owing to inadequate protection or from other causes where the cement is not to his satisfaction. The Contractor shall remove at his cost all rejected cement from the Site without delay.

Storage of cement

Cement shall be delivered at the Site in sound and properly sealed jute/paper bags, each plainly marked with manufacturer's name or registered mark. Cement shall be well protected from weather by tarpaulins or other approved cover during transit. Weight of individual bag containing cement shall be 50 kg and weight of all bags shall be uniform. Weight of cement shall be legibly marked on each bag. Bags in broken or damaged condition shall be rejected.

The Contractor shall provide waterproof and well-ventilated godowns at the specified or approved location at the Site having a floor of wood or concrete raised platform at minimum 450mm above the ground so as to protect the cement against moisture from air or from any other source. Sheds shall be large enough to allow a minimum 300mm gap between the stacked cement and the godown walls to store cement in sufficient quantity to ensure continuity of work and to permit each consignment to be stacked separately therein to permit easy access for inspection. All storage facilities shall be subject to approval by the Engineer.

Immediately upon arrival at the Site, cement shall be stored in the godowns with adequate provisions to prevent absorption of moisture. The Contractor shall use the consignments in the order in which they are received. Cement delivered to the Site in drums or bags provided by the supplier or manufacturer, shall be stored in the drums or bags until used in the Work. Any cement in drums or bags, which has been opened, shall be used immediately on opening. Cement shall not be stored in a godown for more than 3 (three) months if bagged or 6 (six) months, if in bulk or a lesser period as directed by the Engineer. After this period is over, any unused cement shall be removed from the Site.

1.22.4 Admixture

Admixture shall be used to provide excellent acceleration of gaining strength at early age and major increase in strength at all ages by significantly reducing water demand in a concrete mix, especially suitable for pre-cast concrete and other high early strength requirements. Admixture shall conform to BS 5075 Part 3 and ASTM C 494.

1.22.5 Reinforcement

Mild steel bar

This is a type of bar plain and round or deformed in shape of a structural or intermediate grade conforming to ASTM Specification A 510 or A 615 with a yield strength of not less than 280 MPa (N/mm²) i.e. 40 grade.

High strength deformed rod

Reinforcing steel under this type comprises Grade-60 Deformed re-bars. The steel shall conform to ASTM Specification A 617M or A 615M of yield strength not less than 420 MPa (N/mm²). The structural grade shall be made from billets. The ends of the bar shall be machine sheared perpendicular to the axis of the bar. The bars shall be free from injurious defects and shall have a workman like finish.

Cleaning and storage

Steel reinforcement bars and structural steel shall be stored in a way to prevent distortion, corrosion, scaling and rusting. Reinforcement bars and structural steel sections shall be coated with cement

wash before stacking, especially in humid areas. In the case of long time storage or storage in coastal areas, reinforcement bars and steel sections shall be stacked at least 200mm above the ground level.

Steel sections shall be stacked upon platforms, skids or any other suitable supports. Bars of different sizes and lengths and structural sections shall be stored separately to facilitate issues in required sizes and lengths without cutting from standard lengths. Ends of bars and sections of each type shall be painted with separate designated colours.

Tag line shall be used to control the load in handling reinforcing bars or structural steel when a crane is used. Heavy steel sections and bundles of reinforcing bars shall be lifted and carried with the help of slings and tackles.

All bars, prior to its use, shall be cleaned with wire brush to make them free from nail scale, loose rust, dirt, paint, oil, grease or other foreign substances.

Bars of reduced sectional area to excessive rust shall be rejected.

All reinforcing steel shall be stored properly under shed not to be contaminated by oil, grease, dirt or mud.

All stacking and storing of bars shall be the Contractor's responsibility and contingent upon his Tender.

Pre-stressing steel and anchorage

Pre-stressing reinforcement shall comprise high strength seven wire strand, high strength steel wire or high strength alloy bars conforming grade and type as shown on the Drawings.

Un-coated seven-wire strand shall conform to the specifications of AASHTO M 203.

Un-coated stress-relieved steel wire shall conform to the specifications of AASHTO M 204.

Un-coated high-strength bars shall conform to the specifications of AASHTO M 275.

1.22.6 Rustless tying wire

Rustless tying wire of 18 SWG shall be obtained from approved manufacturers and shall, as regards strength, comply with the requirements specified. The Contractor shall, at his own costs, provide binding wires of required specifications.

1.22.7 Lime

Lime shall be stone lime of good quality high calcium lime containing calcium oxide from 95% upwards. The impurities, insoluble in acids, should not exceed 3% for the quick lime and 1% for the hydrated lime. Limes shall conform to the requirements of ASTM C 5 for quick lime and ASTM C 207 for hydrated lime.

Storage and handling of lime

Quicklime shall be slaked as soon as possible. If not possible, it may be stored in compact heaps having only the minimum of exposed area. The heaps shall be stored on a suitable platform under a roof protected from rain and wind. A minimum space of 300mm shall be provided all round the heaps to avoid bulging of walls.

Un-slaked lime shall be stored in a watertight place and shall be separated from combustible materials.

Hydrated lime shall be supplied either in containers or sacks, such as jute bags lined with polyethylene or high density polyethylene woven bags lined with polyethylene or craft paper bags. It shall be stored in a dry room to protect the lime from dampness and to minimize warehouse deterioration.

When dry slaked lime is to be used within a few days, it shall be stored on a covered platform and protected from rain and wind. It shall be kept in a dry airtight godown when immediate use is not required. However, it shall never be stored for more than two months.

Workmen, handling bulk lime, shall wear protective clothing, respirators and goggles. They shall be instructed for cleanliness as a preventive measure against dermatitis and shall be provided with hand cream, petroleum jelly or similar protectors.

1.22.8 Water

Water shall be clean, fresh and free from organic or inorganic matter in solution or suspension in such amount that may impair the strength or durability of the concrete. Water shall be obtained from a supply, where possible. However, it may be taken from any other sources, only if approved. No water from excavation shall be used. Only water of approved quality shall be used for washing shuttering, curing of concrete and similar other purposes.

Water to be used in construction shall be stored in tanks, bottom and the sides of which shall be constructed with brick or concrete. Contact with any organic impurities shall be prevented.

The tank shall be so located as to facilitate easy storage and filling in, and supply for construction works and other purposes.

1.22.9 Fill

Materials for filling shall be uniform in character throughout and free from substances that by decay or otherwise may cause the formation of hollows or cavities or otherwise affect the stability of the filling.

Earth filling shall be of selected materials obtained from the excavation or carted fine sand as approved by the Engineer. No soft chalk or clay or earth with a predominating clay content shall be used. Hard core shall be selected hard clean gravel, broken brick, broken concrete, broken or crushed stone, quarry waste or similar approved materials. Concrete for filling shall be to the proportions specified.

1.22.10 Timber

General

All timbers for temporary or permanent works shall be of best quality, sound, straight and well seasoned. They shall be free from sap, defects, radial cracks, cup-shakes, large/loose/dead knots, or other imperfections and shall show a clean surface with cut.

Timber shall be stored in stacks on well treated and even surfaced beams, sleepers or brick pillars so as to be at least 200mm above the ground level. Members shall be stored separately in layers according to the lengths.

A space of 25mm shall be kept between the members. The longer pieces shall be placed in the bottom layers and the shorter pieces in the top layers. At least one end of the stack shall be in true vertical alignment.

The recommended width and height of a stack are 1.5m and 2.0m respectively. Minimum distance between two stacks shall be 800mm.

The stacks of the timbers shall be protected from hot dry wind, direct sun and rain. Weights may be placed on top of the stacks to prevent wrapping of timber. Nails, metal straps, etc. attached to used timber shall be removed before stacking.

Inspection

All timbers shall be subject to inspection at Site piece by piece and shall be to the approval of the Engineer who may reject such timber as is considered by him to be under-specified. In the case of timber specified to be creosoted, the Engineer may reject such timber before or after creosoting, if specifications are not correctly followed. The Contractor shall provide all necessary labour for handling the timber during inspection free of charge.

Wrought faces and allowances on joiner's work

All joiner's works shall be wrought and finished with a clean, even and smooth face. Thickness shall be given to include 2mm for each wrought face in soft- wood and 1.5mm for hard wood.

Timber piles

Timber piles shall be made of Sal, Sundari, Gajari or any other approved hard wood. They shall be matured, straight and free from large or loose knots, cracks and other defects.

Piles shall have a minimum diameter of 100mm measured at one-third point from the thickest end (butt) without bark. Piles should be straight and a straight line drawn from the center of the butt to the center of the tip shall be contained entirely within the pile.

Timber piles exposed permanently above water shall be treated with a water repellent preservative such as creosote for a minimum period of 24 hours in accordance with BS 5268, Para 5, 1977.

1.22.11 Geo-textile

General

All geo-textiles shall be manufactured and supplied by a firm or firms of reputable geo-textile manufacturers. The Engineer shall approve the quality of geo-textile and the manufacturer as well.

Before placing an order for any quantity of geo-textile, the Contractor shall submit samples and test reports to the Engineer for approval for each type of geo-textile from an independent testing laboratory, approved by the Engineer.

The geo-textiles to be incorporated within the works shall comply with the appropriate Codes and Standards including the following:

ASTM D4491	Standard test methods for water permeability of geo-textile by permittivity.
DIN 53936 (pt1)	Determination of the water permeability coefficient kv1 normal to the geo-textile plane with constant head.
ISO 9073-1	Determination of mass per unit area for non-woven textiles.
ISO 9073-2	Determination of thickness of non-woven textiles.
ISO 9073-3	Determination of tensile strength and elongation of non-woven textiles.

The filter effective opening size, O90, defined as being the grain size of a standard sand corresponding to 90% retention by weight on a sample of the geo-textile in a vibrating sieve apparatus, shall be measured in a wet apparatus using the BAW (Bundesanstalt fur Wasserbau – German Federal Institute for Waterways Engineering) method.

All geo-textiles shall be clearly and uniformly marked on the upper face. The marking shall take the form of an indelible repeat roll imprint at the edge of each geo-textile roll recurring at least every 1.5m.

Geo-textile bags

Geo-textile bags shall be manufactured from short staple non-woven geo-textile weighing not less than 0.8 kg/m², and with O90 not greater than 0.07mm or similar material approved by the Engineer.

Geo-textile bags shall be manufactured to the dimensions and capacity specified on the Drawings and filled with sand which complies with the requirements stated in the preceding Sub-section.

Each bag shall be double stitched along all edges except for the opening at the top of each bag, which shall be wide enough to allow the filling of the bag. The minimum tensile strength of the seam shall be not less than 90% of the tensile strength of the geo-textile. The top of each bag shall have a flap, which shall be closed tightly after filling and then double stitched.

The bags shall be stored under cover, well covered from direct sunlight and to prevent the ingress of dust or mud. They shall be protected from damage by insects or rodents.

1.22.12 Marble

Marble stone

Marble shall be of Italian origin or equivalent and size as per Drawing having approved colour and texture.

Marble chips

Marble chips shall be white in approved colour and shall be of size # 2-3 (retained on screens 6mm and 19mm mesh). The chips shall be of uniform colour and texture and shall be made from white marble stone, a calcareous metamorphic rock, which is capable of being polished and have following properties:

Compressive strength 562 – 844 kg/cm²

Specific gravity 2.72

Unit weight 2563 – 2724 kg/m³

Marble dust

Marble dust shall consist of finely ground white marble stone and 90% shall pass sieve # 100.

1.22.13 Glass

Glass general

All glass shall be obtained from an approved manufacturer and be free from blemishes of all kinds and descriptions, whether surface or internal.

Flat glass

Flat glass shall be provided where specified or directed in the following grades:

- ☐ 24 oz. flat drawn clear sheet glass.
- ☐ 32 oz. clear sheet glass.
- ☐ 6mm thick 'Georgian' rough cast wired glass.
- ☐ 6mm thick polished glass.

Wired glass

Wired glass shall be 6mm thick with wire reinforcements inside and shall be obtained from an approved manufacturer and shall be subject to the approval of the Engineer.

Storage and handling of glass

All glass sheets shall be kept dry and stored in a covered place. Glass sheets shall be lifted and stored upright on their long edges and put in to stacks of not more than 25 sheets. They shall be supported at two points at about 300mm from each end by fillets of wood.

The bottom of each stack shall be about 25mm clear from the base of the wall and other support against which the stack rests. The whole stack shall be as close to upright as possible. Smooth floors shall be covered with gunny bags.

Workmen handling glass sheets, remnants and waste glass pieces and fibre-glass shall be provided with gloves, jelly and other suitable hand protections. In removing glass sheets from crates, great care shall be taken to avoid damages and breakage. Glass edges shall be covered or protected to prevent injuries to workmen.

1.22.14 Wire gauge

Wire gauge general

Gauge for fly proofing shall be of the quality uniformly woven webbing of 23 meshes per square centimeter. The wire for the gauge shall be of best quality 22 SWG brass or copper wire or any other approved materials.

Other materials

Gauge known as "plastic gauge" may also be used as and when required by the Engineer.

1.22.15 Paints and protective materials

Knotting

Knotting shall be uniform dispersion of lac or suitable resin (natural or synthetic) in a suitable solvent.

White lead paint shall be made from pure white lead in accordance with BS 239, mixed with fine boiled linseed oil, turpentine, dryers and pigments and strained free from skins and all extraneous matter before being pigments. If so used, the quantity shall not exceed 8% of the paint mixed ready for the brush. No other ingredient except the colouring matter will be allowed and the colour shall be produced by using the least required amount of colouring matter. The proportions of the ingredients for the various coats shall be subject to the approval of the Engineer.

Red lead paint

Red lead paint shall be made from non-setting red lead in accordance with BS 217, thoroughly ground and well and freely mixed with approximately 15% of boiled linseed oil to give a paint with good covering power, bobby and adhesion. It shall be determined by tests to be made by the Contractor to the satisfaction of the Engineer. The Engineer may select samples of the paint for analysis after a sufficient quantity of the work about to be painted has been mixed.

Linseed oil putty

Putty for stopping and glazing shall consist of whiting/chalk powder thoroughly ground with linseed oil to form a smooth paste, and shall conform BS 544.

Varnishes/wood polish

The material is required to be clear and transparent and when applied shall on drying, give a glossy coating free from fun and specks. The composition of the varnish shall conform to the requirements of BS 274.

White wash

White wash shall be made from pure flat lime brought to the work in an unslaked condition. Water shall be added to this lime in a tub until the mixture is of the consistency of cream and shall be allowed to rest for a period of 48 hours. The mixture shall then be strained through an approved cloth strainer and 4 kg of gum boiled with 12 kg of rice and a suitable quantity of blue shall be added per cubic meter of the mixture.

Colour wash

Colour wash, where not of an approved proprietary brand, shall be made from pure selected fat lime as described above for white wash, to which shall be added and intimately mixed the necessary pigment to produce the tint specified. The pigment shall be to the approval of the Engineer.

Oil bound distemper

Oil bound distemper shall comply with BS 1053 Type-1 and shall be obtained from an approved manufacturer.

Emulsion paints

Robbialac/Berger/Elite Emulsion Paints shall preferably be used but the Engineer may allow any other brands of equivalent standard subject to the production of appropriate test certificates and guarantees.

Creosote

The Creosote is a paint used for preservation of timber. It shall be pure tar distillate of the best quality as obtained and sold under the trade name "SOLIGNUM". The 'SOLIGNUM' shall be clear so as not to mar the timber. Other brands equivalent to 'SOLIGNUM' may also be used, if only approved by the Engineer.

Storage and handling of paint, varnishes, etc.

Paints, varnishes, lacquers and thinners shall be kept in properly sealed or closed containers. The containers shall be kept in a well ventilated location, free from excessive heat, smoke, sparks or flames. The floor of the paint store shall have at least 100 mm thick loose sand on it.

Temporary electrical wiring and fittings shall not be installed in a paint store. When electrical lights, switches or electrical equipment are necessary to be stored or used in the same room, the room shall be designed in a way to reduce explosion risks.

Buckets containing sand shall be kept ready for use. A five-kilogram dry powder fire extinguisher conforming to accepted standards shall be kept at an easily accessible position close to the paint store.

1.22.16 Aluminium members

Aluminium doors, windows, curtain walls, etc. shall be of approved standard conforming to the U.S. Architectural Aluminium Manufacturing Association (AAMA) or equivalent specifications. The frames and sash members shall be of extruded shape made of 6063 – T5 high quality aluminium alloy having a minimum section thickness of 2mm unless otherwise shown on the Drawings or indicated in the BOQ and shall conform to the U.S. Aluminium Association or equivalent standard.

1.22.17 Structural steel for doors and windows

All steels used in doors and windows shall be the products of reputable manufacturer and shall conform to the American Standard Specifications. The sections, sizes and profiles shall be as per the requirements for a specific work as shown on the Drawings.

1.22.18 Pipes

M.S. pipe

M.S. Pipe shall be made from low carbon steel conforming to the requirements of ASTM A 53 and physical requirements as specified therein.

PVC pipe

PVC pipe shall be of unplasticized polyring/chloride and shall conform to BS 3500: 1968/3506:1969 or equivalent. The pipes shall be laid and jointed in accordance with the manufacturer's instructions and to the Engineer's satisfaction.

Storage and handling of pipe

Pipes shall be stored in stacks with stoppers provided at the bottom layer to keep the pipe stack stable. The stack, particularly of smaller diameter pipes, shall be in a pyramid shape. Pipes shall not be stacked more than 1.5m height.

Each stack shall have pipes of the same type and size only. Removal of pipes shall start from the top layer and by pulling from one end. A pipe shall not be stored inside another pipe. The pipes may also be placed alternately length and crosswise.

PVC pipes shall be stored in a shaded area. The ends of pipe, particularly those especially prepared for jointing, shall be protected from abrasion. Damaged portion of a pipe shall be cut out completely.

Pipes of conducting materials shall be stacked on solid level sills and contained in a manner to prevent spreading or rolling of the pipe. For storage in large quantity, suitable packing shall be placed between the layers. During transportation, the pipes shall be so secured as to prevent displacement/rolling.

1.22.19 Gunny bags

The gunny bags used in the permanent works shall be new, 50/75 kg capacity bags similar to those normally used. The Contractor shall submit sample bags to the Engineer for his approval.

1.23 MATERIAL TESTING

1.23.1 General

Notwithstanding the requirements stated in the detailed specifications for individual items, the following minimum tests shall be carried out in the LGED specific laboratories and in the field. In the cases the testing facilities are not available in the LGED laboratories, the tests shall be performed elsewhere as directed by the Engineer.

Contractor's Materials Engineer will be responsible for liaison and coordination with the Site laboratory, the Engineer, field sampling/testing staff and off-Site laboratories to ensure that all sampling, specified tests and inspections are carried out in a timely manner.

No inspection or approval by the Engineer shall relieve the Contractor of any of his duties and obligations under the Contract.

All test types and quantities described in the following Sub-sections are considered "Normal Testing" and anything beyond that in type and quantity is considered as "Special Testing". The Engineer may increase the frequency of testing as per requirement.

1.23.2 Tests

Bricks

For each consignment not exceeding 100,000 bricks, minimum 6 (six) bricks shall be tested to ascertain:

- ☐ Dimensions and unit weight
- ☐ Compressive strength
- ☐ Water absorption
- ☐ Efflorescence

Coarse aggregate

The tests mentioned below shall be carried out for each day's casting or per 15 cubic meter of concrete whichever provides the greater number of tests.

- ☐ Gradation
- ☐ Unit weight
- ☐ Water absorption
- ☐ Specific gravity
- ☐ Abrasion loss/Crushing loss

Fine aggregate

The tests mentioned below shall be carried out for each day's casting or per 15 cubic meter of concrete whichever provides the greater number of tests.

- ☐ Gradation
- ☐ Fineness Modulus (F.M.).
- ☐ Specific Gravity
- ☐ Water absorption
- ☐ Surface moisture

Cement

For each consignment of a particular brand not exceeding 25 tons, at least 3 (three) samples collected random shall be tested prior to the cement be incorporated in to the works to ascertain:

- ☐ Consistency
- ☐ Setting time
- ☐ Compressive strength
- ☐ Fineness

Reinforcement

For each consignment not exceeding 10 (ten) tons or as directed, 3 (three) representative samples of each size of M.S. bar shall be tested for:

- ☐ Cross sectional area
- ☐ Unit weight
- ☐ Measurement of deformation
- ☐ Yield strength
- ☐ Tensile strength
- ☐ Elongation
- ☐ Bending

Only Test Certificates issued by BUET or the concerned regional University of Engineering and Technology shall be accepted by the Engineer when the requisite test facilities are not available with the LGED Laboratories.

Test for water

Water will be tested to ensure that it remains free of oil, salt, acid, alkali, sugar, vegetable or other injurious substances.

Workability test for concrete

The Slump Test shall be carried out as frequently as required by the Engineer and not less than one per hour during placing of concrete.

Strength test for concrete

The compressive strength of the concrete shall be determined by Cylinder Test. The Cylinder moulds shall be 150mm in diameter and 300mm long. Each class of concrete shall be represented by at least six Cylinders. Not less than one group of six test Cylinders shall be made for each 30 cubic meter of structural concrete, but there shall be at least one group of six test Cylinders for each day's concrete work. For columns and girders, one set of test Cylinders would be made from each batch of concrete not exceeding one cubic meter. Samples from which compression test specimen are moulded, shall be obtained in accordance with the Method of Sampling Fresh Concrete (ASTM C 172). The concrete samples would be collected from a point just before final placement or as directed by the Engineer. Cylinders may be collected from any batch (load) including the first. Specimens made to check the adequacy of the proportions for strength of concrete or as a basis for acceptance of concrete shall be made and cured in accordance with methods and curing, concrete compression and flexure test specimens in the field (ASTM C 31 or equal). Strength tests shall be made in accordance with the method of test for compressive strength of moulded concrete cylinders (ASTM C 39 or equal).

Six Cylinders would form a set of sample for strength determination. Three Cylinders shall be tested at seven days and three cylinders shall be tested at twenty-eight days. Each and every twenty-eight days Cylinders shall attain the minimum specified compressive strength. The Contractor shall perform trial mix of his own to determine the characteristic strength or mean strength that has to be attained.

The twenty-eight days strength tests shall be used as a basis for acceptance of the concrete. Seven days tests are made to obtain advance information on the adequacy of strength development. Age-strength relationships shall be pre-established for the materials and proportion used.

Testing geo-textiles

Tests of mass per unit area, thickness and tensile strength in accordance with the Standards listed under the Section on 'Construction Materials' shall be carried out by an approved testing laboratory on samples taken from each quantity of 10,000 m² of geo-textile fabric supplied. The k and 090 values shall be tested on samples taken from every 50,000 m² of geo-textile fabric supplied. Seams shall be tested for tensile strength every 10,000 m of seam.

The geo-technical test results of the underlying embankment soil together with the manufacturer's specification and installation instructions for the proposed cloth, including permeability and porosity (with methods of testing) and a sample of the cloth shall be submitted for the approval of the Engineer.

The sample size for the fabric shall be 2 square meter and shall be marked to indicate its upper side, longitudinal and transverse directions, type of geo-textile and the date that the sample was taken. Seam samples shall be at least 1m in length and the ends of the threads are to be firmly tied by the Contractor or Supplier at the time the samples are taken. Each test shall be carried out on at least five samples.

The Contractor shall bear the expenses of all routine tests. Notwithstanding the submission of reports to the effect that the geo-textile conforms to the Specifications, the Engineer shall at all times be entitled to have additional samples of geo-textile tested, if he is of the opinion that the geo-textile does not conform to the Specifications. The Engineer shall only select samples from ends of geo-textile rolls or geo-textile, which has been cut already.

A geo-textile will be regarded as defective, if any of the specified values is not achieved other than those of unit weight and effective opening size, for which the following tolerances will be permitted:

(a)	Single layered geo-textiles:		
	Unit weight	-	minus 10%
	O90	-	plus or minus 20%
(b)	Composite geo-textiles:		
	Total weight	-	minus 15%
	Single layer weight	-	minus 20%
	O90	-	plus or minus 20%

1.23.3 Expenses for tests

All expenses for the tests as stated in the above Sub-sections would be borne by the Contractor unless otherwise provisions are made in the Tender Documents.

Any tests instructed by the Engineer both in type and quantity beyond those specified above shall be paid to the Contractor, if not specific instructions are there under the concerned items of the Tender Documents.

1.24 OFFICE SPACE AND FACILITIES FOR THE ENGINEER

1.24.1 Field office, Office equipments and stationary articles

In addition to the office space required for his own use, the Contractor shall provide and maintain Field Office with toilet facilities, furniture and office equipment for the use of the Engineer and his staff.

Field Office for the Engineer shall mean a building having a minimum 15 square meter net clear internal floor area exclusive of walls and partitions, staircase and toilet and have number of rooms as required by the Engineer. It shall be constructed in 250mm thick brick wall in appropriate cement mortar with C.I. sheet roofing and a protective ceiling made of hard board and timber to the satisfaction of the Engineer. The floor shall be 75mm thick lean concrete with 30mm thick mortar on the top with a neat cement finish to give a smooth look. The foundation of this building shall be sound to the satisfaction of the Engineer. The building shall have required number of doors and windows. Uninterrupted power supply facility, if necessary, shall be made available by means of arranging a stand-by generator.

Access road to the Field Office, sufficient parking accommodation and hard standing sheds for vehicles along with boundary fencing shall be constructed by the Contractor.

The Contractor shall provide, for each office, one office table and four chairs of standard, approved by the Engineer. Safety helmets in adequate numbers be always made available for use of the staff and the visitors.

Offices shall be maintained watertight and shall be provided with ventilation. All doors shall be fitted with approved locks. Windows shall be provided with separate screens and blinds and shall have interior locking devices too.

All offices, complete with furnishings, fittings, access roads and hard standings, shall be ready, for occupation by the Engineer within four weeks of the date when the Contractor first occupies the Site.

All offices shall be regularly and properly cleaned as long as they are in use.

All access roads and hard standings shall be maintained in a convenient trafficable condition throughout the Contract period.

The general location of the Field Office shall be decided by the Engineer in consideration of the Contractor's Work Plans. The Field Office shall be situated at locations that shall be free from flooding.

The Contractor shall submit for the approval of the Engineer, along with the Tender, Plans and Drawings showing the details for the building including plans and designs for foundations, access roads, sheds, etc. Plans shall also be submitted showing architectural and structural details and the proposed layout of electrical and running water supply, roads and hard standings thereto. The Engineer may require revision of the said plan prior to the approval for construction.

Prior to the occupation of the office, the Engineer may specify to the Contractor the defects in the work whereupon he may occupy the office and withhold payment for the work in this item until the Contractor remedies and makes good the said defects to the satisfaction of the Engineer.

On completion of the Contract the Field Office including furnishings shall become the property of the Employer.

Office equipment and stationary articles

The Contractor shall require to purchase and supply the following Office equipment and consumables to the Engineer:

- (i) One Computer (English) of approved brand with printer and Auto CAD facilities
- (ii) One Photocopy Machine (A3 size)
- (iii) Minor items of field office equipment such as file trays, punches, staplers etc. in reasonable number/quantities as requested by the Engineer.
- (iv) Consumables such as papers, pens, files etc. in reasonable number/quantities as requested from time to time by the Engineer.

Upon completion of the Contract, the office equipment listed above shall remain the property of the Employer.

Survey equipment

As per requirement of the program, survey equipment shall be provided on each contract Site for use by the staff of the Contractor and the Engineer. A tentative list of such survey equipment is given below:

Optical square	1 no
Spirit level (metal 1m long)	1 no.
Steel measuring tape 25m long	1 no.
Steel measuring tape 5m long	1 no.
Leveling staff 3m long	1 no.
Ranging poles	5 nos.
Surveyor's plumb bob	1 no.
Wild T-1A Theodolite with tripod (or equivalent)	1 no.
Wild NA-2 Automatic level with tripod (or equivalent)	1 no.
Traversing targets with tripods	1 no.
Magnetic Compass	1 no.

Miscellaneous tools and minor items of survey equipment such as umbrellas, hammers, knives etc. shall be made available at Site in reasonable numbers at all times for use by the staff of the Contractor and the Engineer.

Consumables such as pegs, stakes, string lines, paint, marking crayons, etc., shall be made available at Site in reasonable numbers and quantities at all times for use by the staff of the Contractor and the Engineer.

Upon completion of the Contract, the survey equipment listed above shall remain the property of the Contractor.

Offices and equipment

The Contractor shall provide and maintain an inventory of all furnishings and equipment and shall replace any equipment, which is lost or irreparably damaged subject to the condition that the Engineer shall ensure his staff to take all reasonable precautions in the handling, operation and transportation of such equipment.

The Contractor shall pay all expenses in respect of water, electricity (where available), garbage cleaning etc. necessary for running the Office and maintaining conducive environment.

The Contractor shall place all necessary support staff such as office boys, cleaners, messengers, road-men, chain-men etc. in required number to the Engineer and his personnel in smooth performing of his responsibilities.

1.24.2 Signboards

The Contractor shall supply, erect and maintain in good condition at least two Identification Signboards of sizes to be specified by the Engineer to be fixed one at each end of the Work at a place clearly visible to the public. The Signboards shall be mounted on steel pipe frames with the required sizes at a height 2m above the ground and shall be sufficiently strong to withstand the wind forces. The board shall be fabricated from steel angle and plates and painted with suitable colours and written in English and/or Bengali as per direction of the Engineer.

Each board shall display:

- The name of the Project
- The name of the Work
- The name of the Employer
- Contract value
- Date of commencement of work
- Date of completion of work
- Other particulars, which will be asked by the Engineer.

1.24.3 Progress in photographs and videos

Photographs and videos showing the progress of works and special photographs showing particular features or other matters of interest in connection with the Work or their surroundings shall be taken every month by an approved qualified photographer/cameraman to the choice of the Engineer. Number of photographs/video clips will not exceed 10 (ten) per month.

Four colour un-mounted prints of a size 250mm on approved photographic paper of every such photograph inscribed with its serial number, date of shooting and a short title shall be furnished to the Engineer every month.

All negatives and video clips shall be numbered, filed and retained at the Site. On completion of the Contract, those shall become the properties of the Employer and shall be handed over to the Employer by the Contractor.

6 (six) complete sets of colour prints of the finished permanent Work, not exceeding 20 (twenty) photographs in number, shall be taken when and as directed by the Engineer prior to finally granting the Contractor the Certificate of Completion and shall be suitably mounted, titled and supplied to the Engineer.

1.24.4 Measurement and payment

Provisions for Office space and facilities for the Engineer shall not be measured.

Payment for all the items as stated below shall be for the full period of the Contract including any extension, if allowed.

Payment for all equipment, signboards, photographs, video clips, services etc. of the Field Office detailed in this Sub-section shall be made as described below, where price and payment shall be the full compensation for complying with this Section of the Specification and the Conditions of the Contract.

Payment of rates for the pay items shall be the full compensation for supplying, erecting and maintaining the Field Office for the Engineer including all furniture, fixtures and fittings, access roads, office equipment, signboards, photographs, video clips etc. all in full compliance with the requirements of this Section.

No separate payment shall be made to the Contractor for providing the requisite tools, minor items and the consumables. Compensation for these items shall be deemed to be included in the other pay items of the BOQ.

Pay Items shall be:

Clause	Description	Unit of measurement

1.24.5	Supply, erection and maintenance of Signboards	Lump sum

1.24.6	Providing, erection and maintenance of Office for the Engineer including all office equipment and consumables	Lump sum

1.24.7	Providing photographs	Lump sum

1.25 PREPARATION & REMOVAL OF EXISTING STRUCTURE

1.25.1 Site preparation

1.25.1.1 Description

This item of work shall consist of clearing the Site, undertaking general type of earthworks, setting out, etc. as shown on the Drawings, stated in the BOQ and/or as instructed by the Engineer.

1.25.1.2 Commencement

The Contractor shall give the Engineer at least 7 (seven) days written notice of his intention to commence work on any part of the Site. Works shall not be commenced until written approval has been received by the Contractor from the Engineer.

1.25.1.3 Drawings

The works are to be carried out in accordance with the Drawings and as directed by the Engineer. It may become necessary or desirable, during the progress of the Work, to change any feature shown on the Drawings in accordance with the actual field conditions. Whenever this may occur, the Contractor shall perform the required works to the revised dimensions in accordance with the written instructions of the Engineer.

1.25.1.4 Setting out

Prior to the commencement of the Work, the Contractor shall study the Drawings and fully understand all aspects of the Work and co-relate the same with the dimensions shown on the Structural Drawings and shall fix up the alignment, set the Bench Mark (B.M) pillars, levels, pegs etc.

The Contractor shall check all the vital measurements of the layout plan of the building and submit a report to the Engineer the deviation, if required any from the dimensions shown in the approved Drawings for the building before starting construction works. In case of any deviation of unacceptable amount, the Engineer will inform the Contractor of the remedial measures, which may be necessary under a particular situation.

Cutting or filling charts, prepared by the Engineer, will be given to the Contractor to sign as a token of his agreement.

1.25.1.5 Earthworks, general

Earthwork shall be undertaken to the lines and levels shown on the Drawings unless directed otherwise by the Engineer. In carrying out the earthworks, the Contractor shall take all necessary precautions to avoid damage to or deterioration of the earthwork materials and existing ground.

1.25.1.6 Cleaning of site

The Site shall be cleared as required to remove all stumps, roots, vegetable and other objectionable materials specifically within the areas for construction of structure, appurtenance and any other facilities indicated on the Drawings or designated by the Engineer. The cleared materials shall be deposited on the approved off-Site areas or burnt as directed by the Engineer.

1.25.1.7 Measurement

The works on Site preparation shall not be measured.

1.25.1.8 Payment

No direct payment shall be made for works required under this Section. Costs for such works shall be deemed included in the related items of the BOQ.

1.25.2 Demolition and removal of existing structure**1.25.2.1 Description**

This item of work shall consist of satisfactory dismantling, removal and disposal of salvage, wholly or in part, of all existing structures and sub-structures within the Site as indicated on the Drawings or in the BOQ and/or as instructed by the Engineer. This item of Work shall also include taking all safety and precautionary measures so as to protect the adjoining properties and the public from any possible accidents.

1.25.2.2 Planning

The Contractor shall engage one experienced Engineer who shall carry out a detailed survey work and a study of the structures to be demolished and the structures in their surroundings before commencing the demolition work. He shall then plan the sequence of operations. The plan shall be approved by the Engineer before any works starts.

The Engineer shall notify the neighbours and the public well about the intended demolition through media. The extent, duration and time of the demolition shall be clearly stated in the notification.

1.25.2.3 Precautions and protection

Protection of adjoining properties

Notification shall be made in writing to the owner of each potentially affected plot, building or structure at least a week before the commencement of works.

The Contractor shall under all circumstances preserve and protect the adjoining plots, buildings or structures from any damages or injuries. This shall be done at his own expenses.

When damage to the adjoining property is imminent, the demolition operation shall be stopped forthwith and shall not be re-started until the necessary measures to prevent such damage have been taken.

Protection of public

The Contractor shall make safe distances and posts prominent signs. He shall either close or protect every sidewalk and road adjacent to the Site. All public roads shall be kept open and unobstructed at all times unless unavoidable circumstances arise.

If a covered walk is considered not necessary, the sidewalk shall be blocked and diversion roads or alternate protection shall be provided.

Precautions prior to demolition

The Contractor shall ensure taking the following precautionary measures prior to any demolition works starts:

- Demolition of any building shall not commence until the required pedestrian protection structures have been built. Dilapidated buildings or structures shall be protected from collapse by way of bracing, shoring, etc. before demolition starts.
- Danger sign shall be posted round the property. All entrances shall be barricaded or manned. Warning lights shall be placed above all barricades during night and dark hours. Watchmen shall be employed to prevent unauthorized entry of the public in the danger zone.
- All utility lines shall be disconnected upon the approval of the relevant Authorities. Temporary service connections for the demolition work shall be taken separately.
- The Site shall be thoroughly cleaned of all combustible materials. All materials of fragile in nature like glass, sanitary fixtures, etc. shall also be removed from the Site.
- Workmen shall be provided with all necessary safety appliances prior to the start of works. Safety precautions for fire shall be provided.

Precautions during demolition

The Contractor shall provide protection against all damages or loss to life and property during, demolition. The Engineer shall depute an experienced and competent Representative to provide constant supervision during the entire period when the demolition works will be carried on.

The Contractor shall make all suitable arrangements to control dust. He shall ensure necessary stacking of all materials and debris in a way as have been stated in the relevant Section/Sub-sections of this Specification.

The demolition Site shall be provided with natural and artificial lighting and ventilation arrangements, which shall be the responsibilities of the Contractor.

The Contractor shall well protect all existing features required during demolition operations with substantial covering to the entire satisfaction of the rules and regulations of the undertakings or they shall be temporarily relocated.

For a building or structure of more than 8m or two storeys in height, all windows and exterior wall openings that are within 6m of floor opening and being used as the passage for debris, shall be solidly boarded. Openings in floors below the level of demolition, not used for removal of materials or debris, shall be barricaded or covered by planks.

1.25.2.4 Performance method

Where a structure is to be replaced, the existing structure shall be demolished to a level up to the bottom of the foundation of the new structure or as directed by the Engineer.

Sequence of demolition operation

In case of a structure to be demolished becomes a building, the following steps and procedures shall be followed:

- The demolition shall proceed in descending order and storey by storey. All works in the upper floor shall be completed and approved by the Engineer prior to disturbing any supporting member on the lower floor. Demolition of the structure in sections may be permitted in exceptional cases only if necessary precautions are ensured.
- Walls shall be removed part by part in reasonably level courses. No wall or any part of the structure shall be left in a condition that may collapse or be toppled by wind, vibration etc.

Fall of the demolished wall in large chunks, which endangers the adjoining property or exceeds the safe load capacity of the floor below, shall be avoided. Debris shall be removed at frequent intervals to avoid piling up and overloading of any structural member.

Platforms shall be provided for demolition of walls less than one and half brick thick. Lateral bracing shall be provided for sections of walls having a height more than 22 times its thickness, or otherwise

considered unsound. No workman shall stand on any wall to remove materials. Staging or scaffold shall be provided at a maximum of 3.5m below the top of the wall.

At the end of each day work, all walls shall be left stable to avoid any danger of getting overturned. Foundation walls, which serve as retaining walls shall not be demolished until the adjoining structure has been underpinned or braced and the earth removed.

- Support/centering shall be provided prior to removal of masonry or concrete floor. Planks of sufficient strength shall be used in shuttering. No person shall be allowed to work in an area underneath a floor being removed; such areas shall be barricaded.

The total area of a hole cut in any intermediate floor for dropping debris shall not exceed 25% of that floor's area. No barricades or rails for guarding the floor hole shall be removed until the storey immediately above has been demolished down to the floor line and all debris cleared from the floor.

In cutting holes in a floor, which spans in one direction, a maximum 300mm wide slit shall be cut at first along the entire length of the slab. The slit shall be increased gradually thereafter.

Planks of sufficient width not less than 50mm thick, 250mm wide and 2m long shall be provided at spacing not greater than 400mm for the workmen to work. These shall be so spaced as to firmly support the workmen against any floor collapse.

- Use of explosives will not be permitted except directed by the Engineer. When explosives are required for blasting, requisite procedures are to be followed and adequate safety measures are to be insured.
- The Contractor shall have to arrange at the Site all plant, machinery and equipment at his own initiative together with making necessary techniques, arrangements and methods.

1.25.2.5 Disposal of demolished materials

Demolished materials shall be disposed off according to their salvage value.

If the salvaged superstructure or any portion of the structure is deemed fit for re-use elsewhere, the usable portions shall be marked and removed without any damages and stockpiled neatly at an accessible point above the highest water level within the Site or at a place as directed by the Engineer.

All other usable materials shall be stockpiled within the Site.

The Contractor shall remove all materials, classed as waste and not considered of value by the Engineer, from the Site but within the limits of the Site at his own expenses. Debris shall be removed from the Site as soon as possible. Priority shall be given to dispose off combustible materials immediately. Materials like glass, nails shall not be strewn about. Standard precautions shall be taken to prevent fire from debris.

1.25.2.6 Materials

All materials so removed/salvaged shall be the property of the Employer unless otherwise specifically stated in the Contract. Any materials, not required by the Employer, shall be classed as waste.

1.25.2.7 Measurement

All activities as described above under this item of work are the responsibilities of the Contractor except otherwise stated.

The Work shall be measured according to the types of structures and shall be measured in cubic meter/ metric ton.

1.25.2.8 Payment

Demolition and removal of existing structures as measured above shall be paid at the Contract unit price per cubic meter or metric ton depending upon the type of works and the price quoted in the Contract. The payment shall be the full compensation for all dismantling, removal and disposal of all debris with carriage, stacking of usable materials, taking all safety measures, all allied items, all

labour, equipment, tools and incidentals necessary to complete the work strictly in accordance with the stated Specifications.

Pay Items shall be:

Clause	Description	Unit of measurement
1.25.2	Demolition and removal of existing structure	
(C/C, R.C.C, Brick work, Timber)		Cubic meter

1.26 EXCAVATION AND BACK-FILL FOR STRUCTURES

1.26.1 Description

This item of work shall consist of excavation in any type of soil/material for the foundation of structures, disposal of excavated materials, construction and removal of cofferdams, sheeting and other temporary works in protecting the stability and safety of the excavated foundations, pumping, de-watering/bailing water from foundations, back-filling of completed structures with suitable back-fill.

No separate payment shall be made for the excavation and back-fill for structures when the works will involve use of cofferdams. The costs of this temporary work shall be deemed included as part of the Tender sum.

The Work shall be carried out at the locations and according to the lines, levels, grades and dimensions shown on the Drawings, stated in the BOQ and/or as directed by the Engineer.

1.26.2 Materials

Excavated material

The Engineer shall classify all excavated materials either as suitable for fill or as waste.

Approved suitable excavated materials free from large lumps, wood or other objectionable materials shall be placed as back-fill above the level of pile except where other materials are shown on the Drawings, stated in the BOQ and/or required by the Engineer.

Ordinary fill

Ordinary fill consists of earth having Liquid Limit not exceeding 50 (STP T3.2) and Plasticity Index not exceeding 20 (STP T3.2) and shall be used as back-fill material above the level of pile caps and areas except where other materials are shown on the Drawings, stated in the BOQ and/or required by the Engineer.

Sand

Unless otherwise stated on the Drawings or in the BOQ or ordered by the Engineer, back-fill material below the top level of pile caps shall consist of sand free from chemical contamination with not more than 10% of the material passing the No. 200 sieve (U.S. size). All other specifications should conform to what have been illustrated under the relevant Sub-section of this Specification. The sand to be used shall be approved by the Engineer prior to placing.

Blinding concrete

Blinding concrete shall be placed as backfill as shown on the Drawings, stated in the BOQ and/or ordered by the Engineer. The material shall conform to the specifications stated below:

Cement

Cement shall conform to the requirements of ASTM specification C 150 Type 1 or similar approved standard for normal Portland cement.

Cement shall be free from any hardened lumps and foreign matter. It shall have a minimum of 90% of particles by weight passing the 75 micron sieve, an initial setting time in excess of 45 minutes and a final setting time of not more than 375 minutes.

All other specifications should conform to what have been illustrated under the relevant Sub-sections of this Specification.

Coarse aggregate

Except otherwise stated, coarse aggregate shall consist of hard, durable angular fragments of crushed stone and/or crushed natural gravel conforming all other specifications illustrated under the relevant Sub-section of this Specification.

Fine aggregate

All specifications should conform to what have been illustrated under the relevant Sub-section of this Specification.

Water

Water shall be subject to the approval of the Engineer and shall be reasonably clear, free from oil, alkali, salts, acid and organic substances and other deleterious materials or objectionable quantities of suspended materials. All other specifications shall be in accordance with the requirements illustrated under the relevant Sub-section of this Specification.

1.26.3 Construction methods

Excavation

The Contractor shall notify the Engineer before commencing excavation of the foundation trenches so that the cross-section, elevations and measurements of the undisturbed ground may be taken. The natural ground adjacent to the structure shall not be disturbed without taking any permission from the Engineer.

Trenches and foundation pits for structures shall be excavated to the lines, grades and elevations as shown on the Drawings or as directed by the Engineer. The elevations of the bottom of the foundations shown on the Drawings are approximate only and the Engineer may order such changes as deemed necessary to provide a secured foundation.

Where unstable soil is encountered at the bed level, it should be brought to the notice of the Engineer and all such unstable soil shall be removed as directed and replaced with suitable materials to provide adequate support for the structure.

On acceptance of the materials forming the bottom of any excavation by the Engineer subsequently becoming unacceptable to him due to exposure to weather condition or due to flooding or have become puddled, soft or loose during the work process, the Contractor shall remove such damaged, soft, or loose materials and make additional excavation as per requirement. Such additional excavation shall be held as excess excavation and the cost of the excess excavation and subsequent replacement with a suitable back-fill shall be at the expenses of the Contractor.

Any erroneous excavation or excess excavation for the conveniences of the Contractor, or over excavation performed by the Contractor for any purpose or reasons shall be at the expenses of the Contractor. If the excavation for foundations exceeds the depths specified, the Contractor shall brought it back to the specified levels with sand, mass concrete or other approved materials conforming Standard Specifications at the Contractor's own expenses.

Excavation shall be sufficiently large to provide necessary working space, shuttering and any other Temporary Works required during construction.

Boulders, roots and any other objectionable materials encountered in excavation, shall be removed. The excavated foundation shall be cleared of all loose materials and cut to a firm surface.

When the footing is to rest on the ground and not on piles, special cares shall be taken not to disturb the bottom of the excavation and excavation to final grade shall be deferred until immediately before the footing is placed. If foundation fill material is required, it shall be placed and compacted in layers not more than 150mm thick or as directed by the Engineer. The dry density on compaction within 300mm below the top level shall not be less than 100% maximum dry density as determined in accordance with STP T4.5 (standard compaction).

In excavating foundation trenches, the last 150mm layer shall not be excavated until immediately before commencing the construction work except that the Engineer shall instruct otherwise. Any damages to the work due to the Contractor's operation shall be repaired at the expenses of the Contractor.

The Contractor shall be solely responsible for the safety and stability of the excavation and shall provide all protective supports, bracing, sheet piles, shoring etc. as required. Shoring should be adequate to provide enough safety to all the adjacent structures and land.

Excavated materials, classified as suitable for fill, shall be stockpiled. Waste materials and suitable fill materials in excess of requirement, shall be disposed of by the Contractor outside the limits of the Site.

The foundation material shall be cleared of all loose and displaced materials and cut to a firm surface, either leveled, stepped or serrated, as specified or shown on the Drawing or directed by the Engineer leaving a smooth solid bed to receive foundation.

No footing, bedding material or structure shall be placed on any foundation until the Engineer has inspected and approved the depth of excavation and the foundation materials.

Poor foundation material

When, in the opinion of the Engineer, the bottom of any excavated foundation is of soft or otherwise unsuitable material, the Contractor shall remove the unsuitable material and fill with sand or blinding concrete at the direction of the Engineer. The sand or concrete shall be placed following the procedures specified for back-filling. Sand shall be clear, all passing a No.4 sieve (U.S. size).

When the ground between the piles is too soft to support the green concrete, the Contractor shall submit his proposal for a bottom form to the Engineer for his approval. Extra excavation and foundation-fill or concrete-fill in such case will not be paid separately.

If the bottom form is carried out by strengthening the ground in the aforementioned way, the Contractor shall, if requested, submit calculations showing that the pile cap will not be harmed during hardening due to differential settlement between the piles and the strengthened ground.

Disposal of excavated material

All excavated materials, so far accepted by the Engineer as suitable, shall be utilized as back-fill or embankment-fill. The surplus materials shall be termed as waste.

Excavated materials, suitable for use as back-fill, shall be deposited by the Contractor in spoil heaps at points convenient for re-handling of the materials during the back-filling operations.

Excavated materials shall be deposited in such places and in such a manner as not to cause damage to roads, services or properties either within or outside the project area and so as to cause no impediment to the drainage of the Site or surrounding areas. The location of spoil heaps shall be subject to the approval of the Engineer.

Waste materials shall be disposed of in accordance with the instruction of the Engineer.

Pumping and bailing

The foundation shall be kept free from water at all times during the construction period. The ground water level shall be maintained at a minimum of 0.9m below the lowest designed excavation level.

Pumping and bailing from any foundation shall be done so as to preclude the possibility of the movement of water through or alongside any concrete being placed. No pumping or bailing will be permitted during the placing of concrete and for at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall or from well points.

The Contractor shall be solely responsible and include in his rates all costs in designing the de-watering system, providing all equipment and accessories required for de-watering. The rates shall also include cost for transportation, furnishing, installation, safe operation and maintaining of the system including operators, mechanics, the supply of power, fuel, lubricants, spares, repairing, etc.

throughout and the removal of the equipment at the end of the construction period under this Contract.

Excavations shall be as dry as possible prior to and during placing concrete. Placing of concrete under water will only be permitted if indicated on the Drawings or approved by the Engineer.

Back-filling

All excavated spaces shall be back-filled around the permanent structure to original ground level. Prior to placing back-fill, all trash, metal, debris, lumber, bricks, soft materials and similar objectionable foreign materials shall be removed from the area to be back-filled. No back-fill shall be placed against any structure without the prior permission of the Engineer.

Any protective support, bracing or shoring shall be removed, as the back-filling progresses in such a manner as to prevent caving-in.

Back-fill shall be of approved materials that will produce a dense and well-compacted filling. The material shall be free from large lumps, organic or extraneous materials.

Ordinary fill placed as back-fill shall be laid and compacted. The moisture content of the fill materials, before compaction, shall be within + 5% of the Optimum Moisture Content. Each layer of materials shall be compacted uniformly using approved compaction equipment and procedures. The materials shall be compacted to achieve not less than 90% Maximum Dry Density (STD) beneath the bottom level. The dry density, after compaction within 300mm below the top level, shall not be less than 95% Maximum Dry Density as determined in accordance with STP and soaked CBR (4 days) should be greater than 4% at 95% Maximum Dry Density. The compacted layer shall be approved by the Engineer before the Contractor can commence a new layer.

Sand back-fill shall be placed and thoroughly compacted in layers of not more than 150mm. Sand should be clear, all passing a No. 4 U.S. Standard Sieve and conforming generally to ASTM C 144 for fine aggregate with F.M. not less than 1.2 or as required by the Engineer.

Layers of filling shall be tested as directed by the Engineer. Each compacted layer shall not be covered until the Engineer is satisfied that the specified degree of compaction has been achieved.

In placing back-fill, the materials shall be placed in, as far as possible, to approximately the same height on each side of the structure. If conditions require appreciable higher back-filling on one side, the additional materials shall not be placed until permission is given by the Engineer on being satisfied by himself that the structure has enough strength to withstand any created pressure.

In general, no structure shall be subject to the pressure of back-filling until 3 (three) days on expiry of the period designated for removal of forms. This period shall be extended if abnormal curing conditions exist.

Adequate provisions shall be made for drainage during placing back-fill.

Cofferdam

The term "cofferdam" denotes any temporary or removable structure, constructed to hold the surrounding earth, water or both, out of the excavation whether such structure is constructed of earth, timber, steel, concrete or any combination of these. The term includes earth dikes, timber cribs, sheet piling, removable steel shells and all bracings and it shall be understood to include excavation enclosed by pumping wells and well points.

Cofferdams shall be constructed so as to control water to preclude sliding and caving-in of the walls of the excavation.

The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction and removal of any required forms and the inspection of the interior and to permit pumping.

If possible, cofferdams shall be so designed that no cross bracing shall be left in place. If this is not possible, bracing left in place shall be of structural steel. The end of such structural members that would be exposed when the structure is completed shall be boxed back at least 50mm behind the face. The resulting holes shall be completely filled with concrete.

In general, sheet-piling cofferdams shall extend well below the bottom of the footings and shall be well braced and made maximum watertight.

When conditions are encountered which, in the opinion of the Engineer, render it impossible to de-water the foundation before placing of brickwork or concrete, the Engineer may require the construction of a concrete foundation or seal. This shall be placed as directed by the Engineer. The foundation shall then be de-watered and the footing placed.

When foundation piles are to be driven inside a cofferdam and it is judged impossible to de-water the cofferdam before placing concrete, the excavation may be extended below the design level to a depth sufficient to allow for swell of the materials during pile driving operations. Any materials that rise above the design level shall be removed.

Where it is possible to de-water the cofferdam, the foundation materials shall be removed to exact grade after the foundation piles are driven.

The natural streambed adjacent to the cofferdam shall not be disturbed without the permission of the Engineer. Any excavation adjacent to the cofferdam shall be back-filled to the original ground level to the satisfaction of the Engineer.

Unless otherwise provided, cofferdams shall be removed on completion of the structure without disturbing or marring the finished work. The Engineer may order the Contractor to leave any part or the whole of the cofferdam in place and this shall not entitle the Contractor to claim for any additional payments.

The Contractor shall submit Drawings showing his proposed methods of cofferdam construction. However, the Contractor shall remain fully responsible for the adequacy of the design for strength and stability and for the safety of the people working therein.

1.26.4 Measurement

The volume of excavation and back-fill shall be measured in cubic meter.

The quantity of excavation for structures to be measured for payment shall include excavation for all structures.

Back-filling with previously excavated materials shall not be measured or paid for separately but shall be deemed included within the rate for excavation.

Volumes to be excavated for blinding concrete shall not be measured and the price for the excavation thereof shall be included in the above measured item for excavation and back-fill.

Back-fill with concrete or sand, where directed by the Engineer, including concrete seals shall be measured separately as the volume within the plan outline and top and bottom surfaces. Concrete or sand, placed to back-fill excavation beyond the excavation required, will not be measured for payment.

If sand fill is ordered over top level of pile cap, the fill shall be the specified filling volume measured on the Drawings up to the profiles agreed upon in writing by the Engineer.

Removal of cofferdams, slides, silting or filling, if required, shall neither be measured nor paid for.

1.26.5 Payment

The work measured shall be paid for at the Contract unit prices per cubic meter as shown in the Bill of Quantities. The payment shall be the full compensation for all excavations and back-filling for structures including supply of all materials, labour, equipment, tools and incidentals necessary to the successful completion of the work. The payment shall also be the full compensation for excavation and subsequent back-filling of working space around the foundation structure for shoring and other protective supports, for construction and removal of cofferdams, for de-watering and for disposal of surplus excavated materials by hauling to any distance at approved locations.

Should it be necessary, in the opinion of the Engineer, to lower the footings to an elevation below the level shown on the Drawings, payment for the excavation and backfill for structures required below

plan level down to and including an elevation 1.5m below plan level for any individual footing will be made at a unit price equal to 115% of the Contract unit price and payment for the excavation from an elevation greater than 1.5m below plan level down to and including an elevation 3m below plan level will be made at a unit price equal to 125% of the Contract unit price for "Excavation and Back-filling for Structures". No additional extra compensation will be allowed for any required cofferdam adjustments arising from such lowering of footings.

In case where the extra depth required for any footing or footings exceeds 3m, a supplementary agreement shall be made covering the quantities recovered from depths in excess of 3m below the plan grade.

Payment for Back-filling shall be included in the pay item for "Excavation and Back fill for Structures" except for sand fill and concrete fill. These fill types shall be measured as provided above and paid for at the concerned Contract unit prices. However, no compensation shall be made for less Back-filling with excavated materials or more surplus to waste in the pay item of "Excavation and Back-filling for Structures".

All payments for the Back-filling and compaction of those areas, which were removed as structural excavation shall be included in the appropriate unit rates as shown below.

Pay Items shall be:

Pay Items shall be:

Clause	Description	Unit of measurement
1.26	Excavation and back-fill for structures	Cubic meter
1.26	Concrete back-fill for structures	Cubic meter
1.26	Sand back-fill for structures	Cubic meter

1.27 DE-WATERING SYSTEM

1.27.1 Description

This item of work shall consist of draining out of surface water and/or controlling water accumulated from any source that may require the use of pumps, other mechanical devices or the use of well point or tube-well system. All works to be carried out as per the stipulation of the BOQ and/or as instructed by the Engineer.

1.27.2 Types of de-watering system

One or both of the following de-watering systems shall be adopted considering the actual field conditions and requirements for proper execution of work.

- ☐ De-watering by Sub-surface Water Control System
- ☐ De-watering by Surface Water Control System

1.27.3 Contractor's responsibilities

The Contractor shall be solely responsible and include in his rates for the following tasks:

- ☐ The design of the de-watering system including the collection of the requisite data, preparation of Plans and Drawings of the necessary de-watering system.
- ☐ Providing all equipment and accessories required for de-watering by the Surface Water Control System and Sub-surface Water Control System for satisfactory execution of the work.
- ☐ Transportation, furnishing, installation, safe operation and maintaining of the system including operators, mechanics, supply of power, fuel, lubricants, spares, repairing, etc. throughout and the removal of the equipment at the end of the construction period under this Contract.

The Contractor shall provide continuous supervision of the system by the persons competent to recognize adverse conditions as they develop and take immediate corrective measures. The supervisor whose name and hours of duty duly furnished to the Engineer by the Contractor, shall have thorough knowledge of the system including the ability to make minor emergency repairs.

The control of water throughout the time of this Contract shall be the full responsibilities of the Contractor. The ground water table shall be maintained at minimum of 0.9m below the lowest designed excavation level. Control methods shall be subject to the approval of the Engineer including the Contractor's equipment, plans, methods, installation and operation procedures, etc.

The control methods adopted by the Contractor shall be subject to the approval of the Engineer including equipment, plans, methods, installation, operation, monitoring, maintenance procedures and precautions against the failure of any part of the system. The precautions shall include sufficient standby pumping plant and essential spare parts. The standby pumping plant shall comprise at least one pump and the standby pumping capacity shall be at least 10% of the total working capacity.

1.27.4 Site information

Any sub-soil investigation conducted by the LGED will be made available for the Contractor's review. The LGED assumes no responsibility regarding the correctness of these data. It is the responsibility of the Contractor to verify all sub-surface conditions prior to submitting his tender.

1.27.5 De-watering by sub-surface water control system

General

De-watering by Sub-surface Water Control System is defined as controlling water accumulated from any source requiring the use of well point or tube-well system.

Works to be performed under this Section include furnishing, installing, maintaining, operating and removing the sub-surface water control system including observation wells, so that the required excavation can be safely and properly performed and the structure built and back-filled to the elevation as shown on the Drawings.

Precautionary measures

Excavation shall not be made below a level 1m above the ground water level shown to exist by the water level in the observation wells. If the distance to the ground water table becomes less than 1m or the Engineer has any reason to believe that rising ground water is likely to endanger either the open excavation or the structure, back-filling may be ordered by the Engineer as a precaution against failure.

If for any reason, ground water control is lost and ground water appears in any portion of the excavation, the Contractor shall take immediate action to control and confine the flow. Any portion of the final grade which, in the opinion of the Engineer, has been damaged by the action of the ground water, shall be excavated as directed by the Engineer and back-filled in accordance with the Specifications at no extra cost to the Contract.

If it becomes necessary for any reason to stop the sub-surface de-watering operations before the construction of sub-structure is complete, the Engineer may order the Site to be flooded up to the surrounding ground water level as de-watering is discontinued. Under no circumstance shall the Site be flooded by allowing the ground water to rise through the soil. If it becomes necessary to flood the Site as described above, all equipment that can be damaged shall be removed to safety/a safe place.

The cost of all such back-filling, flooding and subsequent draining and re-excavation shall be included in the lump sum price for de-watering and no extra payment beyond the Contract price will be allowed.

Operation

The sub-surface De-watering System shall be operated 24 hours of a day on all days of a week during the period that de-watering is required. The Contractor shall take prior precautions against failure of any part of the system.

Monitoring wells

Observation wells of 40mm diameter G.I. pipes with 1.25m long wire mesh strainer and full filters shall be installed by the Contractor to suitably monitor the ground water levels maintained by the Contractor's de-watering system. The depth of wells shall be a minimum of 3m below the lowest level of the foundation excavation. The Contractor shall provide a means for locking the access to the

observation wells and shall maintain a log book with daily readings of sub-soil water levels recorded every three hours, which shall be made available at all times for inspection. The logbook shall be periodically checked and authenticated by the Engineer's Representative.

Removal of system

The de-watering system shall be removed when the construction has progressed to a stage that Site de-watering is no longer required; but only after receiving the written permission from the Engineer. Certain portions of the Contractor's de-watering system may be left in the ground when construction procedures will so require and when written permission of the Engineer is obtained. Any such portion of the de-watering system shall be plugged, capped and/or otherwise rendered harmless to the Work and the public.

1.27.6 De-watering by surface water control system

General

Evacuation of surface water is defined as draining out surface water by use of pumps, sump pump, gravel drain or other mechanical devices, but without requiring the use of a well point or tube-well system. Such water may accumulate from percolation, rain or pumping floodwater in to the area or any other source or combination of sources.

Work to be performed under this Sub-section include furnishing, installing, maintaining, operating and removal of the surface water draining system for de-watering the accumulated water from the area so that the desired construction can safely and properly be performed. The discharge line or the drainage system for the disposal of the evacuated water shall be constructed by the Contractor at his own costs in accordance with the approved Drawing and by arranging private lands, if needed any.

Operation of de-watering system

The Contractor shall make all arrangements for pumps, fuel, lubricants, maintenance and operation of the equipment and the whole Surface De-watering System and shall take precautions in advance against failure of any part of the system.

Removal of system

The Surface De-watering System shall be removed upon obtaining written permission from the Engineer when the construction has progressed at a stage that Site de-watering is no longer required.

1.27.7 Measurement

The work shall be measured for payment as an item on a lump sum basis as specified in the BOQ.

1.27.8 Payment

Payment shall only be admissible on implementation of the item of the BOQ and on the basis of the Engineer certifying that the work was necessary and implemented for the proper execution of construction work satisfying all Specifications described above. Payment shall be made at Lump Sum rate as quoted in the Contract. The rate shall cover the full compensation for all measures including the cost of labour, equipment, materials, tools required for this purpose and other incidentals necessary to complete this item of work strictly in accordance with the Specifications stated above and/or as accepted by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
1.27	Pumping and bailing out water/de-watering of work Site	Lump sum

1.28 EARTH FILLING AND SAND FILLING

1.28.1 Earth filling

1.28.1.1 Description

This work shall consist of filling any place by furnishing, placing, compacting and shaping suitable earth material of acceptable quality obtained from approved sources to make up levels to the lines, levels, grades, dimensions and cross sections in accordance with these specifications and as shown on the Drawings and/or as instructed by the Engineer.

1.28.1.2 Materials

All fill materials shall be free from roots, sods or other deleterious materials.

All fill materials shall be stockpiled outside the working areas. Materials shall be tested and approved by the Engineer.

The selected fill so stockpiled, shall satisfy the following criteria:

- Liquid limit of fraction passing 425 micron sieve shall not exceed 50%
} STP Sec. 3
- Plasticity index of fraction passing 425 micron sieve shall not exceed 20%
- The dry density after compaction in layers more than 300mm below top level shall not be less than 90% of the maximum dry density as determined in accordance with STP T4.5 (Standard Compaction).
- The dry density after compaction within 300mm below the top level (or such greater depth if shown on the plans and drawings) shall not be less than 95% maximum dry density as determined in accordance with STP T4.5 (Standard Compaction).
- Soaked (4 day) CBR greater than 4% at 95% MDD (STD).
- The moisture content at the time of compaction shall be the optimum moisture content (Standard Compaction) $\pm$ 5%.
- Sampling to be carried out as per STP Section 2 and Sub-section 4.1.

1.28.1.3 Construction methods

General

Prior to placing any fill upon any area, all clearing and grubbing operations shall be completed following the procedures stated below.

The original ground surface should be prepared by scarifying, watering, aerating and compacting. The dry density after compaction shall not be less than 90% of MDD (STD).

Filling in swamps or water shall be carried out as indicated on the Drawings and as described in these Specifications. The Contractor shall, when ordered by the Engineer, excavate or displace swampy ground and backfill with suitable materials. Such backfill shall be river or beach sand unless otherwise directed by the Engineer.

The materials that are borrowed from canals or other waterlogged areas for use as fill material, being saturated, shall initially be stockpiled to drain the excess water before placing it in the designated areas.

Clearing

Clearing shall consist of the removal and disposal of everything above foundation level except those the Engineer directs are to be left undisturbed. The materials to be cleared shall include but not necessarily be limited to trees, stumps, logs, bush, undergrowth, grass, crops, loose vegetable matter and structures unless provided elsewhere.

All tree stumps shall completely be removed within the limits of earthwork.

Clearing shall also include the removal of existing fences, remnants of buildings, etc.

Grubbing

Grubbing shall be confined to major roots beneath the excavations.

In agricultural areas where the ground has been formed into ridges of dikes, the ground shall be roughly leveled or graded to form a surface suitable for filling and to the satisfaction of the Engineer.

Ownership of cleared materials

All cleared materials shall, unless otherwise provided for in the Contract, be the property of the Department.

Spreading and compaction of earth fill

Earth carried from outside shall be placed on the land to be developed in horizontal layers and each layer shall not exceed a loose thickness that is required to obtain a compacted thickness of 150mm. The earth of each basket is to be placed near to the earth placed before it and spread systematically. The Contractor shall not be allowed to throw earth in heaps.

The materials to be compacted shall be deposited in horizontal layers on the land to be developed with a loose thickness as stated above. The clods of earth shall be broken down to a maximum size of 25mm by striking the clods with the back of a spade or by using wooden drag or ladder or by any other suitable means before the next basket of earth is thrown close to it. Distribution of materials shall be made in such a way that the compacted materials will become homogeneous and free from lenses, pockets, streaks or other imperfections. Excavating and placing operations shall be such that the materials, when compacted, will be blended sufficiently to secure the best practicable degree of compaction, impermeability and stability and for this purpose the preceding compacted layer shall be scarified before placing a new layer.

All fill materials shall generally be compacted mechanically. However, under some special circumstance and when specifically allowed under the BOQ, the fill may be allowed to be compacted manually.

If the density measurement checks fall below the specified density level, re-compacting shall be required irrespective of the field compaction trial results. The Contractor shall be carried out such works

Earth fill materials, which does not contain sufficient moisture requirement for compaction in accordance with the requirements of this Sub-section shall be reworked and watered as per direction of the Engineer. The Contractor shall carry out this work at his own expenses.

Earth fill materials containing excess moisture shall be reworked and dried prior to or during compaction. Drying of wet materials shall be performed by methods proposed by the Contractor and approved by the Engineer at the expenses of the Contractor.

Compaction of every layer shall have to be approved by the Engineer. In the event the Contractor fails to obtain the approval of the Engineer of a fill layer, the materials above the unsatisfactory layer shall be removed and the unsatisfactory layer shall be re-compacted to satisfy the specifications at the expenses of the Contractor.

Manually compacted fill

Fill shall be placed and compacted in layers for 150mm maximum compacted thickness, uniformly spread and compacted over the fill area of each layer. If for any reason, progress in compaction of the fill is interrupted for any unreasonable time, the surface area of the fill shall be scarified or ploughed before compaction continues. Each layer shall be compacted, using controlled manual compaction methods to achieve at least 85% of the Standard Proctor maximum dry density.

Compaction of every layer shall have to be approved by the Engineer. In the event the Contractor fails to obtain the approval of the Engineer of a fill layer, the materials above the unsatisfactory layer shall be removed and the unsatisfactory layer shall be re-compacted to satisfy the specifications at the expenses of the Contractor.

Under special circumstances and if directed by the Engineer, the Contractor shall excavate 5 to 10 trial pits each of size 2m long, 1m wide and 2m depth or to a depth of the improved land (whichever is less) at random spacing to test the degree of compaction. The size of voids encountered shall not exceed 5 cm in diameter and the number of voids shall be less than 10 per square meter.

Procedures for manual compaction

The earth shall be compacted manually using concrete drop hammers each weighing 6 kg to 7 kg, fitted with a shaft of about 1.5m long. Ramming shall reduce the voids and shall continue until no further shrinkage of earth is possible by ramming.

Before commencing ramming, the moisture content of the soil shall be increased or decreased as per requirement by sprinkling the soil with water or by allowing natural drying of the soil as applicable so as to ensure that the materials shall have a moisture content of not less than 5% or greater than 5% dry of the optimum moisture required for the purpose of compaction. Both wetting and drying may be aided by furrowing the fill and then re-spreading when the moisture content is suitable.

If the moisture content exceeds the aforementioned tolerance, the compaction operations shall not proceed until the material is wetted or allowed to dry out, as the case may be to obtain optimum moisture content within the permitted tolerances. However, there may be an exception with a specific approval of the Engineer. No adjustment in price shall be made on account of any operations of the Contractor related to wetting or drying the materials or on account of any delays occasioned thereby.

The preceding operations shall continue layer after layer until the top of the filling is reached.

Mechanical compaction

In the case of mechanical compaction, area of development, designated on the Drawings or by the Engineer, shall be compacted to the lines and grades shown on the Drawings or established by the Engineer. The Contractor's operations in importing materials, designated for use, shall be such as will result in an acceptable gradation of material when placed as determined by the Engineer.

Just prior to and during placement operations, the materials shall have a moisture content of not greater than 5% wet or less than 5% dry of the optimum moisture required for the purpose of compaction, as determined by Test No. 12 of BS 1337 and approved by the Engineer. The materials shall be so worked as to have uniform moisture content throughout the entire layer.

If the moisture content exceeds the aforementioned tolerance, the compaction operations shall not proceed until the materials are wetted or allowed to dry out, as the case may be to obtain the optimum moisture content within the permissible tolerances. However, there may be an exception with a specific approval of the Engineer. No adjustment in price shall be made on account of any operations of the Contractor related to wetting or drying the materials or on account of any delays occasioned thereby.

When the material has been conditioned and placed as specified or directed, it shall be compacted with appropriate motorized vibratory compaction equipment or tampers of adequate weight and size as approved by the Engineer. Each layer shall be compacted to obtain at least 98% compaction of the maximum dry density. If the test results show that the density has not met the requirement, the Contractor shall have to carry out further compaction until the required density is achieved.

The in-situ dry density of the compacted fill shall be determined by the Sand Replacement Method described in Test No. 15 of BS 1377 or by other similar approved tests at locations as ordered by the Engineer.

1.28.1.4 Measurement

Measurements for earth filling works shall be taken for payment in cubic meters on cross sections compacted and accepted in place. The volume to be measured will be the net volume of required and accepted filling, actually constructed and completed in accordance with the Specifications, to the lines, levels and cross sections required as per the Drawings or such other dimensions as directed by the Engineer. This stipulation of volume determination will be regardless of the method of excavation, filling, re-sectioning and backfilling at structures or type of materials.

The cross sections to be used shall be measured by pre-work (after clearing and stripping) and post-work field surveyed sections. Pre-work sections of the portion of the work allotted to the Contractor, computed through survey works, shall be signed by the Contractor before executing the works for retention by the Engineer.

1.28.1.5 Payment

The unit rate paid per cubic meter for earth filling shall be in accordance with the Contract unit price, which payment shall constitute the full compensation for furnishing all materials and providing all labour, tools and equipment and works as specified. The rate shall also include costs of all other items related therewith and all incidentals, which may need to be completed to execute the work strictly in accordance with the Specifications and/or as per the directions of the Engineer.

Costs of all works and the cost of lead, lift or carriage shall be included in the unit rates for the relevant item of earth filling works of the BOQ of the Contract. Unless otherwise specified, no royalties will be paid for the purchase of earth from a private land regardless of its distance from the Site. No additional payment shall be made for purchasing a land and excavating the fill outside the rate agreed in the Contract for the item of earth filling works.

No direct or separate payment shall be made for works required under the other sub-items of this item. Costs for such works shall be deemed to have included in the related items of the BOQ.

Payment shall only be made when all works have been completed in accordance with the designed sections satisfying all specifications and accepted by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
1.28.1	Earth filling	Cubic Meter
1.28.1	Manual compaction of earth	Cubic Meter
1.28.1	Mechanical Compaction of earth	Cubic Meter

1.28.2 Sand filling**1.28.2.1 Description**

This work shall consist of filling in foundation trenches, inside plinth or at any other places by furnishing, placing, compacting and shaping suitable sand of acceptable quality and F.M. to make up levels to the lines, levels, grades, dimensions and cross sections in accordance with these specifications and as shown on the Drawings or BOQ and/or as instructed by the Engineer.

1.28.2.2 Material

Materials shall be of natural sand free from vegetable matters, from soft particles and from clay. F.M. of sand shall be in accordance with the stipulations of the BOQ or as per the direction of the Engineer.

All fill materials shall be stockpiled outside the working areas. Materials shall be tested and approved by the Engineer.

The selected sand fill so stockpiled, shall satisfy the following criteria:

- The fraction passing the 425 micron sieve shall have a Plasticity Index not greater than 10 (STP Section-3).
- The material shall have a soaked CBR value not less than 8% when compacted to 98% of maximum dry density as to be determined by STP T 4.5.

1.28.2.3 Construction methods

General

Prior to placing any sand fill upon any area, all clearing and grubbing operations shall be completed. Within the limits of sand filling, tree stumps shall completely be removed.

The original ground surface should be prepared by scarifying, watering, aerating and compacting.

Spreading and compaction of sand fill

Sand fill shall be placed on the desired place in horizontal layers and each layer shall not exceed a loose thickness that will be required to obtain a compacted thickness of 150mm. Sand in each basket is to be placed near to the sand placed before it and spread systematically. The Contractor shall not be allowed to throw sand in heaps.

The compacted materials should become homogeneous and free from lenses, pockets, streaks or other imperfections. Placing operations shall be such that the materials, when compacted, will be blended sufficiently to secure the best practicable degree of compaction, impermeability and stability and for this purpose the preceding compacted layer shall be scarified before placing a new layer.

All fill materials shall generally be compacted mechanically. However, under some special circumstance and when specifically allowed under the BOQ, the fill may be allowed to be compacted manually.

If the density measurement checks fall below the specified density level, re-compacting shall be required irrespective of the field compaction trial results. The Contractor shall carry out such works at his own expenses.

Sand fill materials not containing sufficient moisture requirement for compaction in accordance with the requirements of this Sub-section, shall be reworked and watered as per the direction of the Engineer. The Contractor shall carry out this work at his own expenses.

Sand fill materials containing excess moisture shall be reworked and dried prior to or during compaction. Drying of wet materials shall be performed by methods proposed by the Contractor and approved by the Engineer at the expenses of the Contractor.

Compaction of every layer shall have to be approved by the Engineer. In the event the Contractor fails to obtain the approval of the Engineer of a fill layer, the materials above the unsatisfactory layer shall be removed and the unsatisfactory layer shall be re-compacted to satisfy the specifications at the expenses of the Contractor.

Procedure for manual compaction

Sand shall be compacted manually by using concrete drop hammers each weighing 6 kg to 7 kg, fitted with a shaft of about 1.5m long. Ramming shall reduce the voids and shall continue until no further shrinkage of sand is possible by ramming.

Before commencing ramming, the moisture content of sand shall be increased or decreased as per requirement by sprinkling water or by allowing natural drying of sand as applicable so as to ensure that the materials shall have a moisture content of not less than 3% or greater than 3% dry of the optimum moisture required for the purpose of compaction respectively.

The compaction operations shall not proceed until the material is wetted or allowed to dry out, as may be required, to obtain optimum moisture content within the tolerances as permitted above. However, there may be an exception with a specific approval of the Engineer. No adjustment in price shall be made on account of any operations of the Contractor in wetting or drying the materials or on account of any delays occasioned thereby.

The preceding operations shall continue layer after layer until the top of the filling is reached.

Mechanical compaction

In the case of mechanical compaction, area of filling, designated on the Drawings or by the Engineer, shall be compacted to the lines and grades shown on the Drawings or established by the Engineer. The Contractor's operations in importing materials, designated for use, shall be such as will result the desired F.M.

Just prior to and during compacting operations, the materials shall have a moisture content of not greater than 3% wet or less than 3% dry of the optimum moisture required for the purpose of compaction, as determined by Test No. 12 of BS 1337 and approved by the Engineer. The materials shall be so worked as to have uniform moisture content throughout the entire layer.

If the moisture content is less than optimum by more than 3% or is greater than optimum by more than 3%, the compaction operations shall not proceed until the material is wetted or allowed to dry

out, as may be required, to bring the optimum moisture content within the tolerances. However, there may be an exception with a specific approval of the Engineer. No adjustment in price shall be made on account of any operations of the Contractor in wetting or drying the materials or on account of any delays occasioned thereby.

When the material has been conditioned and placed as specified or directed, it shall be compacted with appropriate motorized vibratory compaction equipment or tampers of adequate weight and size as approved by the Engineer. Each layer shall be compacted to obtain at least 98% compaction of the maximum dry density (STD). If the test results show that the density has not met the requirement, the Contractor shall have to carry out further compaction until the required density is achieved.

1.28.2.4 Measurement

Measurement shall be taken for payment on the compacted volume of completed and accepted works in cubic meter. The cross sections to be used will be the areas bound by the original ground (existing) shaped or leveled, the sides and the bottom of the foundation or the floor.

1.28.2.5 Payment

Payment for sand filling shall be made at the Contract unit price per cubic meter measured as provided above which price shall constitute the full compensation for furnishing all materials with their storage, placing, leveling and shaping, wetting or drying, compacting the fill materials and providing all equipment, tools and all incidentals necessary to complete the work true to the Specifications and/or as per the directions of the Engineer.

Payment shall only be made when all works have been completed in accordance with the designed sections satisfying all Specifications and accepted by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
1.28.2	Sand filling	Cubic Meter
1.28.2	Manual compaction of sand	Cubic Meter
1.28.2	Mechanical Compaction of sand	Cubic Meter

1.29 BRICK MASONRY AND BRICK WORKS

1.29.1 Brick masonry work

1.29.1.1 General

This Sub-section shall apply to construction of all brick masonry works at the different places of a building.

1.29.1.2 Description

This item of work shall consist of constructing brick masonry work in cement mortar with specified proportion in required thickness and height. The work shall include supply of all labour, materials, tools and equipment, carriage and the performance of all works necessary for the construction of the brick masonry. All works including scaffolding shall be carried out in accordance with these Specifications conforming to the levels, dimensions and designs as shown on the Drawings, in the BOQ and/or as directed by the Engineer.

1.29.1.3 Materials

Bricks

Bricks shall be of First Class in quality unless otherwise required and shall comply with the requirements as stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C 150 Type 1 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregates shall consist of natural sand conforming to the requirements of ASTM C 144 and ASTM C 33 or BDS 243.

Sand shall be completely non-saline, non-plastic and free from all clay, roots and all organic impurities.

Minimum F.M. of sand for any type of brickwork shall normally be 1.5 unless otherwise required for a specific work.

All other properties of Fine Aggregate shall be the same as have been described under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substances and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

1.29.1.4 Soaking of bricks

Before use in works, all bricks shall be soaked in clear water for a minimum period of 24 hours. Soaking shall be discontinued 2 hours before use so that at the time of laying they are skin dry. Such soaked bricks shall be stacked on a clean place where they shall not be spoiled by dirt or any other objectionable materials.

1.29.1.5 Preparation of mortar

Cement mortar for brick masonry works shall generally consists by volume of one part Ordinary Portland cement and four parts screened sand or one part Ordinary Portland cement and six parts screened sand unless otherwise required by the Drawings or instructed by the Engineer. In each mortar, just enough water shall be added and the components mixed and thoroughly incorporated together to give workability appropriates to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform and cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture. Water shall then be added sparingly, only the minimum necessary to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after water is added. The adding of additional water and re-tempering (cement mortar that stiffened because of evaporation of water) shall be permitted only within 30 minutes from the time of addition of water at the time of initial mixing.

1.29.1.6 Construction methods

The method and equipment used for transporting and placing the bricks and mortar shall be such as will not damage the brick or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar and bricks shall be clean and free from set mortar or other deleterious foreign substances.

All brick masonry works shall be placed only after the foundation surfaces have been prepared satisfactorily in accordance with the Specifications and the Engineer's instructions.

The bricks shall not be placed during rain sufficiently heavy or prolonged, which will wash the mortar from the bricks. Mortar already spread, but becomes diluted by rain, shall be removed and replaced before further continuing the work at the Contractor's own expenses.

All bricks to be used in brick masonry works with mortar joints shall be completely soaked in water for a minimum period of 24 hours before they are used. The bricks shall be used within two hours of taking out of water. All bricks shall be free from water adhering to their surface when they are placed in the brickwork.

Before laying bricks in foundation, a bed of lean concrete of thickness not less than 75mm shall be laid to prepare a smooth seat on which the brick works will rest. Immediately thereafter, the first course of bricks shall be laid.

Bricks shall be laid in English bond unless otherwise directed by the Engineer and shall be set with both bed and vertical joints filled with mortar and shall be bedded in by firmly tapping with the handle of the trowel. The face with the frog mark shall be placed upward to ensure that the frog mark is filled with mortar. Bricks shall be skillfully laid with the level courses, uniform joints, square corners, plumb verticals and true surfaces except when otherwise shown on the Drawings and/or directed by the Engineer.

Bricks, used on face, shall be selected whole or uniform size and with true rectangular face. Only full bricks shall be used in the brick works unless becomes absolutely necessary for breaking points or maintaining bond.

Bricks shall be laid on full bed of mortar and shall be slightly pressed so that mortar gets into all the surface pores of bricks to ensure proper adhesion. Bricks shall be laid, where possible, from one face only and each brick shall be set with both horizontal and vertical joints filled with mortar and the bricks shall be bedded in by firmly tapping with the handle of the trowel. Mortar joints shall be checked and any hollow or defective joints shall be racked and filled with mortar immediately.

Each course shall break the joints with the course below. All horizontal joints shall be parallel and all vertical joints in alternate courses shall be directly over one another. In thick walls or foundations, not only the face joints but the inside joints also shall break course.

The thickness of mortar in any joints shall not be less than 6mm and not more than 10mm and the height of four courses as laid shall not exceed more than 25mm the height of four dry bricks stacked one upon the other.

All brick masonry works shall be truly plumbed and shall always be carried out regularly along their entire length throughout the structure. When the entire works cannot be carried out in even courses, the break shall be made at regular steps each of a length of at least 1-1/2 times its height. Unless otherwise directed, no overhead work shall be allowed. Toothenning may be done where future extension is contemplated but shall be used as an alternative to racking back.

Where specified, fabric reinforcement shall be embedded completely in mortar. During construction of steining members, bars shall be placed accurately in accordance with the Drawings and/or as directed by the Engineer.

The surface of each course shall be thoroughly cleaned from all dirt before another course is laid on top of it. If the mortar in any course has begun to set, the joints shall be racked out to a depth of 25mm before any subsequent course is laid. When the top course has been exposed for more than two weeks, it shall be removed and the surface below shall be thoroughly cleaned before any more courses are added.

When fresh masonry is to be placed against the existing surface of structures, these surfaces shall be cleaned of all loose materials, roughened and wetted as directed by the Engineer so as to effect a good bond with the new work.

1.29.1.7 Scaffolding

The scaffolding shall be sound and strong to withstand all loads likely to be imposed upon it and subject to the Engineer's approval. Pole going into the masonry should be at a place, which can be filled with a header brick. The holes, which provide resting space for horizontal members shall not be left in masonry under 1m in width or immediately near the skewbacks of arches. The holes left in the masonry work for supporting the scaffolding shall be filled and made good.

1.29.1.8 Protection and curing

Brick masonry works shall be protected during construction for a minimum period of 3 days after laying against harmful effects of weather by suitable covering. During hot weather, all finished or partly completed works shall be covered or wetted in such a manner as will prevent rapid drying of the brickwork.

All brick masonry, requiring mortar, shall be cured as it is constructed for not less than 7 days on completion of the last course by keeping continuously wet with water or by covering with water saturated materials or by other curing methods as may be approved by the Engineer.

On completion of the work, all visible surfaces shall be free from all damages and/or debris and shall look clean. Cares shall be taken that bricks are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

1.29.1.9 Finishing of surfaces

General

The surfaces shall be finished by "Jointing" or "Pointing". The surfaces which shall remain exposed shall be pointed and those which shall be buried underground shall be jointed. The mortar for finishing shall be prepared as stated under the Sub-section on 'Mortars' of this Section.

Jointing

In jointing, the face joints of the mortar shall be worked out while still green to give a finished surface flushed with the face of the brick masonry works. The faces of brick masonry works shall be cleaned to remove any splash of mortar during the course of raising the brick masonry.

Pointing

For pointing, the joints shall be squarely raked out to a depth of 15mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing shall then be finished to proper type given on the Drawings or as required under the BOQ and/or as directed by the Engineer.

If type of pointing is not mentioned on the Drawings or BOQ, flush pointing shall be used. For groove pointing, after the mortar has been filled and pressed into the joints and finished with the edges of the bricks, it shall be grooved along the center with a half round tool of such width as may be specified by the Engineer. Such works shall only be carried out within the period that the mortar remains green. The excess mortar shall then be cut off from the edges of the lines and the surfaces of the masonry shall also be cleaned of all mortars.

1.29.1.10 Repairing of brick masonry work

On completion of any brick masonry works, if any bricks is found out of alignment or level or does not conform to the lines and grades shown on the Drawings or gives a defective surface, it shall be removed and replaced by the Contractor at his own expenses as per the instructions of the Engineer

1.29.1.11 Extension to the existing brick masonry work

Where existing brick masonry works is required to be extended, the existing skin courses shall be carefully removed as directed by the Engineer. The old exposed brick masonry works and joints shall be carefully prepared and cleaned and thoroughly watered immediately prior to commencing extension of the brick masonry.

1.29.1.12 Replacement of defective brick masonry work

The extent of replacement of defective brick masonry works shall be jointly surveyed by the Contractor and the Engineer at the start of the work and the location of all repairs needed shall be recorded and permanently marked in paint.

Defective brick masonry works shall be carefully removed in a sequence as instructed by the Engineer. The existing stability and structural integrity of walls and arches shall not be impaired during this operation and the Contractor shall remain fully responsible in this respect. To this effect he shall ensure providing all temporary supports as would be necessary. The defective brick masonry works shall be removed on an incremental basis, if this is deemed desirable and new brick masonry works shall be carefully constructed so that the structural integrity is maintained.

1.29.1.13 measurement

The quantity of completed brick masonry works (both new and extension of the existing brick masonry works) including flush pointing as accepted by the Engineer shall be measured in cubic meter in accordance with the dimensions shown on the Drawings and/or as directed by the Engineer.

1.29.1.14 Payment

The works measured as provided above shall be paid at the relevant Contract unit prices per cubic meter and per square meter as would be applicable as per the BOQ. The payment shall constitute the full compensation for furnishing, storage, transporting, preparing, laying, racking out joints and curing of all materials and labour including scaffolding, tools and equipment and all incidentals necessary to complete the item. The payment shall also constitute full compensation for all temporary measures to retain the stability of the existing structures and for removal and replacement of any defective brick works and mortar.

Pay Items shall be:

Clause	Description	Unit of measurement
1.29.1	New and extended brick masonry work	Cubic Meter
1.29.1	Replacement of existing defective brick masonry work	Cubic Meter
1.29.1	Brick pointing	Square Meter
1.29.1	Re-pointing of existing joints of the brick masonry work	Square Meter

1.29.2.1 Description

Works covered by this item shall consist of constructing 50mm and 100mm thick brickwork with First Class clinker pressed Machine Made Bricks laid normally or on edge pasted on wall, column, beam, floor and sun shed bottom or elsewhere as required by the Drawings or as per the instruction of the Engineer.

1.29.2.2 Materials

Bricks

Machine Made Ceramic Bricks shall be of First Class in quality and shall comply with the requirements of First Class Machine Made Bricks as stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C 150 Type 1 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregates shall consist of natural sand conforming to the requirements of ASTM C 144 and ASTM C 33 or BDS 243.

Sand shall be completely non-saline, non-plastic and free from all clay, roots and all organic impurities.

Minimum F.M. of sand for this type of brickwork shall normally be 1.5 unless otherwise required for a specific work.

All other properties of Fine Aggregate shall be the same as have been described under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substances and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

1.29.2.3 Mortar

Portland cement mortar for installing ceramic wall shall comply with the requirements of ANSI A 108.1 and be of the composition specified in the Table given below.

Walls	Scratch coat	1 cement, 1/5 hydrated lime*; 4 dry or 5 damp sand
	Setting bed and leveling coat	1 cement; 1/2 hydrated lime; 5 damp sand to 1 cement; 1 hydrated lime; 7 damp sand
Floors	Setting bed	1 cement; 1/10 hydrated lime; 5 dry or 6 damp sand; or 1 cement; 5 dry or 6 damp sand
Ceilings	Scratch coat or sand bed	1 cement; 1/2 hydrated lime 2 1/2 dry sand or 3 damp sand

Note:* Lime may be excluded from mortar if trial mixes indicate the desired workability and performances are achieved without lime.

1.29.2.4 Construction methods

The method and equipment used for transporting and placing bricks and mortar shall be such as will not damage the bricks or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar and bricks shall be clean and free from set mortar or other deleterious foreign substances.

The bricks shall not be placed during rain sufficiently heavy or prolonged, which will wash the mortar from the bricks. Mortar already spread but becomes diluted by rain, shall be removed and replaced before continuing the work at the expenses of the Contractor.

All bricks to be used in the works shall be completely soaked in water for a minimum period of 24 hours before they are used. The bricks shall be used within two hours of taking out of water. All bricks shall be free from water adhering to their surface when they are placed in the brickwork.

The bricks used on face shall be selected whole or uniform size and with true rectangular face. Only full bricks shall be used in the brickwork unless and otherwise becomes absolutely necessary.

Works shall be built plumbed and shall be carried out regularly throughout the entire area of the structure by very skilled masons. Brick shall be laid, as per the Design and Drawings and only the smooth face of the Machine Made Bricks shall be used. Bricks shall be laid on full bed of mortar and shall be slightly pressed so that mortar gets into all the surface pores of bricks to ensure proper adhesion. Thickness of horizontal and vertical joints shall be as per the Drawings. Exposed joints shall be raked out and groove pointed as per requirement and/or directed by the Engineer. The face of the works shall be kept clean as work proceeds.

1.29.2.5 Scaffolding

The scaffolding shall be sound and strong to withstand all loads likely to be imposed upon it and subject to the Engineer's approval. Pole going into the masonry should be at a place, which can be filled with a header brick. The holes, which provide resting space for horizontal members shall not be left in masonry under 1m in width or immediately near the skewbacks of arches. The holes left in the masonry work for supporting the scaffolding shall be filled and made good to resemble with the entire surfaces unless otherwise required by the Engineer.

1.29.2.6 Protection and curing

In exposed situation the works shall be protected during construction against harmful effects of weather by suitable covering during and for a period immediately following construction until the mortar has sufficiently hardened. During hot weather, all finished or partly completed works shall be covered or wetted in such manner as will prevent rapid drying of the brick masonry works.

All brick masonry, requiring mortar, shall be cured as it is constructed for not less than 7 days on completion of the last course by keeping continuously wet with water or by covering with water saturated material or other curing methods approved by the Engineer.

On completion of the work, all visible surfaces shall be free from damage or debris and shall look clean. Cares shall be taken that bricks are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

1.29.2.7 Finishing of surfaces

General

The surfaces shall be finished by "Pointing". The surfaces which shall remain exposed shall be pointed. The mortar for finishing shall be prepared as stated under Sub-section on 'Mortars' of this item of work.

Pointing

The joints shall be squarely raked out to a depth of 15mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing shall then be finished to proper type given on the Drawings.

For groove pointing after the mortar has been filled and pressed into the joints and finished off level with the edges of the bricks, it shall while still green be grooved along the center with a half round tool of such width as may be specified by the Engineer. The excess mortar shall then be cut off from the edges of the lines and the surfaces of the masonry shall also be cleaned of all mortars.

1.29.2.8 Repairing of brick work

On completion of works, if any bricks is found out of alignment or level or does not conform to the lines and grades shown on the Drawings or shows a defective surface, it shall be removed and replaced by the Contractor at his expenses.

1.29.2.9 Measurement

The quantity of Machine Made brick masonry works shall be measured in square meter of the finished visible surfaces on wall, column, beam, floor and sun-shed bottom or elsewhere as required and as will be acceptable to the Engineer qualitatively. Addition may be made for thresholds and deduction for openings of the floor and other construction.

1.29.2.10 Payment

The works measured as provided above shall be paid at the relevant Contract unit prices as shown in the BOQ. The payment shall constitute the full compensation for furnishing, storage, transporting, preparing, laying, recessed pointing and curing of all materials and labour including scaffolding, tools and equipment and all incidentals necessary to complete the item. The payment shall also constitute full compensation for all temporary measures to retain the stability of the existing structures and for removal and replacement of any defective brick works and mortar.

Pay Items shall be:

Clause	Description	Unit of measurement
1.29.2	Machine made ceramic brick masonry works	Square Meter

1.29.3 Brick masonry work in partition wall

1.29.3.1 Description

This item of work shall consist of constructing flat-brick brick masonry walls or brick-on-edge brick masonry walls with brick masonry works of 1st class bricks and in cement mortar with specified proportion in required heights. All works shall be carried out in accordance with these Specifications conforming to the levels, dimensions and designs as shown on the Drawings and/or as directed by the Engineer.

1.29.3.2 Materials

Bricks

Bricks shall be of First Class in quality unless otherwise required and shall comply with the requirements as stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C 150 Type 1 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregates shall consist of natural sand conforming to the requirements of ASTM C 144 and ASTM C 33 or BDS 243.

Sand shall be completely non-saline, non-plastic and free from all clay, roots and all organic impurities.

Minimum F.M. of sand for this type of brickwork shall normally be 1.5 unless otherwise required for a specific work.

All other properties of Fine Aggregate shall be the same as have been described under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substances and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

1.29.3.3 Soaking of bricks

Before use in works, all bricks shall be soaked in clear water for a minimum period of 24 hours. Soaking shall be discontinued 2 hours before use so that at the time of laying they are skin dry. Such soaked bricks shall be stacked on a clean place where they shall not be spoiled by dirt or any other objectionable materials.

1.29.3.4 Mortar

Unless otherwise specified on the Drawings, cement mortar for brick masonry works shall generally consists by volume of one part Ordinary Portland cement and four parts screened sand unless otherwise required by the Drawings or instructed by the Engineer. In each mortar, just enough water shall be added and the components mixed and thoroughly incorporated together to give a workability,

appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform and cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture. Water shall then be added sparingly, only the minimum necessary to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after water is added. The adding of additional water to and re-tempering (cement mortar that stiffened because of evaporation of water) shall be permitted only within 30 minutes from the time of addition of water at the time of initial mixing.

1.29.3.5 Construction methods

Construction methods shall be similar to that have been described in the relevant portion under the Sub-section on 'Brick Masonry Work' of this Section.

1.29.3.6 Measurement

Brick partition walls shall be measured in square meter of actually exposed brick surfaces wall that has been actually performed and accepted by the Engineer from which areas for all openings and incorporated foreign structures such as lintels, columns, beams, etc. shall be deducted.

1.29.3.7 Payment

The amount of completed and accepted work measured as provided above shall be paid at the relevant Contract unit prices as shown in the Bill of Quantities. The payment shall constitute the full compensation for furnishing, storing, transporting, preparing, laying, racking out joints and curing of all materials, all labours including scaffolding, tools and equipment and all incidentals necessary to complete the item. The payment shall also constitute full compensation for all temporary measures to retain the stability of the existing structures and for removal and replacement of any defective brick works and mortar.

Pay Items shall be:

Clause	Description	Unit of measurement
1.29.3	Brick masonry works in partition wall	Square Meter

1.29.4 Brick flat soling

1.29.4.1 Single layer brick flat soling

1.29.4.1.1 Description

This item of work shall consist of providing brick soling laid flat in single layer to the lines, grades, levels, dimensions, cross sections and satisfying other requirements as shown on the Drawings and/or as directed by the Engineer.

1.29.4.1.2 Materials

Bricks

Bricks shall be of First Class in quality unless otherwise required and shall comply with the requirements as stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Sand

Unless otherwise directed by the Engineer minimum F.M. of sand for Brick Flat Soling should normally be 0.8 that should satisfy all properties of fine aggregate as have been described under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

1.29.4.1.3 Construction methods

The bricks shall be laid flat in one layer, frog mark downwards with the shortest side vertical on the compacted, trimmed and prepared surface unless otherwise shown on the Drawings or instructed by the Engineer. Bricks shall be laid in a regular and uniform manner. Interstices of bricks shall be filled with sand of approved F.M and water shall be applied by sprinkling. No brick shall be laid on a foundation or any surface until the same has been inspected and approved by the Engineer. The gap between two adjacent bricks should not exceed 10mm.

Brick shall be laid and the interstices shall be tightly filled with sand in a manner that no brick shall move under any condition.

1.29.4.1.4 Measurement

Brick flat soling shall be measured in square meter for areas covered by the same and completed in accordance with the Specifications and accepted by the Engineer.

1.29.4.1.5 Payment

The amount of completed and accepted works measured as provided above shall be paid at the relevant Contract unit price as shown in the Bill of Quantities. The price and payment shall constitute the full compensation for all costs for completion of the work and supplying, furnishing, transportation and storage of all required materials, including costs of all labours, equipment, tools and all incidentals necessary to complete the work satisfying the requirements of this Sub-section, as shown on the Drawings, as stated in the BOQ and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
1.29.4.1	Single layer brick flat soling	Square Meter

1.29.4.2 Double layer brick flat soling

1.29.4.2.1 Description

This item of work shall consist of providing brick soling laid flat in double layers to the lines, grades, levels, dimensions, cross sections and satisfying other requirements as shown on the Drawings and/or as directed by the Engineer.

1.29.4.2.2 Materials

Bricks

Bricks shall be of First Class in quality unless otherwise required and shall comply with the requirements as stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Sand

Unless otherwise directed by the Engineer minimum F.M. of sand for Brick Flat Soling should normally be 0.8 that should satisfy all properties of fine aggregate as have been described under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

1.29.4.2.3 Construction methods

The first layer of the brick soling shall be laid flat, frog mark downwards with the shortest side vertical on the compacted, trimmed and prepared surfaces unless otherwise shown on the Drawings or instructed by the Engineer. The interstices shall be filled with sand of approved FM, brushed in and the completed layer shall be sprinkled liberally with water. Then a sand cushion of 25mm thickness (minimum) with same type of sand should be placed over the first layer. Second layer of the bricks

shall be laid flat on the sand cushion in a regular and uniform manner as stated above. Interstices of bricks shall be filled with sand of approved F.M, brushed in and sprinkling water as did in the case of first layer. No bricks shall be laid on a foundation or any surface until the same has been inspected and approved by the Engineer.

Bricks shall be laid, sand cushion shall be provided between the layers and the interstices shall be tightly filled with sand in a manner that no bricks shall move under any condition.

1.29.4.2.4 Surface tolerance

In the areas where Double Layer Brick Flat Soling is to be placed, any deviation in excess of 5mm from the specified surface within 3 meter shall be corrected by removal, reshaping and relaying of bricks at the own expenses of the Contractor.

1.29.4.2.5 Measurement

Brick flat soling in double layer shall be measured in square meter for areas covered by the same and completed in accordance with the Specifications and accepted by the Engineer.

1.29.4.2.6 Payment

The amount of completed and accepted works measured as provided above shall be paid at the relevant Contract unit price as shown in the Bill of Quantities. The price and payment shall constitute the full compensation for all costs for completion of the work and supplying, furnishing, transportation and storage of all required materials, including cost of all labour, equipment, tools and all incidentals necessary to complete the work satisfying the requirements of this Sub-section, as shown on the Drawings, as stated in the BOQ and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
1.29.4.2	Double layer brick flat soling	Square Meter

1.29.5 Herring bone bond brick laying

1.29.5.1 Description

This item of work shall consist of a base composed of 1st class bricks, laid on edge in a herring-bone pattern, placed over a prepared single layer brick flat soling in accordance with these Specifications and to the lines, grades, levels, dimensions, cross sections and satisfying other requirements as shown on the Drawings and/or as directed by the Engineer.

1.29.5.2 Materials

Bricks

Bricks shall be of First Class in quality unless otherwise required and shall comply with the requirements as stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Sand

Unless otherwise directed by the Engineer minimum F.M. of sand for Brick Flat Soling should normally be 0.8 that should satisfy all properties of fine aggregate as have been described under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

1.29.5.3 Construction methods

A sand cushion of 25mm thickness (minimum) with sand of approved F.M. shall be placed over the previously laid brick flat soling. Bricks shall then be laid on edge with 125mm across the surface in a single layer in a herring-bone pattern to the lines, grades, levels, dimensions and cross section shown on the Drawings and as required by the Engineer. The edge of the layer shall be made with cut bricks to produce a line, which is compatible with brick edging. The interstices shall be filled with sand of approved FM brushed in and the completed layer shall be sprinkled liberally with water.

Brick shall be laid, sand cushion shall be provided between the layers and the interstices shall be tightly filled with sand in a manner that no brick shall move under any condition.

1.29.5.4 Surface tolerance

In the areas where Herring-bone-bond brick layer to be placed, any deviation in excess of 5mm from the specified surface within 3 meter shall be corrected by removal, reshaping and relaying of bricks at the own expenses of the Contractor.

1.29.5.5 Measurement

Herring-bone-bond brick layer shall be measured in square meter for areas covered by the same and completed in accordance with the Specifications and accepted by the Engineer.

1.29.5.6 Payment

The amount of completed and accepted works measured as provided above shall be paid at the relevant Contract unit price as shown in the Bill of Quantities. The price and payment shall constitute the full compensation for all costs for completion of the work supplying, furnishing, transportation and storage of all required materials, including cost of all labour, equipment, tools and all incidentals necessary to complete the work satisfying the requirements of this Sub-section, as shown on the Drawings, as stated in the BOQ and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
1.29.5	Herring-bone-bond layer excluding brick flat soling	Square Meter

2.0 SPECIFICATION FOR STRUCTURE OF BUILDING

2.1 Concrete for structures

2.1.1 Description

This work shall consist of construction of all Portland Cement Concrete in structures, with or without reinforcement, which shall involve furnishing, placing, finishing and curing of concrete. All items of concrete work shall include elements of structures constructed by cast-in-place and pre-cast methods using either plain or reinforced concrete or any combination thereof and shall conform to the specifications and requirements of the different Sub-sections of this item of work. All structures shall be built in a workman like manner to the lines, grades and dimensions shown on the Drawings or as directed by the Engineer.

All concrete works shall be carried out in accordance with BS 8110 or ASTM C-685 and as specified by the Engineer.

All sampling and testing of constituent materials shall be carried out in accordance with the provisions of the appropriate British or American Standard and all sampling and testing of fresh and hardened concrete shall be carried out in accordance with the provisions of BS 1881 "Method of Testing Concrete" or similar under ASTM C 39.

2.1.2 Materials

General

Concrete shall be manufactured with the essential ingredients of Portland cement, fine aggregate, coarse aggregate and water as specified and shall be well mixed and brought to the proper consistency. Type and source of ingredients used in concrete shall conform to the approved samples and shall not be varied. The requirement for concrete, its constituent materials, methods and procedures shall conform to any of the Standard Specifications of ASTM, or BS or BDS or any other equivalent standard unless otherwise specified herein or directed by the Engineer.

Materials shall conform to the requirements specified below and in the relevant Section titled 'Construction Materials' of this Specification.

Cement

Cement used in the works shall be Ordinary Portland Cement complying with the requirements of ASTM C 150 Type 1 or BS 12 or BDS 232 or equivalent standard. Special cements shall conform to the requirements provided by the Engineer.

Use of cement

Cement of different manufacturers and with different brands or types shall be kept separately and shall not be used in the same mix.

Consignment of cement shall be used in the order of delivery.

Only one brand, grade or kind of cement shall be used in a given structure, except upon the written permission of the Engineer.

Coarse aggregate

Coarse aggregate for all types of Concrete with the exception of blinding concrete shall conform to the requirements of ASTM C 33.

Coarse aggregate shall be hard, durable, clean, free from dust and other deleterious materials. The grading of the coarse aggregate shall be such that when combined with the approved fine aggregate and cement, it shall produce workable concrete of maximum density.

Nominal size of coarse aggregate

Different sizes of coarse aggregates should be mixed in proportions, which would be determined during trial mixes. The coarse aggregate to be used in the concrete mix shall be dry mixed from different sizes in specified/selected proportion one day before casting.

Nominal size of the coarse aggregate shall not be larger than one-fifth of the narrowest dimension between sides of forms or one-third the depth of slabs or three-fourth the minimum clear spacing between individual reinforcing bars or bundle of bars.

Fine aggregate

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a Fineness Modulus not less than what will be specified for a particular type of concrete. It shall conform to the requirements of ASTM C-33 or BDS 243 or equivalent standard.

Water

All sources of water for use in concrete shall be subject to the approval of the Engineer. Water shall be reasonably clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious to concrete or reinforcement and shall not contain any visibly solid material. Water whose concentration of chloride ion is in excess of 3,000 ppm (parts per million) shall not be used for the production of concrete. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. Such comparison shall be made by means of standard cement tests for soundness, time of setting and mortar strength. Any indications of unsoundness, change in time of setting of plus or minus 30 minutes or more, or reduction of more than 10 percent in mortar strength shall be sufficient cause for rejection of the water under test.

Admixtures

Suitable admixtures may be used in concrete mixes with the prior acceptance of the Engineer. The type and source of admixture, and the amount added and method of use shall be to the acceptance of the Engineer, who shall be provided with the following data:

- ☐ The manufacturer's recommended dosage and detrimental effects of under-dosage and over-dosage.
- ☐ The chemical name of the main active ingredients in the admixture.
- ☐ Whether or not the admixture contains chloride and, if so, the chloride content of the admixture expressed in percentage of equivalent anhydrous calcium chloride by weight of admixture.
- ☐ Whether or not the admixture leads to the entraining of air when used at the manufacturers recommended dosage.
- ☐ Evidence of previous satisfactory performance of concrete containing the additive.

Admixtures containing chloride other than impurities from admixture ingredients shall not be used in concrete containing embedded aluminium, or in concrete cast against permanent galvanized metal forms.

In admixtures for use in reinforced concrete, the chloride ion content shall not exceed one percent by weight of the admixture.

If more than one admixture is used, the admixtures shall be compatible with each other and shall be incorporated into the concrete mix in correct sequence so that the desired effects of all admixtures are obtained.

Fly ash or other pozzolans used as admixtures shall conform to 'Specification for Fly Ash and Raw or Calcined Natural Pozzolan for use as a Mineral Admixture in Portland Cement Concrete (ASTM C 618)'. All air entraining admixtures shall conform to 'Specification for Air entraining Admixtures for Concrete (ASTM C 260)'.

Air entraining and chemical admixtures shall be incorporated into the concrete mix in a water solution. The water so included shall be considered to be a portion of the allowed mixing water. Admixtures

shall be incorporated through a dispensing system sufficiently accurate to deliver within + 5% of the approved dosage rate.

All admixtures shall be used strictly in accordance with the manufacturer's instructions. A 'Literature of Compliance' of the admixture shall be furnished to the Engineer for each shipment of admixture used in the work. The said literature shall be based upon laboratory test results from an approved testing facility and shall authenticate that the admixture meets all requisite specifications.

2.1.3 Testing of materials

General

All tests shall be performed at Site and/or in the LGED Laboratories. Testing outside the scope of Site or LGED Laboratories shall be carried out at a recognized laboratory that will be designated by the Engineer. The test results shall be authenticated by the Head of the Laboratory.

Cement

Hydraulic cement shall be sampled and tested in accordance with the standard methods referred to in STP Section 10 and AASHTO M 85.

Cement may be sampled either at the factory or at the Site of the Work as provided in the Specifications.

The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement, either at the factory or upon delivery. If this is not done or if additional tests are necessary, the Contractor may be required to re-handle the cement in the store for the purpose of obtaining the required samples.

Sampling shall normally be instructed by the Engineer for every stored 200 cubic meter of concrete production with the concerned cement type or if the source of cement has been changed.

Aggregate

Tests to assess the suitability of the aggregates proposed for use in concrete to be placed in the permanent works shall be as follows:

- ☐ Grading
- ☐ Magnesium sulphate soundness
- ☐ Specific gravity and water absorption
- ☐ Clay, silt and dust content
- ☐ Organic impurities
- ☐ Sulphate and chloride content
- ☐ Elongation and flakiness
- ☐ Potential alkali reactivity
- ☐ Los Angeles Abrasion Test
- ☐ Aggregate drying shrinkage.

These tests are to be carried out in accordance with the appropriate ASTM Standards and the results shall comply with the limits given therein or as otherwise stated in this Specification. Grading shall be carried out at least at a weekly interval when concrete is being produced on a regular basis or before the start of production when irregular.

The Contractor shall supply samples of the aggregate materials proposed to be used for testing of Elongation and Flakiness Index, Los Angeles Abrasion Value (coarse aggregate) and Fineness Modulus (fine aggregate) and grading and other tests as required by the Engineer.

From the aggregate materials proposed by the Contractor, samples shall be selected according to STP Section 1 and 2 in the presence of the Engineer. The samples shall be brought to the Site

laboratory and tested for proving their conformance with the relevant Section on 'Material Testing' of this Specification and of this Sub-section.

The quality control of the aggregate shall be as directed by the Engineer. Grading shall normally be checked daily.

Moisture content of the aggregate shall be determined daily and at any time when a change in the moisture content is expected.

If the Contractor proposes to change the source of supply of aggregates, samples from the new source shall similarly be supplied and tested.

Grading of mixed coarse aggregate shall be checked at Site.

Water

The water used in mixing or curing concrete shall be tested by methods described in AASHTO Test Method T 260.

In sampling water for testing, care shall be taken that the containers are clean and that samples are representative.

When comparative tests are made with a water of known satisfactory quality, any indication of unsoundness, marked change in time of setting, or a reduction of more than 10 percent in mortar strength, shall be sufficient cause for rejection of the water under test.

Water shall be tested before commencement of work or any time required by the Engineer, or if the source is changed.

Admixtures

The Contractor shall submit to the Engineer specifications and samples of any admixtures or additives that he proposes to use at least 28 days before the commencement of construction or manufacture of the particular structure on which he intends to use the admixture.

Any tests the Engineer may require on concrete mixes on account of the Contractor's proposal to use additives shall be carried out at the expenses of the Contractor.

2.1.4 Composition of concrete

Concrete classes

The class of concrete and properties applicable to the concrete in various parts of structures shall be as specified in the following table.

Each mix shall be designed to ensure optimum workability, prevent segregation and produce a dense, durable concrete by adjusting the fine and coarse aggregate proportions following procedures as stated under the Sub-section of 'Design of Concrete Mix' of this Specification.

Concrete Class	28 day Cylinder Strength in kg/cm ² (minimum)	Coarse Aggregate Type	Mix Ratio (by volume) (only indicative)
A-1	250	Crushed stone	1 : 1.5 : 3
A-2	210	Crushed stone	1 : 2 : 4
A-3	200	Picked Jhama Brick Chips	1 : 1.5 : 3
A-4	170	Picked Jhama Brick Chips	1 : 2 : 4
B-3	105	Picked Jhama Brick Chips	1 : 3 : 6

The various classes of concrete shall be placed at locations as would be specified on the Drawings (if so) or elsewhere as directed by the Engineer.

Strength requirement is the only determining factor for acceptance of any above stated class of concrete. The mix ratio only shows the minimum cement requirement and it shall not put the Engineer under any obligation to accept concrete unless the requisite strength is established. If required, the cement content has to be increased to attain the desired strength without any additional costs to be paid to the Contractor.

Strength of each and every cylinder tested should conform the aforementioned specified value. Trial mixes for every class of concrete with representative material from the Site, shall be prepared by the Contractor in the laboratory in accordance with the approved procedures. The nominal strength in these tests shall exceed the specified minimum strength by 10%.

If required, suitable admixtures as approved by the Engineer would have to be added to the concrete mix to attain the desired strength without any additional costs to be paid to the Contractor. The effect of the admixture shall be carefully observed by trial mix and tests before its use.

As the work progresses, the Engineer reserves the right to change the proportions from time to time, if conditions warrant so in the interest of satisfactory output. Any such changes will be made at no additional compensation to the Contractor.

2.1.3 Regulation of water content

The amount of water used in the concrete for volume batching shall be regulated to adjust for any variation of the moisture content or grading of the aggregates as they enter the mixer as follows:

The batched volume of damp fine aggregate shall be corrected to the equivalent volume of dry aggregate. The volume of moisture in the aggregates shall be deducted from the free water to be added to the mix. To expedite correction to fine aggregate, a "bulking curve" showing the relation between moisture content and increase over dry volume shall be prepared in advance by tests on the fine aggregate used. The Engineer may direct the use of a slump less than that specified whenever concrete of such lesser slump can be consolidated into place by means of vibration specified herein. Addition of water to overcome stiffening of the concrete before placing will not be permitted. Concrete shall have uniform consistency from batch to batch. Aggregate shall not be batched for concrete when free water is dripping from the aggregate.

Concrete mix proportions shall be such that the concrete is of adequate workability and can properly be compacted. Suggested ranges of values of workability of concrete for some placing conditions are given in the following Table.

Degree of Workability	Placing conditions	Nominal maximum aggregate (mm)	Compacting factor	Slump mm
Very low	Small sections (i.e. pre-cast or > 300mm thick) subjected to intensive vibration and large sections to normal vibration	20	0.78	0 – 10
		40	0.78	0 – 25
Low	Simple reinforced sections with vibration and large sections without vibration	20	0.85	10 – 25
		40	0.85	25 – 50
Medium	Simple reinforced sections without vibration and heavily reinforced sections with vibration	20	0.92	25 – 50
		40	0.92	50 – 100
High	Heavily reinforced sections without vibration	20	0.95	50 – 125
		40	0.95	100 - 175

When the consistency of the concrete is found to exceed the nominal slump, the mixture of subsequent batches shall be adjusted to reduce the slump to a value within the nominal range. Batches of concrete with a slump exceeding the maximum specified shall not be used in the work.

If concrete of adequate workability cannot be obtained by the use of the minimum cement content as would be allowed, the cement and water content shall be increased without exceeding the specified water/cement ratio, or an approved admixture shall be used.

2.1.6 Durability of concrete

Special exposures

For concrete intended to have low permeability when exposed to water, the water cement ratio shall not exceed 0.50.

For corrosion protection of reinforced concrete exposed to brackish water, sea water or spray from these sources, the water cement ratio shall not exceed 0.40.

If minimum requirement of concrete cover as given under the Section on 'Reinforcing Steel' is increased by 12mm, water cement ratio may be increased to 0.45.

The requirement of water cement ratio on Normal Weight Aggregate Concrete, if exposed to Sulphate containing solutions, shall be calculated using the weight of cement meeting the requirements of ASTM C 150 or C 595 plus the weight of fly ash or pozzolan satisfying ASTM C 618 and/or slag satisfying ASTM C 989.

Sulphate exposures

Concrete to be exposed to sulphate containing solutions or soils shall conform to the requirements of the Table given below or be made with a cement that provides sulphate resistance with the maximum water cement ratio provided in the Table.

Calcium chloride shall not be used as an admixture in concrete exposed to severe or very severe sulphate containing solutions, as defined in Table given below.

Requirements for Normal Weight Aggregate Concrete
Exposed to Sulphate Containing Solutions

Sulphate exposure	Water Soluble Sulphate (SO ₄) in soil (percent by weight)	Sulphate (SO ₄) in water (ppm)	Cement Type ¹	Maximum Water Cement Ratio, by weight
Negligible	0.00-0.10	0-150		
Moderate ²	0.10-0.20	150-1500	II, IP(MS), IS(MS), P(MS), I(PM) (MS) I(SM) (MS)	0.50
Severe	0.20-2.00	1500-10,000	V	0.45
Very severe	Over 2.00	Over 10,000	V plus pozzolan ³	0.45

- Note :**
1. For types of cement see ASTM C150 and C595.
 2. Sea water
 3. Pozzolan that has been determined by test or service record to improve Sulphate resistance when used in concrete containing Type V cement.

Corrosion of reinforcement

For corrosion protection, maximum water soluble Chloride ion concentrations in hardened concrete at ages from 28 to 42 days contributed from the ingredients including water, aggregates, cementitious materials, and admixtures, shall not exceed the limits specified in the Table given below. When testing is performed to determine water soluble Chloride ion content, test procedures shall conform to AASHTO T 260, "Methods of Sampling and Testing for Total Chloride Ion in Concrete and Concrete Raw Materials".

Maximum Chloride Ion Content for Corrosion Protection

Type of member	Maximum water soluble Chloride ion (C1) in Concrete, percent by weight of cement
Reinforced concrete exposed to chloride in service	0.15
Reinforced concrete that will be dry or protected from moisture in service	1.00
Other reinforced concrete construction	0.30

When reinforced concrete will be exposed to brackish water, sea water, or spray from these sources, the above requirements for water cement ratio, or concrete strength and minimum cover requirements (shown under the relevant Sub-section of the Section on 'Reinforcing Steel') shall be satisfied.

2.1.7 Design of concrete mix

When designing the concrete mix, the following conditions shall be considered:

- Strength : The class of the concerned concrete is to be as shown on the Drawings (if shown). The class is the specified cylinder strength of 28 days and shall be determined as indicated above in the Table under the Sub-section on 'Concrete Classes' of this Section.
- Water/Cement Ratio : The ratio of free water to cement when using saturated surface dry aggregate shall be as low as possible and not to exceed 0.50 by weight for all concrete.

For concrete in pile caps in contact with the ground, the water cement ratio shall not exceed 0.45.
- Cement Type and Minimum Content : Type-1 Cement shall be used for all classes for "Concrete".
- Minimum Filler Content : Filler is defined as fine concrete aggregates including cement with a grain diameter less than 0.25mm. It shall not be less than (except mass concrete) 435 Kg per cubic meter Concrete for maximum 20mm size Coarse Aggregate. The same for maximum 40mm size Coarse Aggregate shall not be less than 350 kg per cubic meter of Concrete.
- Coarse Aggregate : The maximum size of the coarse aggregate shall be either 40mm or 20mm and the grading and quality shall be as indicated in the portion of 'Coarse Aggregate' under the Sub-section on 'Construction Materials' of this Specification or as specified on the Drawings or as directed by the Engineer.
- Fine Aggregate : The grading and quality is to be as indicated in the portion of Sub-section on 'Fine Aggregate' under the Section on 'Construction Materials' of this Specification or as specified on the Drawings or as directed by the Engineer.

Workability : The concrete shall be of suitable workability to obtain full compaction. Slumps measured by STP T 8.1.1 shall be in accordance with the values shown unless otherwise required or approved by the Engineer.

The designed concrete mix shall be approved by the Engineer to meet the requirements for each structural component.

Prior to the commencement of concrete operations, the Contractor shall design a mix for the concrete and prepare and test concrete samples of this mix under laboratory conditions. Preliminary mixes shall be repeated and adjusted as necessary to produce a concrete mix meeting the requirements stated under the Sub-section on "Composition of Concrete" of this Specification. The details of the mix and test results shall be submitted to the Engineer for his approval.

Following the Engineer's approval of the mix design, the Contractor shall prepare a trial mix in the presence of the Engineer. The trial mix shall be batched, mixed and handled using the same methods and plant, the Contractor proposes to use. The mix shall comprise not less than half a cubic meter of concrete. The proportions of cement, aggregates and water shall be carefully determined by weight in accordance with the Contractor's approved mix design and sieve analysis shall be made for the fine and coarse aggregates.

Twelve concrete cylinder samples shall be made from the trial mix in the presence of the Engineer. The concrete cylinders shall be made, cured, stored and tested in accordance with BS 1881 or any other equivalent Standards. Six cylinders shall be tested at 7 days and six cylinders shall be tested at 28 days. If the strength of any of the cylinders tested at 28 days is recorded below the characteristic strength, the Contractor shall redesign the mix, make further preliminary mixes for the Engineer's approval. He shall then undertake additional trial mixes and test the resultant samples until a satisfactory mix is obtained and approved by the Engineer.

From the same mix as that from which the test specimens are made, the workability of the concrete shall be determined by the slump test in accordance with STP T 8.1.1. The remainder of the mix shall be cast in a wooden mould and compacted. After 24 hours, the sides of the mould shall be struck off and the surface examined in order to satisfy the Engineer that an acceptable surface can be obtained with the mix.

When a proposed mix has been approved, no variation shall be made in the mix proportions, or in the type, size, grading zone or source of any of the constituents without the consent of the Engineer. He may require further trial mixes to be made before any such variation is approved.

Until the Engineer approves the results of trial mixes for a particular class of concrete, no concrete of the relevant class shall be placed in the works.

During production, the Engineer may require additional trial mixes before a substantial change is made in the materials or in the proportions of the materials to be used. However, it will not need to be carried out when adjustments are made to the mix proportions during production in order to minimize the variability of strength and to approach more closely the target mean strength.

Trial mixes for mass concrete are not requested provided the Contractor is able to submit test results from mixes carried out before which prove that the demanded quality of the mass concrete is according to the Specifications.

When the Contractor intends to purchase factory-made pre-cast concrete units, trial mixes may be dispensed with provided that evidence is given to satisfy the Engineer that the factory regularly produces concrete, which complies with the Specifications. The evidence shall include details of mix proportions, water-cement ratios, slump tests and strengths obtained at 28 days.

Selection of the trial mix is the ultimate responsibility of the Contractor regardless of its approval accorded by the Engineer.

2.1.8 Proportioning of mix

Proportions of materials for concrete shall be such that:

- a) Workability and consistency are achieved for proper placement into forms and around reinforcement, without segregation or excessive bleeding.
- b) Resistance to special exposures to meet the durability requirements are provided, and
- c) Conformance with strength test requirements is ensured.

The approved mix shall be proportioned by weight or, except cement by volume, if volume batching is approved by the Engineer. Allowance shall be made for the moisture content of the aggregates.

Fine and coarse aggregates and water may only be measured by volume in boxes or containers approved by the Engineer. Cement shall be added to Concrete Mixer by whole number of bags only.

2.1.9 Concrete in blinding layers

The blinding concrete/lean concrete (Mix 1:3:6) shall be mixed in proportion by volume wherever specified on the Drawings. Ordinary Portland Cement and well-graded aggregate of maximum nominal size, not exceeding 40mm, shall be used unless otherwise specified.

2.1.10 Batching

General

The Contractor shall provide and maintain suitable measuring equipment and devices of good order required to determine and control accurately the relative amount of various materials entering the mix.

All measurements shall be by weight/volume and shall be accurate within a tolerance of 1% for each batch. Besides, the deviation from the average amount of filler from ten samples of different batches of fresh concrete should not be more than 6%.

Satisfactory methods of handling materials shall be employed.

A batching plant shall be used for measuring materials but alternative methods proposed by the Contractor may be considered subject to the approval of the Engineer. The batching plant shall include bins, weighing hoppers and scales for the fine aggregate and for each separated size of coarse aggregate. If cement is used in bulk, a bin, hopper and scales for the cement shall be included. The container shall be watertight.

Provisions satisfactory to the Engineer shall be made for batching other components of the mix at the batching plant or at the mixer, as may be necessary. The batching plant may be either of stationary or of mobile type. It shall always be properly leveled within the accuracy required for the proper operation of the weighing mechanisms.

Bins and hoppers

Bins with adequate separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely in to the weighing hopper. Means of control shall be provided so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. A port or other opening for removing an overload of the several materials from the hopper shall be provided.

Weighing hoppers shall be constructed so as to discharge fully.

Scales

The scales for weighing aggregates and cement shall be of either the beam type or the dial type without spring. They shall be accurate within one-half of 1% under operating conditions throughout the range of use. Ten 25 kilogram weights shall be available for checking the accuracy. All exposed fulcrums, clevises and similar working parts of scales shall be kept clean. When beam-type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 100 kilograms of load and upto 25 kilograms over-load. All weighing and indicating devices shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls.

Cement may be measured by weight, or in standard bags weighing 50 kilograms net each. When measured by weight, a separate satisfactory scale and hopper shall be provided together with a boot or other approved device to transfer the cement from the weighing hopper.

The amount of water shall be measured by weight separately on an individual scale or may be measured by volume.

Any solid admixture, to be added, shall be measured by weight. However, liquid or pest admixtures may be measured by volume or weight.

2.1.11 Quality control of concrete

General

The Contractor shall assume the full responsibility that the quality of the concrete conforms to the Specifications and this responsibility shall not be waived by the tests carried out and the test results approved by the Engineer. The Contractor shall thus at his own discretion establish additional testing procedures as necessary.

The Contractor shall be responsible for providing samples of concrete and its constituent materials either for testing by himself or for testing at the Engineer's laboratory or laboratory designated by the Engineer. For this purpose, concrete test cylinders, which shall be made in accordance with BS 1881/ASTM C 31 shall be deemed to be 'Samples'. All sampling of constituent materials shall be carried out in accordance with the provisions of the appropriate British/American Standard and all sampling of fresh and of hardened concrete shall be carried out in accordance with the provisions of BS 1881/ASTM C 31 unless such provision is at variance with the Specification.

The tests, which the Contractor is required to undertake on behalf of the Engineer, are those to be carried out on fresh concrete at the place of final deposit, or elsewhere at Site as directed by the Engineer.

Adjustment of water/cement ratio

The Contractor shall test aggregates for moisture content and so determine the water- cement ratio of the fresh concrete. Determination of water-cement ratio shall be carried out as required by the Engineer and the results and calculations shall be submitted to him.

Slump tests

Slump testing of concrete shall be carried out as required by the Engineer. The minimum is one test at the commencement of each casting, one per hour of casting and one each time a strength test specimen is taken.

The Engineer shall make available a slump cone at Site and the testing shall be carried out in accordance with STP T 8.1.

The slump of concrete to be used in the works shall not exceed the slump of the trial mix by more than 10% and shall in any case be not more than the maximum specified.

Compressive strength

The Contractor shall, in the presence of the Engineer, sample concrete for testing from the batching and mixing plant at the time of pouring of concrete into the forms or elsewhere. Samples shall be obtained at uniform intervals throughout the production or delivery of concrete for a given placement.

The Contractor shall carry out cylinder testing of concrete strength as required by the Engineer. A minimum of three test cylinders shall be taken for each day's casting or for every 15 cubic meters of concrete cast in larger pours.

After stripping, each cylinder shall be indelibly marked with the date of taking cylinder, location in the structure and prescribed number.

The Engineer shall make available 2 sets of three test moulds (cylinder) at Site. Samples for testing shall be taken in the presence of the Engineer and shall be dated.

Test s cylinder shall be tested for 7 days and 28 days compressive strength in accordance with STP T 8.2.

A strength test result shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days. Strength level of an individual class of concrete shall be considered satisfactory if both of the following requirements are met:

- a) Average of three consecutive strength tests equals or exceeds the specified strength.
- b) No individual strength test (average of two cylinders) falls below the specified strength by more than 3.5 N/mm².

However, the following may be an alternative –

The average strength of the three consecutive cylinders, tested at 28 days, shall exceed the specified strength. One out of the three cylinders tested may have a value less than the specified strength provided that it is not less than 85% of the specified strength, except that not more than one test result per element may be below the specified strength.

Failure to pass tests

If cylinders taken at Site during the progress of the works fail to reach the specified strength, no further pouring of concrete shall take place until the cause of the failure has been established and corrective measures have been taken to the satisfaction of the Engineer.

The Engineer may require that core samples are taken and tested in accordance with ASTM C 42 or a similar standard or other tests be performed on sections of the works made from the suspect concrete. If such tests fail to demonstrate the integrity of the sections of the works, all sections made with the suspect concrete shall be removed from the Site. Costs of all such tests and removal of concrete including the cost of the concrete shall be borne by the Contractor.

Testing hardened concrete

Entire operation shall be carried out as per the approval of the Engineer with due precaution so that the structural integrity is no way affected. The Contractor shall remain responsible for any negligence. If approved by the Engineer, on each specific occasion, hardened concrete liable to rejection shall be tested for compressive strength in accordance with ASTM C 42 at the Contractor's expenses. Unless otherwise directed, cores shall be 150mm in diameter. At least three specimens shall be cored and tested from the locations as directed by the Engineer.

If the average compressive strength of the core specimens, so obtained, is equal to or greater than 85% of the specified 28-days cylinder, compressive strength for that section of the work (the concrete represented by the core specimen) shall be considered to be structurally satisfactory.

If the concrete is considered to be structurally satisfactory, the holes left by the removal of the test cores shall be appropriately repaired or as directed by the Engineer. Unless otherwise directed, concrete that will fail to meet the requirements of the Specifications shall be removed and replaced in an approved manner without any extra costs to the Employer.

2.1.12 Concrete construction

2.1.12.1 General

The Contractor shall, in due time and as soon as possible, submit his proposed construction methods and work programme along with Shop Drawings to the Engineer and shall obtain his approval before commencement of any works.

The Contractor shall maintain an adequate number of trained and experienced supervisors and foremen at the Site to supervise and control the Work.

2.1.12.2 Mixing concrete

General

All concrete shall be mixed in batch mixers. It may be mixed at the Site of construction, at a central plant, or in transit. Each mixer shall have attached to it, in a prominent place, a manufacturer's plate showing the capacity of the drum in terms of mixed concrete and the speed of rotation of the mixing drum.

Mixers at the Site of construction

Mixers at local Sites shall be approved drum-type capable of combining the aggregate, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. The mixer shall be equipped with a suitable charging hopper, water storage and a water-measuring device, accurate within 1%. Controls shall be so arranged that the water can be applied only while the mixer is being charged. Suitable equipment for discharging the concrete shall be provided. The mixer shall be cleaned at suitable intervals. The pickup and throw over blades in the drum shall be replaced when they have lost 10% of their depth.

The mixer shall be operated at a drum speed of not less than 15 nor more than 20 revolutions per minute at the recommended speed of the manufacturer. The batched materials shall be so charged into the drum that a portion of the water shall enter in advance of the cement and aggregates and the water shall continue to flow into the drum for a minimum time of 5 seconds after all the cement and aggregates are in the drum. Mixing time shall be measured from the time all materials, except water, are in the drum and shall, in the case of mixers having a capacity of 1 cubic meter or less, not be less than 50 seconds nor more than 70 seconds. Mixing shall be continued for at least 90 seconds after all materials are in the drum, unless a shorter time is shown to be satisfactory by the mixing uniformity tests of 'Specification for Ready Mixed Concrete' (ASTM C 94). In the case of dual drum mixers, the mixing time shall not include transfer time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein. Any concrete mixed less than the specified minimum time shall be discarded and disposed of by the Contractor at his own expenses.

The volume of concrete, mixed per batch, shall not exceed the mixer's nominal capacity in cubic meters as shown on the manufacturer's guaranteed capacity standard rating plate on the mixer. However, an overload upto 20% of the mixers nominal capacity may be permitted provided concrete test data for strength, segregation and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

Re-tempering concrete by adding water or by other means shall not be permitted. Concrete, which is not of the required consistency at the time of placement, shall not be used.

Central plant mixers

These mixers shall be of approved drum type capable of combining the aggregate, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Central plant mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. The water system for a central mixer shall be either a calibrated measuring tank or a meter and shall not necessarily be an integral part of the mixer.

The mixer shall be cleaned at suitable intervals. It shall be examined daily for changes in interior condition. The pick-up and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

Central plant mixers, which have a capacity of 2-5 cubic meters and greater than 5 cubic meters, may permit a minimum mixing time of 90 seconds and 120 seconds respectively provided a mixing analysis and tests of the job materials indicate such produced concrete is equivalent to strength and uniformity to that attained as stated in the preceding paragraphs.

Hand mixing

The Engineer shall normally not allow any hand mixing in the preparation of concrete. However, under some special circumstances, exigencies and for small works, it may be compelling to allow hand mixing while preparing the concrete. In the case hand mixing is allowed, the procedures stated below shall be followed in a chronological order:

- Water-tight platform should be constructed with cement concrete or bricks. The size of the platform shall be such that it will be possible to accommodate the requisite quantity of mixture in a single batch. The materials of a single batch should be calculated out carefully.
- The requisite quantity of sand, being determined at a certain proportion, should be measured in a wooden box of specified size and to be spread on the platform with uniform thickness and the top is to be leveled. The requisite quantity of cement should also be measured and spread with uniform thickness over the stack of sand.
- Sand and cement as stacked above shall have to be mixed up by reversing with spade starting from one end and progressing towards the other. This procedure to be carried on carefully, thoroughly and repeatedly in such a manner that the mixture ultimately turns into a uniform colour and density. The mixture should then be stacked in a heap on a portion of the platform.
- The requisite quantity of coarse aggregate should then be stacked on the left out spaces of the platform and the top surface be leveled. The previously mixed sand and cement mixture shall than be spread with uniform thickness over the coarse aggregate. The height of these two layers in combination should better not to exceed 250mm. They are then to be thoroughly mixed with spade for several times. In each time, the mixing should proceed from one end. The mixing shall be continued until the mixture takes a uniform colour and density. The mixture will than be stacked with uniform height and leveled (the height of the stack may normally be maintained at 250mm).
- The top surface of the stack will than be shaped concave and the requisite amount of water to be poured in. It is then be thoroughly mixed with spade with caution and as quickly as possible. The mixing shall be continued till the mixture takes a uniform colour and density. The mixture shall invariably be conveyed, placed, compacted and to be given the final shape within 45 minutes on mixing.

2.1.12.3 Conveying concrete

General

Concrete shall be conveyed from the mixer/batching plant to the place of final deposit as rapidly as possible by methods that will prevent segregation or loss of materials. Conveying equipment shall be capable of providing a supply of concrete to the place of deposit without segregation of ingredients and without interruptions sufficient to permit loss of plasticity between successive increments. Re-mixing of concrete shall not be allowed. Concrete, which does not reach its final position in the forms within the stipulated time, shall not be used.

Mixed concrete shall be transported from the central mixing plant to the work Site in agitator trucks or upon written permission by the Engineer in non-agitator trucks. Delivery of concrete shall be so regulated that placing is at a continuous rate unless delayed by the placing operations. The intervals between delivery of batches shall not be so great as to allow the concrete in place to harden partially, and in no case such an interval shall exceed 30 minutes.

Agitator trucks

Unless otherwise permitted in writing by the Engineer, agitator trucks may be used for transportation of central plant mixed concrete. Agitator trucks shall have watertight revolving drums suitably mounted and shall be capable of transporting and discharging the concrete without segregation. The agitating speed of the drum shall not be less than 2 or more than 6 revolutions per minute. The volume of the mixed concrete permitted in the drum shall not exceed the manufacturer's rating nor exceed 80% the gross volume of the drum.

Upon approval by the Engineer, open-top revolving-blade truck mixers may be used in lieu of agitating trucks for transportation of central plant mixed concrete.

The interval between introduction of water into the mixer drum and final discharge of the concrete from the agitator shall not exceed 45 minutes. During this interval the mix shall be agitated continuously.

Non-agitator-trucks

Bodies of non-agitating equipment shall be smooth, watertight metal containers equipped with gates that will permit control of the discharge of the concrete. Covers shall be provided when needed for protection against weather.

The non-agitating equipment shall permit delivery of the concrete to the work Site in a thoroughly mixed and uniform mass with a satisfactory degree of discharge.

Uniformity shall be satisfactory, if samples from the one-quarter and three-quarter points of the load do not differ by more than 30mm in slump. Discharge of concrete shall be completed within 30 minutes after the introduction of the mixing water to the cement and aggregate.

Truck or transit mixers

These shall be equipped with electrically actuated counters by which the number of revolutions of the drum or blades may readily be verified and the counters shall be actuated at the commencement of mixing operations at designated mixing speeds. The mixer when loaded shall not be filled to more than 60% of the drum gross volume. The mixer shall be capable of combining the ingredients of the concrete in to a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

Except when intended for use exclusively as agitators, truck mixers shall be provided with a water-measuring device to measure accurately the quantity of water for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount.

Truck mixers may be used for complete mixing at the batch plant and as truck agitators for delivery of concrete to job Site or they may be used for complete mixing of the concrete at the job Site. They shall either be a closed watertight revolving drum or an open top revolving blade or paddle type.

The amount of mixing shall be designated in number of revolutions of the mixer drum. When a truck mixer is used for complete mixing, each batch of concrete shall be mixed for not less than 70 nor more than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as the "mixing speed". Such designation shall appear on a metal plate attached to the mixer. If the batch is at least 0.5 cubic meter less than guaranteed capacity, the number of revolutions at mixing speed may be reduced to not less than 50. Mixing in excess of 100 revolutions shall be at the agitating speed. All materials, including the mixing water, shall be in the mixer drum before actuating the revolution counter, which will indicate the number of revolutions of the drum or blades.

When wash water (flush water) is used as a portion of the mixing water for the succeeding batch, it shall be accurately measured and taken into account in determining the amount of additional mixing water required. When wash water is carried on the truck mixer, it shall be carried in a compartment separate from the one used for carrying or measuring the mixing water. The Engineer will specify the amount of wash or flush water and may specify a "dry" drum, if wash water is used without measurement or without supervision.

When a truck is used for complete mixing at the batch plant, mixing operations shall begin within 30 minutes after the cement has been added to the aggregate. After mixing, the truck mixer shall be used as an agitator, when transporting concrete, at the speed designated as agitating speed by the manufacturer of the equipment. Concrete discharge shall be completed within 45 minutes after the addition of cement to the aggregates. Each batch of concrete, delivered at the job Site, shall be accompanied by a time slip issued at the batching plant, bearing the time of departure therefrom. When the truck mixer is used for the complete mixing of the concrete at the job Site, the mixing operation shall begin within 30 minutes after cement has been added to the aggregates.

The rate of discharge of the plastic concrete from the mixer drum shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully opened.

2.1.12.4 Handling and placing of concrete

Concrete placing shall not be commenced without the written approval of the Engineer or his representative. This approval shall be in the form of a standard checklist approved by the Engineer prior to the commencement of the Work. The checklist shall be filled in and approved by the Engineer or his representative during his inspection and acceptance of materials, plant and equipment, concrete pouring arrangements, the positioning, fixing and condition of reinforcement and any other items to be embedded including the cleanliness, alignment and suitability of the containing surfaces or formwork.

The temperature of concrete at the time of placing shall not exceed 35°C.

In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from the interior of forms. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall entirely be removed from the forms and not be buried in the concrete.

The concrete shall be placed in the position and sequences indicated on the Drawings, and Specification or as directed by the Engineer. The concrete shall be placed in clean, oiled formwork and compacted before initial set has occurred. In any event concrete shall not be placed later than 30 minutes from the time of mixing.

Concrete shall be placed in horizontal layers and each layer shall not be more than 600mm thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the batches. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer that has not taken the initial set.

The concrete shall be deposited as far as possible in its final position without re-handling or segregation and in such a manner so as to avoid displacement of the reinforcement and other embedded items or formwork.

Open troughs and chutes shall be of metal or metal line. The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall be permitted only on written authorization of the Engineer. Where chutes are used to convey the concrete, their slopes shall not be such as to cause segregation. Where long steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement. In case an inferior quality of concrete is produced by the use of such conveyors, the Engineer may order discontinuation of their use and the installation of a satisfactory method of placing.

Pneumatic placing of concrete shall be permitted only if authorized by the Engineer. The equipment shall be so arranged that a vibration does not damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 3m from the point of deposit. The discharge lines shall be horizontal or inclined upwards from the machine. At the conclusion of placement, the entire equipment shall be thoroughly cleaned.

Placement of concrete by pumping shall be permitted only if authorized by the Engineer. The equipment shall be so arranged that vibrations do not damage freshly placed concrete. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there is no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

For simple spans, concrete shall preferably be deposited by beginning at the centre of the span and working from the centre towards the ends. Concrete in girders shall be deposited uniformly for the full

length of the girder and brought up evenly in horizontal layers. For continuous spans, the concrete placing sequence shall be as shown on the plans or agreed by the Engineer.

Concrete in slab and girder haunches less than 1m in height shall be placed at the same time as that in the girder stem.

Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise provided.

Concrete in T-beam or deck girder may be placed in one continuous operation, if permitted by the Engineer.

Concrete in columns and pier shafts shall be placed in one continuous operation unless otherwise directed.

Unless otherwise permitted by the Engineer, no concrete shall be placed in the superstructure until the column forms have been stripped off sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be applied to the supporting structures until they have been in place at least 14 days unless otherwise permitted by the Engineer.

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable materials to a sufficient depth to expose sound concrete. To avoid visible joints as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a "feather edge" might be produced at a construction joint, an inset form shall be used to produce a blocked out portion in the preceding layer which shall produce an edge thickness of not less than 150mm in the succeeding layer. Work shall not be discontinued within 450mm of the top of any face unless provision has been made for a coping less than 450mm thick, in which case, if permitted by the Engineer, a construction joint may be made at the under side of the coping.

Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon the reinforcement steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete while cleaning the reinforcement steels.

Where concrete is required to be placed against undisturbed ground, the entire space between the finished concrete surface and the ground, including any over-break, is to be completely filled with concrete of the specified class. The concrete shall be well rammed and compacted to ensure that all cavities are filled and the concrete is everywhere in contact with the ground. Where permitted by the Engineer, any extensive patches of over-break may first be filled with concrete belonging to the appropriate Class as directed by the Engineer.

Where concrete is required to be placed against a metal surface to which it is required to adhere, care shall be taken to work the concrete well into the re-entrant angles and to ensure contact by hammering the metal part on its free side provided that this is done without damaging the metal or its protective coating, if any.

Concrete shall not be dropped through a height greater than 1200mm except with the approval of the Engineer who may order the use of bankers and the turning over of the deposited concrete by hand before being placed.

When placing operations would involve dropping the concrete more than 1200mm, it shall be deposited through sheet metal or other approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcement bars, which are projected.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clean.

The laying of concrete shall be carried out in such a way that the exposed faces of concrete shall be plain, smooth, sound and solid, free from honeycomb and excrescencies. After compaction the exposed concrete surface shall be struck off smooth with hand held steel floats. No plastering of imperfect concrete faces will be allowed. Any concrete that is defective in any way shall, if so ordered by the Engineer, be cut out and replaced to such depth or be made good in such manner as the Engineer may direct.

Construction joints shall be formed in the work where indicated on the Drawings or as previously approved by the Engineer. Where necessary, the Contractor shall allow for working beyond ordinary working hours to allow each section of concrete to be completed in a continuous pour with the placing of concrete carried upto each construction joint.

2.1.12.5 Depositing concrete under water

Concrete shall not be deposited in water except with the approval of the Engineer and under his immediate supervision and in this case the method of placing shall be as defined in this portion.

Concrete deposited in water shall be with 10 percent excess cement. It shall be carefully placed in a compact mass in its final position by means of Tremie, a bottom opening bucket or other approved methods and shall not be disturbed after being deposited. Special cares must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces. The forms under water shall be watertight.

The discharge end of the Tremie shall be closed at the start of work so as to prevent water entering the tube and shall be entirely sealed at all times. The Tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow shall be continuous until the work is completed. Concrete slump shall be in between 100mm and 150mm.

Depositing of concrete by the opening bucket method shall conform to the following specifications. The top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited. When discharged, it shall be withdrawn slowly until it goes well above the concrete.

2.1.12.6 Compaction of concrete

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration subject to the following provisions:

- The vibration shall be internal unless special authorization of other methods are given by the Engineer or as provided herein.
- Mechanical vibrators of the capacity as approved by the Engineer shall be used in conjunction with or without hand rammers, poker or any other means as directed by the Engineer.
- Vibrators shall be of a type and design as approved by the Engineer. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 4,500 impulses per minute.
- The intensity of vibration shall be such as to visibly affect a mass of concrete of 20mm slump over a radius of at least 450mm.
- Vibrators must be operated by skilled workmen engaged/appointed by the Contractor mainly for this job.
- Surface vibrators of the type of Pan-vibrators, or vibrating screens shall be used for compacting castings of shallow depth as directed by the Engineer.
- The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. Spare vibrators shall be readily on hand in case of breakdown.

- Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into the corners and angles of the forms.
- Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point, to the extent that localized areas of grout are formed.
- While using immersion vibrators in walls, these should be lowered to the bottom of the wall before depositing of concrete is started and pulled up as it proceeds. When using vibrators, concrete can be placed from bottom to top of wall in one process, provided it is laid in regular layers. Cares should be taken to ensure that vibrators are not trapped under a great depth of concrete.
- Application of vibrators shall be at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.
- Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete, which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms.
- Vibration shall be supplemented by such spading as is necessary to ensure smooth surface and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.
- In columns, deep beams and walls mild striking by mallets at the outer faces of the form works should also be done simultaneously during use of vibrator for compaction.

The provisions of this Sub-section shall also apply to pre-cast piling, concrete cribbing and other pre-cast members except that the manufacturer's methods of vibration may be used, if approved by the Engineer.

2.1.13 Protection of concrete from adverse conditions

General

Concrete shall be protected from damage from the effects of sunshine, dry wind, rain, running water or mechanical damage for a continuous period, until the concrete has reached at least three quarters of its 28-days strength, but for not less than 10-days. Temperature of the concrete mixture shall require to be maintained between 100C and 320C unless otherwise provided herein. The Contractor shall submit his proposals to achieve this protection for the Engineer's approval.

Damaged concrete shall be removed and replaced generally. However, it may be repaired to an acceptable condition if found appropriate by the Engineer.

Protection from rain

During rainy weather, proper protection shall be given to ingredients, production methods, handling and placing of concrete. If required in the opinion of the Engineer, the concrete depositing operation shall be postponed and newly placed concrete shall be protected from rain after forming proper construction joint for future continuation.

Protection from hot weather

During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation that could impair required strength or serviceability of the member or structure.

Under a temperature above 32oC surfaces of forms, reinforcing steel, steel beam flanges etc. that remain in contact with the mix shall be cooled down below this temperature by means of water spray or by any other appropriate methods.

Protection from cold weather

Under a cold weather condition, temperature of the concrete shall be maintained not below 7oC during the curing period for the first six days on placement of concrete unless pozzolan cement or fly ash cement is used. Periods to be followed in the later case has been shown in the table given below:

% of cement replaced by weight with pozzolans	Required period of controlled temperature
10%	8 days
11-15%	9 days
16-20%	10 days

However, this requirement may be waived in the case the compressive strength of 65% of the specified 28-days design strength is achieved in 6-days.

If external heating is used in maintaining the requisite temperature, heat shall be applied and withdrawn gradually and uniformly so that the concrete surface is not heated more than 32oC.

Temperature of concrete at the time of placement in sections less than 300mm in thickness shall not be less than 16oC when the air temperature is below 2oC.

Special requirements for roof slabs

Prior to the application or curing, concrete being placed and finished for roof slabs shall be protected from damage due to rapid evaporation when the weather is low humid, windy or having high temperature. Such protection shall be adequate to prevent premature crusting of the surface or an increase in dry cracking. In providing such protection the humidity of the surrounding air shall be raised with fog sprayers operated upwind of the deck.

Concrete exposed to salt water

Unless otherwise specifically provided, concrete for structures exposed to salt water shall be mixed for a period of not less than 2 minutes and water content of the mixture shall be carefully controlled and regulated so as to produce concrete of maximum impermeability. The concrete shall be thoroughly consolidated as necessary to produce maximum density and a complete lack of rock pockets. Unless otherwise shown on the Drawings, the clear distance from the face of the concrete to the reinforcing steel shall not be less than 100mm. No construction joints shall be formed between levels of extreme low water and extreme high water or the upper limit of wave action as determined by the Engineer. Between these levels the forms shall not be removed, or other means provided to prevent salt water from coming in direct contact with the concrete for a period of not less than 30 days after placement. Except for the repair of any rock pockets and the plugging of form tie holes, the original surface, as the concrete comes from the forms, shall be left undisturbed. Special handling shall be provided for pre-cast members to avoid even slight deformation cracks.

2.1.14 Perforations and embedding of special devices

The Contractor is responsible for determining in advance of making any concrete pours, all requirements for perforation of concrete sections or embedding therein of special devices of other trades, such as conduits, pipes, weep holes, drainage pipes, fastenings, etc. Any concrete, poured without prior provision having been made, shall be subject to correction at the Contractor's own expenses.

Devices to be embedded in the concrete shall be shown on the Drawings or directed by the Engineer.

Conduits, pipes and sleeves of any material not harmful to concrete and within the limitations specified herein shall be permitted to be embedded in concrete with the approval of the Engineer, provided they are not considered to replace structurally the displaced concrete.

Conduits and pipes of aluminium shall not be embedded in structural concrete unless effectively coated or covered to prevent aluminium concrete reaction or electrolytic action between aluminium and steel.

Conduits, pipes, and sleeves passing through a slab, wall, or beam shall not impair significantly the strength of the construction.

Conduits and pipes, with their fittings, embedded within a column, shall not displace more than 4% of the area of cross-section on which strength is calculated or which is required for fire protection.

Except when the Engineer approves Drawings for conduits and pipes, embedded conduits and pipes within a slab, wall or beam (other than those merely passing through) shall satisfy the following:

- i. They shall not be larger in outside dimension than 1/3rd the overall thickness of slab, wall, or beam in which they are embedded.
- ii. They shall not be spaced closer than 3 diameters or widths on centers.
- iii. They shall not impair significantly the strength of the construction.

Conduits, pipes and sleeves shall be permitted provided that they are not exposed to rusting or other deterioration, have nominal inside diameter not over 50mm and are spaced not less than 3 diameters on centers.

Pipes and fittings shall be designed to resist effects of the material, pressure, and temperature to which they will be subjected.

No liquid, gas, or vapor excepting water, not exceeding 300C nor 0.3 N/mm² pressure, shall be placed in the pipes until the concrete has attained its design strength.

Piping in solid slabs, unless it is for radiant heating, shall be placed between the top and bottom reinforcements.

Concrete cover for pipes, conduits, and fittings shall be not less than 40mm for concrete exposed to earth or weather nor 20mm for concrete not exposed to weather or in contact with the ground.

Reinforcement with an area not less than 0.002 times the area of concrete section shall be provided normal to piping.

Piping and conduit shall be so fabricated and installed that cutting, bending, or displacement of reinforcement will not be required.

2.1.15 Curing of concrete

General

In order to prevent loss of water, all newly placed concrete shall be cured by use of one or more of the methods specified herein. The Engineer shall select the method that should be followed for curing a concrete of particular type of work or member. Curing shall commence immediately after the free water has left the surface and finishing operations are complete. In the case the concrete surface begins to dry before the selected cure method is applied, the surface of the concrete shall be kept moist by a fog spray application so as to prevent any damages to the surfaces.

Curing by other than steam or radiant heat methods shall continue uninterrupted for at least 7 days except that when pozzolans in excess of 10 percent, by weight, of the Portland cement are used in the mix. When such pozzolans are used, the curing period shall be at least 10 days. For other than top slabs of structures, the above curing periods may be reduced and curing may be terminated when test cylinders, cured under the same conditions as the structure, indicate that concrete strength of at least 70 percent of that specified has been reached.

High early strength concrete shall be maintained above 100C and in a moist condition for at least the first three days, except when cured in accordance with Accelerated Curing Method.

During periods of hot weather, water shall be applied to the concrete surfaces being cured by the liquid membrane method or by the forms-in-place method, if considered necessary by the Engineer. The process shall continue for a period that the Engineer determines a cooling effect is no longer required.

Materials:

Water

Water used in curing of concrete shall be subject to approval and shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other injurious substances. Water shall be tested in accordance with and shall meet the suggested requirements of AASHTO T 26. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

Liquid membranes

Liquid membrane forming compounds for curing concrete shall conform to the requirements of ASTM C 309.

Waterproof sheet materials

Waterproof paper, polyethylene film, and white burlap polyethylene sheet shall conform to the requirements of ASTM C 171.

Methods

Forms-in-place method

Formed surfaces of concrete may be cured by retaining the forms in place for the required time.

Water method

Concrete surface shall be kept continuously wet by ponding, spraying or covering with materials that are kept continuously and thoroughly wet. Such materials may consist of cotton mats, multiple layers of burlap or other approved materials, which do not discolour or otherwise damage the concrete.

Liquid membrane curing compound method

The liquid membrane method shall not be used on surfaces where a rubbed finish is required or on surfaces of construction joints unless it is removed by sand blasting prior to placement of concrete against the joint. Type 2 white pigmented liquid membranes may be used only on the surfaces that will not be exposed to view in the completed works or on surfaces where their use has been approved by the Engineer.

When membrane curing is used, the exposed concrete shall be thoroughly sealed immediately after the free water has left the surface. Formed surfaces shall be sealed immediately after the forms are removed and necessary finishing has been done. The solution shall be applied by power-operated atomizing spray equipment in one or two separate applications. Hand-operated sprayers may be used for coating small areas. Membrane solutions containing pigments shall be thoroughly mixed prior to use and agitated during application. If the solution is applied in two increments, the second application shall follow the first application within 30 minutes. Satisfactory equipment shall be provided, together with means to properly control and assure the direct application of the curing solution on the concrete surface so as to result in a uniform coverage at the rate of 4.5 liters for each 14 square meter of area.

If the film is damaged by inclement weather condition or in any other manner during the curing period and before the film has dried sufficiently, a new coat of the solution shall be applied to the affected portions equal in curing value to that specified above.

Waterproof cover method

This method shall consist of covering the surface with a waterproof sheet material so as to prevent moisture loss from the concrete. This method may be used only when the covering can be secured adequately to prevent moisture loss.

The concrete shall be wet at the time the cover is installed. The sheets shall be of the widest practicable width and adjacent sheets shall overlap a minimum of 150mm and shall be tightly sealed with pressure sensitive tape, mastic, glue, or other approved methods to form a complete waterproof cover of the entire concrete surface. The paper shall be secured so that wind will not displace it. Should any portion of the sheets be broken or damaged before expiration of the curing period, the

broken or damaged portions shall be immediately repaired. Sections that have lost their waterproofing qualities shall not be used.

Accelerated curing

Curing by high-pressure steam, steam at atmospheric pressure, heat and moisture or other accepted processes, shall be permitted to accelerate strength gaining and reduce time of curing.

Accelerated curing shall provide a compressive strength of the concrete at the load stage considered, at least equal to the required design strength at that load stage.

Curing process shall be such, as to produce concrete with a durability at least equivalent to that obtained for concrete cured by the above methods.

The use of accelerated curing method for concrete containing other types of cement or any admixture shall be subject to the Engineer's acceptance.

Field cured specimens

The Engineer may require strength tests of cylinders cured under field conditions to check adequacy of curing and protection of concrete in the structure.

Field cured cylinders shall be cured under field conditions in accordance with "Practice for Making and Curing Concrete Test Specimens in the Field" (ASTM C 31).

Field cured test cylinders shall be moulded at the same time and from the same samples as laboratory cured test cylinders.

Procedures for protecting and curing concrete shall be improved when the strength of field cured cylinders at the test age designated for determination of f_c is less than 85% of that of companion laboratory cured cylinders. The 85% limitation shall not apply, if field cured strength exceeds f_c by more than 3.5 N/mm².

2.1.16 Finish and finishing

General

Surface irregularities shall be classified as "abrupt" or "gradual". Offsets caused by displaced or misplaced form sheathing or lining of form sections, or loose knots in forms or otherwise defective formwork, will be considered as "abrupt" irregularities. All other irregularities will be considered as gradual irregularities.

Where a surface is partly below and partly above the final ground level, the finish for the exposed surface shall extend for 0.15m below the ground level.

The formed surfaces, which will be permanently buried under earth, will require no treatment for abrupt or gradual irregularities. However, repair of defective concrete and filling of holes left by the removal of fasteners from the ends of tie rods shall be undertaken.

All abrupt and gradual irregularities on all exposed surfaces shall be removed by sack rubbing or sand blasting or grinding or by all these methods or any other methods approved by the Engineer, which is not harmful to the concrete. The permissible surface irregularities shall not exceed 6mm for abrupt irregularities and 13mm for gradual irregularities. The permissible irregularities may be reduced at places of the surface where, in the opinion of the Engineer, the formed finish does not provide the desired effect and no extra payment shall be permissible for such work.

Holes, honeycombs, or other defects left by forms shall be promptly repaired in accordance with the relevant Sub-section of this Specification.

All surfaces such as blinding concrete, opening for second stage concrete etc. on which concrete is to be placed subsequently, shall not be finished for abrupt or gradual irregularities.

Generally, concrete surface shall remain as cast and no plastering work will be performed on it. The formwork shall be lined with a material approved by the Engineer to provide a smooth finish of uniform

texture and appearance. This material shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one structure. The Contractor shall repair any imperfections in the resulting finish as required by the Engineer for which no extra payment shall be made to him. Internal ties and embedded metal parts will be allowed only with the Engineer's specific approval.

Concrete surface finishing

Skilled workmen shall perform finishing of concrete surfaces to the satisfaction of the Engineer. Exposed flat concrete surfaces shall be screed to produce an even and uniform surface and then they shall be given a trowel finish unless otherwise specified on the Drawings. All exposed and unprotected edges shall be given 20mm x 20mm chamfers.

The Concrete surface finish on upward facing, horizontal or sloping faces shall be, except for blinding concrete or otherwise stated on the Drawings, a "fair" surface. A 'fair' surface shall be obtained by screeding and trowelling with a wood float.

Screeding shall be carried out following compaction of the concrete by the slicing and tamping action of a screed board running on the top edges of the formwork or screeding guides to give a dense concrete skin true to line and level.

Wood float trowelling shall be carried out after the concrete has stiffened and the film moisture has disappeared. Working should be kept to the minimum compatible with a good finish and the surface shall be true to the required profile to fine tolerance. Whenever necessary, the Contractor shall provide and erect overhead covers to prevent the finished surfaces from being marred by rain drops or dripping water.

The surface of blinding concrete shall be obtained by screeding as described above.

Where a "fine" surface is indicated on the Drawings, this shall be obtained in a similar manner to "fair" surface except that a steel float shall be used in lieu of the wood float.

Formed surface for painting exposed to view shall be smooth and free from projections and shall be rubbed smooth immediately after the forms are removed. Formed surfaces shall be classified as follows:

- Unexposed concrete surfaces upon or against which backfill or concrete is to be placed, require no treatment except the removal and repair of defective concrete.
- Exposed surfaces shall have a very smooth, sound surface by control of formwork, concrete placement and repair of abrupt surface irregularities by grinding or rubbing of high spots and filling of voids.

Ordinary finish

An ordinary finish is defined as the finish left on a surface after the removal of the forms when all holes left by form ties have been filled and all irregular projections and any other minor surface defects have been mended. The surface shall be true and even, free from depression fins or projections.

The concrete shall be struck off with a straight edge and floated to true grade. Under no circumstance, the use of mortar topping for concrete surfaces shall be permitted.

Grout cleaning

Grout cleaning may be called for on the Drawings or required by the Engineer because of unsatisfactory appearance. The operation requires that the surface is wetted and uniformly covered with a grout consisting of 1 part cement to 1.5 parts fine sand. White cement shall be used for all or part of the cement in the grout to give the colour required to match the concrete. The grout shall be uniformly applied with brushes or a spray gun and all air bubbles and holes shall be completely filled. Immediately after the application of the grout, the surface shall be vigorously scoured with a cork or other suitable float. While the grout is still plastic, the surface shall be finished with a sponge rubber or other suitable float removing all excess grout. This finishing shall be done at the time when grout will

not be pulled from the holes or depressions. After being allowed to be thoroughly dry, the surface shall be vigorously rubbed with a dry burlap to completely remove any dried grout. There shall be no visible film of grout remaining on the surface after this rubbing and the entire cleaning operation of any area must be completed on the day it is started. If any dark spot or steak remains after this operation, they shall be removed with a fine-grained silicon carbide stone, but the rubbing shall not be as much to change the texture of the surface. Unless it is required by the Drawings or directed by the Engineer, grout cleaning should be delayed until the final clean up of the Work.

Rubbed finish

On removal of forms, the rubbing of concrete shall be started as soon as its condition permits. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for a minimum period of 3 hours. Sufficient time shall elapse before wetting down to allow the mortar used in patching to have thoroughly set. A medium coarse carborundum stone shall be used for rubbing a small amount of mortar on the face. The mortar used shall be composed of cement and fine aggregate mixed in the same proportions as that used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time. The final finish shall be obtained by rubbing with a fine carborundum stone and water until the entire surface is of a smooth texture and uniform colour.

After the final rubbing has been completed and the surface has dried up, burlap shall be used to remove loose powder. The final surface shall be free from unsound patches, paste, powder and objectionable marks.

Any surface that has been given a rubbed finish shall be protected from subsequent construction operations. Any surface not protected, shall be cleaned and again rubbed, if necessary to secure a uniform and satisfactory surface at the own expenses of the Contractor.

On completion of initial rubbing, curing shall be continued.

Tooled finish

Tooled finishing shall be carried out by treating the surface with an approved heavy duty power hammer fitted with a multi-point tool, which shall be operated over the surface to remove 5mm to 6mm of concrete and expose maximum areas of coarse aggregate.

Aggregate left embedded shall not be fractured or loose. 25mm wide bands at all corners and arises shall be left as cast. The finished surfaces shall have even and of uniform appearance and shall be washed with water upon completion.

Sandblasted finish

Sandblasted finishing will be carried out on a thoroughly cured concrete surface with hard, sharp sand to produce an even fine-grained surface in which the mortar has been cut away, leaving the aggregate exposed.

Wire brushed or scrubbed finish

Wire brushed or scrubbed finish will be performed as soon as the forms are removed and while the concrete is yet comparatively green. The surface shall be thoroughly and evenly scrubbed with stiff wire or fiber brushes, using a solution of muriatic acid. The proportion of the solution shall constitute of one part acid to four parts water. This shall be continued until the cement film or surface is completely removed and the aggregate particles are exposed, leaving an even-pebbled texture presenting an appearance grading from that of fine granite to coarse conglomerate, depending upon the size and grading of aggregate used. When the scrubbing has progressed sufficiently to produce the texture desired, the entire surface shall be thoroughly washed with water to which a small amount of Ammonia has been added in order to remove all traces of acid.

Inspection and making good

Concrete surface shall be inspected for defects and for conformity with the Specifications and where appropriate, for comparison with approved sample finishes. Subject to the strength and durability of

the concrete being unimpaired, the making good of surface defects may be permitted but the standard of acceptance shall be appropriate to the type and quality of the finish specified to ensure satisfactory performance and durability. On permanently exposed surfaces, great care is essential in selecting the materials and the mix proportions to ensure that the final colour of the faced area blends with the parent concrete in the finished structure.

Voids can be filled with fine mortar, preferably incorporating Styrene Butadiene Rubber (SBR) or Polyvinyl Acetate (PVA), while the concrete is still green or when it has hardened. Fine cracks can be filled by wiping a cement grout, a SBR, PVA or latex emulsion, a cement/SBR or a cement/PVA slurry across them. Fins and other projections shall be rubbed down.

Protection

High quality surface finishes are susceptible to damage during subsequent construction operations and temporary protection may have to be provided in vulnerable areas. The protective measures, among others, include the strapping of laths to arrises and the prevention of rust being carried from exposed starter bars to finished surfaces.

2.1.17 Second stage concrete

Unless shown on the Drawings or otherwise instructed by the Engineer, second stage concrete shall be of class for major RCC structures.

Block-outs for second stage concrete and the specifications and locations of the embedded parts shall be in accordance with the Drawings.

The surface against which the second stage concrete are to be placed shall be thoroughly cleaned to make the surface free from all loose particles, organic substances, oil, grease, rust, plastic materials, wood and defective concrete.

The projected parts of the embedded items or the parts that will remain embedded shall be thoroughly cleaned of oil, grease and rust. All such parts shall be true to dimensions, plumb and levels as shown on the Drawings and directed by the Engineer.

2.1.18 Factory made pre-cast concrete elements

The Engineer shall approve in writing any supplies of pre-cast concrete elements. The Engineer, if he so desires, may withdraw the approval later on.

All concrete works of such elements shall fully conform all requirements of this Specification.

The supplier shall maintain standard laboratory facilities.

Concrete members, specified to be fabricated as pre-cast concrete units, shall be fabricated with concrete of the specified class placed into a grout tight mould. If so required, the mould shall be laid on a vibrating table and vibration should be applied while concrete is placed.

Members, structurally dependent on a rigid fixing with the adjoining structures, should not in general be permitted to be pre-cast.

Unless otherwise approved by the Engineer, pre-cast concrete members shall neither be moved from the casting position until the concrete has attained a compressive strength of 80% of the specified 28-days strength, nor transported until it has gained a strength of 90% of the specified 28-days strength.

Extreme cares shall be taken in handling and moving pre-cast concrete members. Pre-cast girders and slabs shall be transported in an upright position. Shock shall be avoided and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as and when the member would be in its final position. If the Contractor finds it expedient to transport or store pre-cast units in other than this position, it shall be done at his own risks after notifying the Engineer of his intention to do so. Any units rejected shall be replaced at the Contractor's own expenses by an acceptable unit.

All details on the handling and transportation of pre-cast members shall be submitted in writing to the Engineer for his approval.

Each pre-cast member is to be uniquely and permanently marked so as to show its type, date of casting and reinforcement.

Handling and stacking of pre-cast units

The Contractor shall give the Engineer full details of his proposed methods of handling, transportation and stacking of pre-cast concrete units. The Engineer will examine these in details and will either approve the methods or order modifications to ensure that the units are not subject to excessive stresses. The finally approved methods are to be adhered to at all times and the Contractor shall be deemed to have included in his rates for all measures required to handle, transport and stack the units safely and without undue stressing. However, such approval by the Engineer shall neither relieve the Contractor from his full responsibilities and liabilities of safe transportation and installation of any pre-cast units at the designated location as shown on the Drawings or as directed by the Engineer without any damage nor to make any deviation from the Specifications in fabricating the unit.

2.1.19 Control of heat in structures

The Contractor shall establish measures to control the heat deriving from the hydration of the concrete in structures of major dimensions. Temperature gradients introducing risks of cracking shall not occur and the temperature shall not exceed 70°C.

The Contractor shall also establish measures to avoid harmful excessive heat generation in massive structures, such as cooling down aggregates before mixing.

The Contractor shall submit in due time a proposal for the establishment of the aforementioned measures to the Engineer for his approval. The measures shall immediately be changed, if requested by the Engineer even later.

2.1.20 Back-fill to structures

All spaces, which have been excavated but are not occupied by the concrete structure shall be back-filled and compacted with materials acceptable to the Engineer or as shown on the Drawings and/or as per the directions of the Engineer.

2.1.21 Cleaning up

Upon completion of structure and before final acceptance, the Contractor shall remove all forms and scaffoldings, etc. down to 0.5m below the finished ground line. Excavated or garbage materials, rubbish etc. shall be removed from the Site, which shall be left in a neat condition satisfactory to the Engineer.

2.1.22 Measurement

The concrete of the several different grades and types completed in place in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer and accepted by the Engineer shall be measured by either the cubic meter for each class of concrete included in the BOQ or by the unit for each type of pre-cast concrete member listed in the BOQ. In computing quantities, the dimensions used shall be those shown on the Drawings or ordered by the Engineer; but the measurement shall not include any concrete used for the construction of temporary works or which is included in other billed items. No deduction from the measured quantity shall be made for drainage openings and pipes of less than 300mm in diameter, conduits, chamfers, reinforcement bars and expansion joint filler materials. However, deduction will be made for the volume of concrete displaced by piles embedded in the concrete.

The quantities of reinforcing steel and other related items as shown in the Contract Documents, which are included in the completed and accepted structure shall be separately measured for payment as per the provisions made under the Section on 'Reinforcing Steel' of this Specification.

Formwork and false work shall not be measured separately but shall be deemed to be an integral part of the concrete items.

Surface finishes shall not be measured separately but shall be deemed to be an integral part of the concrete items.

Joints including fillers and expansion joints shall not be measured separately unless they are specified as separate items in the BOQ.

The number of pre-cast concrete members of each type listed in the BOQ will be the number of acceptable members of each type furnished and installed in the work.

2.1.23 Payment

The cubic meters of concrete and the number of pre-cast concrete members, measured as provided above will be paid for at the Contract unit prices per cubic meter or the Contract unit prices per each member for each type or class as would be applicable as per the BOQ.

Payment for concrete of the various classes and for pre-cast concrete members of the various types shall be considered to be the full compensation for the costs for furnishing all materials including their transportation and storage, providing all equipment, labourers and incidentals and for doing all works involved in constructing the concrete work complete in place as shown on the Drawings and as specified. Such payment shall also include the full compensation for placing of rod in position, mixing the concrete mixture, concrete pouring, compacting by vibrator machine and curing, furnishing and placing expansion joint fillers, sealed joints, water-stops, drains, vents, miscellaneous metal devices and the drilling of holes for dowels and the grouting of dowels in drilled holes, unless payment for such works would be specified under another item of the BOQ.

Payment for all types of concrete work shall be considered to be the full compensation for the costs of furnishing and installing and removal of all temporary works like staging, formwork, working platforms, cranes, transporting, placing, compaction, finishing, curing and rendering of the concrete as specified till the concrete work becomes self-supporting and can perform its intended functions.

The Contractor's rates shall be fully inclusive of all costs of all laboratory tests to be carried out as specified under different sub-items unless any payment is separately specified under the BOQ.

The payment shall be the full compensation of all incidentals necessary to complete the Work.

Payment for pre-cast units shall include all concrete, formwork, transport and erection and where applicable any bolts or other devices and bedding necessary to fix them in their permanent positions, all incidentals and all other works that will be necessary for full completion from transportation to safe erection of the members at the designated locations as shown on the Drawings or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
2.1	Concrete Class as detailed on the Drawings and specified in the Bill of Quantities.	Cubic Meter
2.1	Pre-cast concrete elements as detailed on the Drawings and as specified in the Bill of Quantities.	Number/ Linear Meter/ Cubic Meter

2.2 False work and forms

2.2.1 Scaffolding (false work)

Scaffolding is defined to be any temporary structure required to support structural elements of concrete, steel, masonry, or other materials at the time of their construction or erection.

Plans, Drawings and structural calculations in details shall be submitted to the Engineer for approval, but in no case shall the Contractor be relieved of his responsibilities for results obtained by using this Document.

All scaffolding shall be designed and constructed to provide the necessary rigidity and strength to safely support all loads imposed and produced in the finished structure, the lines and grades indicated on the Drawings. The supports shall be designed to withstand the worst combination of self-weight, formwork weight, formwork forces, reinforcement weight, wet concrete weight, construction and wind loads, together with all incidental dynamic effects caused by placing, vibrating and compacting the concrete. No harmful cracking should occur in the placed concrete. The Engineer may require the Contractor to employ screw jacks or hardwood wedges to take up any settlement in the formwork either before or during the placing of concrete.

All scaffolding, exceeding 20m or six storeys in height, shall be constructed of noncombustible or fire-retardant materials.

Scaffolding shall be founded on a solid base, which is safe against undermining, protected from softening and capable of supporting the loads imposed on it. Scaffolding which cannot be founded on a satisfactory footing shall be supported on piling, which shall be spaced, driven and removed in a manner approved by the Engineer.

Horizontal and inclined bracings shall be provided for posts higher than 3m. Spans of beam bottoms shall be supported by posts with maximum 1m apart when steel is used and instructions from the manufacturer/supplier shall be strictly followed. Spacing of the props under beams shall consider the increased load and shall be posted closer than those under the floor slab.

Scaffolding can, in certain cases, be supported on structures already constructed. In that case, the Contractor shall submit in due time to the Engineer in writing all information on the loading from the scaffolding as requested. The Engineer shall consider the loading and submit his approval in writing.

Scaffolding shall be set to give the finished structure the camber shown on the Drawings or specified by the Engineer. If any weakness develops or the scaffolding shows undue settlement or distortion during construction, the work shall be stopped and any structure affected thereby shall be removed and the scaffolding shall be further strengthened before work is resumed. Suitable screw jacks, pairs of wages or other devices shall be used at each post to adjust scaffolding to grade.

All materials used in the construction of the scaffolding shall conform to the corresponding ASTM or BS Standards or any other equivalent International Standards. Material tests and certificates may be required by the Engineer. Examinations of welding may also be requested. Test loading of the scaffoldings may be requested for the determination of the flexibility and the strength. All expenses of the tests and examinations of scaffoldings shall be borne by the Contractor on non-reimbursable basis.

Scaffolds shall be made from strong bamboo poles, wooden posts, steel pipes or any other suitable materials. They shall be adequately tied to vertical members resting on firm floor. Strong ropes shall be used to tie up bamboo poles. In addition, cross-bracing with bamboo or wooden posts shall be provided along with ties or guys of steel wire or rod not less than 6mm in diameter.

Good, sound and uniform bamboo shall be collected in sufficient quantities for providing scaffolding, propping, temporary staging, ramp etc. The bamboos shall be free from any defects, firmly ties to each other and joints made smooth. Joining members only with nails shall be prohibited. Bamboos for vertical support shall not be less than 75mm in diameter and shall be straight as far as possible. Bamboos may be used as vertical support for up to a height of 4m, if horizontal bracings are provided at the centre. Splicing shall be prohibited.

After stripping the formwork, the bamboo posts shall be cleaned and stacked vertically in shade protected from rain and sun. Defective or damaged bamboo posts shall be removed from the Site.

Timber posts shall be used in supporting formwork upto a height of 6m. The posts shall not be less than 80mm in diameter at any place and shall spread to at least 150mm in diameter at the top. The timber posts shall be supported on timber planks at the bottom. Either the bottom or the top of the posts shall be wedged with a piece of triangular wood peg for easy removal. Adequate horizontal and

inclined braces shall be used for all timber centering. All timber posts shall be carefully inspected before use and members with cracks and excessive knots and crookedness shall be discarded. The joints shall normally be made with bolts and nuts. No rusted or spoilt threaded bolts and nuts shall be used.

When steel scaffoldings are used, it shall be painted in a manner that no mark of corrosion shall appear on the permanent concrete structures.

The Engineer shall only select the type of scaffolding. Bamboo scaffolding will only be used, if agreed and allowed by the Engineer. All scaffoldings shall remain in place for a period, which shall be determined by the Engineer.

Scaffold shall be dismantled after use piece by piece. Holes in the wall shall be filled up with the same materials as that of the wall. Filled up holes shall have uniformity in texture and colour with the surrounding surface. Crash striking shall not be allowed.

Triangular wooden wedges shall be put under the posts for easy dismantling of the members. Timber planks or steel sheets shall be placed at a time below the vertical or inclined posts covering several posts.

Materials and joints in scaffolding shall be inspected from time to time both before and after erection for the soundness, strength, damage due to weathering etc. Inspections shall be made for spillage of material or liquids, loose material lying on the gangways and proper access to the platform.

The scaffold shall be secured to the building at enough places; no ties shall be removed. Warning sign, prohibiting the use of any defective or incomplete scaffold and working in bad weather and high wind, shall be posted in a prominent place. Inspections shall be made for the observance of these requirements.

2.2.2 Formwork

Definition

Formwork is defined to be an enclosure or panel, which contain the fluid concrete and withstand the forces due to its placement and consolidation. Forms in turn be supported on scaffolding.

General

The work to be performed under this Sub-section includes the furnishing and installing and removing of forms for all cast-in-places concrete work as shown and noted on the Drawings and as specified herein or as directed by the Engineer.

Forms shall be substantial and sufficiently tight to prevent leakage of mortar. Forms shall be of sufficient rigidity to prevent objectionable distortion of the formed concrete surface due to pressure of the concrete and other loads incidental to construction operations. They shall be properly braced or tied together to maintain position and shape. Forms and their supports shall be so designed as not to damage previously placed structure.

Relevant provisions of the American Concrete Institute (ACI) issue of ACI 347 on 'Recommended Practice for Concrete Formwork' or some other generally accepted Standards shall apply for the structural designing of the formwork, except as they may be modified herein.

Materials

Formwork shall be constructed from sound materials of sufficient strength, properly braced, struted and shored as to ensure rigidity throughout the placing and compaction of the concrete without visible deflection. The materials used be of wood, steel or other approved materials and shall be mortar-tight. Formwork shall be so constructed that it can be removed without shock or vibration to the concrete.

Formwork for concrete, permanently exposed to public inspection, shall be faced with plain 28/26 gauge steel sheet fitted over 38mm thick wooden plank panels suitably braced or steel framing faced with minimum 12/14 BWG mild steel sheet. Formwork for cement concrete blocks shall be fabricated from M.S. sheet of sufficient thickness to prevent any distortion.

Where metal forms are used, all bolts and rivets shall be countersunk and well grounded to provide a smooth plane surface.

Where timber is used, it shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may mark the surface of concrete.

Form ties shall be prefabricated rod, flat band, or wire type, or threaded internal disconnected type, of sufficient tensile capacity to resist all imposed load of freshly placed concrete and having external holding devices of adequate bearing area. Ties shall permit tightening and spreading of forms and shall leave no metal closer than 25mm from surface. Ties shall fit tight to prevent mortar leakage at holes in forms. Removable ties shall be coated with non-staining bond breaker. All ties shall be protected from rusting at all times. No wire ties or wood spreaders shall be permitted. Cutting ties back from concrete face will not be permitted. Ties for exposed Architectural Concrete shall be plastic cone snap ties.

Construction method

The Contractor shall submit for the approval of the Engineer details of the methods and materials proposed for formwork to each section of the Work. Details of all proposed wrought formwork and formwork to produce special finishes are to be submitted for approval in writing to the Engineer before any material is hauled at Site. If the Engineer so requires, samples of formwork shall be constructed and concrete be placed so that the proposed methods and finish effect can be demonstrated.

All joints shall be close fitting to prevent leakage of grout. At construction joints the formwork shall be tightly secured against previously cast or hardened concrete in order to prevent stepping or ridges to exposed surfaces.

Where the Contractor proposes to make the formwork from standard sized manufactured formwork panels, the dimensions of such panels shall be approved by the Engineer before they are used for construction of the Work. The finished appearance of the entire elevation of the structure and the adjoining structures shall be considered when planning the patterns of joint lines caused by the formwork and by construction joints to ensure continuity of horizontal and vertical lines.

Formwork shall be constructed to provide the correct shape, lines and dimensions of the concrete shown on the Drawings. Due allowance shall be made for any deflection, which will occur during the placing of concrete within the formwork. Panels shall have true edges to permit accurate alignment and provide a neat line with adjacent panels and at all construction joints. All panels shall be fixed with their joints either vertical or horizontal, unless otherwise specified or approved.

Formwork shall be provided for the top surfaces of sloping work where the slope exceeds 15° with the horizontal and shall be anchored to enable the concrete to be properly compacted and prevent floating. Cares shall be taken to prevent air being entrapped. Openings for inspection of the inside of the formwork and for the removal of water used for washing shall be provided and so formed as to be easily closed before placing concrete.

Formwork for exposed concrete surfaces

All exposed concrete surfaces are to be 'form finish' and shall be cast in any approved formwork and shall be free from honeycomb, fins, projections and air holes. All external angles to form finish concrete surfaces shall be chamfered as directed.

Forms for concrete surfaces exposed to view shall produce a smooth surface of uniform texture and colour substantially equal to that which would be obtained with the use of plywood conforming to the National Institute of Standards and Technology Product Standard PSI for Exterior B-B Class I Plywood. Panels lining such forms shall be arranged so that the joint lines form a symmetrical pattern conforming to the general lines of the structure. The same type of form lining material shall be used throughout each element of a structure. Such forms shall be sufficiently rigid so that the undulation of the concrete surface shall not exceed 3mm when checked with a 1.5m long straight edge or template.

The Contractor shall submit shuttering Drawings and details of pattern and the method of forming joints in the exposed (form finish) concrete to the Engineer for his approval. All changes and

modification made by the later shall be appropriately incorporated by the former and final approval whereof be obtained from the Engineer.

Unless otherwise stated on the Drawings, wrought formwork shall be used for all permanently visible concrete surfaces. Wrought formwork shall be such as to produce a smooth and even surface free from perceptible irregularities. Tongues and grooved paneled boards, plywood or steel forms shall have their joints flushed with the surface. The formwork shall be formed with approved standard size panels. The panels shall be arranged in a uniform approved pattern, free from defects likely to be detected in the resulting concrete surface.

In all types of formwork to form finished exposed concrete, only non-steining mould oil shall be used as approved by the Engineer.

The respective usage of the same formwork to cast form-finished exposed concrete shall be as decided by the Engineer and in no case the formwork, not guaranteed to produce the required form-finish to the satisfaction of the Engineer, shall be used.

The exposed concrete shall have a uniform finish. The finish of the concrete when shuttering and formwork are removed will generally be without any blemish and will be such as will not require touch up. Slight touch up for a small spot or two, if necessary shall be carried out skillfully so as to be synonymous with the entire surfaces.

The finished surfaces shall be within the specified tolerances and full cover to the reinforcement steel shall be maintained.

Formwork for non-exposed concrete surfaces

Unless otherwise stated on the Drawings, rough formwork may be used for all surfaces, which are not permanently exposed. Rough formwork may be constructed of plain butt-joined sawn timber. But the Contractor shall ensure that all joints between boards shall be grout-tight.

The finished surfaces shall be within the specified tolerances and full cover to the reinforcement steel shall be maintained.

2.2.3 Formed surfaces and finish

The formwork shall be lined with a material approved by the Engineer so as to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and so joined and fixed to its backing as not to impart any blemish. It shall be of the same type and obtained from only one source throughout the construction of any individual structure. The Contractor shall make good any imperfection in the finish as required by the Engineer. Internal ties and embedded metal parts will be allowed only with the specific approval of the Engineer.

2.2.4 Sizes of timber and other sections for formwork

Scaffolds, formwork and components thereof shall be capable of supporting without failure, at least two times the maximum intended load. The following types of loading shall be considered in designing the formwork:

- a) Weight of wet concrete : 20 kN/m³.
- b) Live load due to workmen and impact of ramming or vibrating : 15-40 kPa (light duty for carpenter and stone setters, medium duty for brick layers and plasterers, heavy duty for stone masons).
- c) Allowable bending stress (flexural tensile stress) in soft timbers : 8,000 kPa.

The sizes for formwork elements specified in the Table given below are applicable for spans of upto 5m and height of upto 4m. In case of longer span and height, formwork and support sizes shall be determined by calculating the load and approved by the Engineer before use.

Sizes of timber and other sections for formwork

Types of Formwork	Members Size in mm
Flat sheetings for slab bottoms, columns and beam sides	25 to 50
Beam bottoms	75x100 to 150x150
Vertical posts	75x100 to 150x150
Bamboo posts	Minimum 75 dia
Timber posts	Not less than 100 dia at mid-length and 80 dia at thin end
Joist and ledgers supporting sheetings of slab	50x100 to 75x200
Studs for supporting vertical wall sheetings	50x100 to 150x150
Columns yokes-horizontal cross, pieces supporting vertical sheetings	50x100 to 100x100

2.2.5 Quality of shuttering

General

The shuttering shall have smooth and even surface and its joints shall not permit leakage of cement grout.

Ply-board shuttering material shall be well seasoned free from projecting nails, splits or other defects that may mark the surface of concrete. It shall not be so dry as to absorb water from concrete and swell and bulge, nor so green or wet as to shrink after erection.

The timber shall be accurately sawn and plain on the sides and the surface coming in contact with concrete.

Wooden formwork with metal sheet lining or steel plates stiffened by steel angles shall also be permitted. Where metal forms are used, all bolts and nuts shall be countersunk and well grounded to provide a smooth plain surface.

The chamfers, leveled edges and mouldings shall be made in the formwork itself. Opening for fixture and other fittings connected with the services shall be provided in the shuttering as directed by the Engineer.

Clamps shall be used, to its practicality, to hold the forms together. Where use of nails is unavoidable, it shall be kept to minimum number and these shall be left projected so that they can easily be withdrawn. Use of double-headed nails shall be preferred.

Tolerances

The formwork shall be made so as to produce a finished concrete true to shape, lines, levels, plumb and dimensions as shown on the Drawings subject to the following tolerances unless otherwise specified in this document or Drawings or as directed by the Engineer.

- Sectional dimension + 5mm
- Plumb + 1 in 1000 of height
- Levels + 3mm before any deflection has been taken place

Tolerances given above are specified for local aberrations in the finished concrete surface and should not be taken as tolerance for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Errors, if noticed in any lift/tilt of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

2.2.6 Preparation of formwork

General

The formwork shall be arranged in a manner as to readily be dismantled and removed from the cast concrete without shock, disturbance or damage. Where necessary, the formwork shall be so arranged that the soffit form, properly supported on props only, can be retained in position for such period as may be required by maturing conditions or Specification.

The surfaces of formwork shall be free from foreign matters, projecting nails and the like, splits or other defects, and all formwork shall be cleaned and made free from standing water, dirt, shavings, chippings or other foreign matter before concrete is placed,

Before placing concrete, all built-in reinforcement bars, anchoring, steel beams, cables, fixing truss, bolts, pipes or conduits or any other fixtures shall be fixed in their correct positions. The cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without the approval of the Engineer.

All exterior and interior angles on the finished concrete of 900 or less shall be given 12mm – 20mm chamfers unless otherwise shown on the Drawings or directed by the Engineer. When chamfers are to be formed, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer.

No ties or bolts or other devices shall be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer. The whole or part of any such support embedded in the Reinforced Concrete shall be capable of removal so that no part, remaining embedded in the concrete, shall be nearer than 75mm from the surface. Holes left after removal of such supports shall be neatly filled with well-reamed dry-pack mortar following the procedures described in the relevant Sub-section of this Specification.

All rubbish shall be removed from the interior of the forms before the concrete is placed. After cleaning and prior to placement of reinforcing steel, the formwork in contact with the concrete shall be treated with a suitable non-staining mould oil or suitable approved release agent to prevent sticking of the concrete. Such works shall not discolour or otherwise injure the surface of the concrete. Care shall be taken to prevent the oil from coming in contact with the reinforcement or mixing with the concrete. At construction joints, surface-retarding agents shall be used only where ordered by the Engineer.

All formwork shall be inspected and approved by the Engineer before concrete is placed in it. However, this shall not relieve the Contractor from the requirements as to soundness, finish and tolerances of the concrete specified in this Specification or elsewhere acknowledged as Standard. If, at any period of the work during or after placing the concrete, the forms show signs of sagging or bulging, the concrete shall be removed to the extent directed by the Engineer, the forms brought to the proper position and new concrete placed. No allowance shall be made to the Contractor for such extra works.

Removal of forms

Forms shall not be removed without the approval of the Engineer. In the determination of the time for the removal of forms, consideration shall be given to the location and character of the structure, the weather, the materials used in the mix and other conditions influencing the early strength of the concrete. Extreme cares shall be taken to ensure that the method of removal shall not cause overstressing of the concrete or damage to its surface.

Forms shall be removed in such a manner as to permit the structure to uniformly and gradually take the stresses due to its own weight as not to impair safety and serviceability of the structure. All concrete to be exposed by form removal shall have sufficient strength not to be damaged thereby.

Forms shall not be removed in the cases of footing forms where the removal would endanger the safety of the cofferdams, forms from enclosed cells where access is not provided, deck forms in the cells that do not interfere with the future installation of utilities shown on the Drawings, or other works.

Except for concrete being post-tensioned, no concrete shall be subjected to loading which will induce a compressive stress in it exceeding one-third of its compressive strength at the time of loading, or one-third of the specified characteristic strength whichever is less. It may be possible to use shorter periods before striking forms by determining the strength of the concrete in the structural element.

Forms supporting cast-in-situ concrete in flexure may be struck when the strength of the concrete in the element is 10 N/mm² or twice the stress to which it will be subjected, whichever is greater provided that striking at this time will not result in an unacceptable deflection. This strength may be assessed by test on cylinder/cube cured under the same conditions as the concrete in the element as far as possible.

Forms on upper sloping faces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any repair or treatment required on such sloping surfaces shall be performed at once.

If the floor is to be used to support construction loads, props should be retained for 28 days unless the Contractor can prove the requisite concrete strength by tests.

The form shall be removed slowly, as the sudden removal of wedges is equivalent to a shock load on the partly hardened concrete.

Materials and plants shall not be stacked on any newly constructed floor unless sufficient support is maintained to withstand such loads without damaging the floor.

The following table is a guide to the minimum periods that must elapse between the completion of the concreting operations and the removal of formwork. No formwork shall be removed without the permission of the Engineer and such permission shall not relieve the Contractor of his responsibilities regarding the safety of the structure.

Type and position of formwork	Approximate period (days)
Side of beams, walls and columns (unloaded)	5
Slab soffits (props supporting)	14
Removal of props to slabs	21
Beam soffits (props supporting)	21
Removal of props to beams	28

Notwithstanding the foregoing, the Contractor shall be held responsible for any damages arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

2.2.7 Openings

Temporary and permanent openings in concrete shall be framed neatly with provisions for keys or reinforcing steel as shown on the Drawings or as directed by the Engineer.

2.2.8 Defects in formed surfaces

Workmanship in formwork alongwith concrete placing shall be such that concrete shall normally require no repair to surfaces being perfectly compacted and smooth.

If any blemish is revealed after removal of formwork, the Contractor shall obtain immediately the Engineer's decision concerning remedial measures to be undertaken. Notwithstanding the specifications and provisions stated under the Sub-section on 'Finish and Finishing' of this Specification, such measures may include but shall not be limited to the following:

- ☐ Fins, pinholes, bubbles, surface discolouring and mirror defects may be rubbed down with sacks immediately on removal of the form.
- ☐ Abrupt and gradual irregularities may be rubbed down with carborundum stone and water after concrete has been fully cured.
- ☐ Deep honeycombed concrete shall be repaired within 24 hours of striking the formwork by cutting back to sound concrete. The concrete shall be cut back at least 50mm behind face reinforcement. Cut edges shall be regular and not feathered. Recasting shall be with the same concrete as the original casting. The Engineer shall approve the formwork and its method of placing in this case also.
- ☐ Under some circumstances, abrupt and gradual irregularities of shallow honeycombed concrete may be repaired by cutting back and reforming with an approved epoxy resin or mortar in accordance with the manufacturer's instructions.

Regardless of the above repairing measures, any structure containing excessive honeycomb, as would be termed by the Engineer, shall be subject to rejection by the Engineer. The Contractor, on receipt of written orders from the Engineer, shall remove and rebuild such portions of the structure at his own expenses.

2.2.9 Holes to be filled

Holes on the concrete surfaces formed by formwork supports or the like shall be filled with dry pack mortar made from one part by weight of ordinary Portland cement and three parts of specified fine aggregate approved by the Engineer. The mortar shall be mixed with sufficient water only to make the materials stick together when being moulded in the hands. All construction materials shall conform to the requirements as described previously and under the relevant Sub-sections of the Section on 'Construction Materials' of this Specification.

The Contractor shall thoroughly clean any hole that is to be filled and break out any loose, broken or cracked concrete or aggregate and remove any dry cement from the hole. The surrounding concrete shall be soaked until the whole surface that will come into contact with the dry pack mortar has been covered and darkened by absorption of the free water by the cement. The surface shall then be dried so as to leave a small amount of free water on it.

The dry pack material shall then be placed and packed in layers having a compacted thickness of not more than 10mm. Compaction shall be carried out by using a hardwood stick and a hammer and shall extend over the full area of the layer. Special cares should be taken to compact the dry pack against the sides of the holes.

After compaction, the surface of each layer shall be scratched before further loose material is added. The holes shall be slightly overfilled. The surface shall be finished by laying a hardwood block against the dry pack fill and striking the block several times.

2.2.10 Approval of scaffoldings and form

Plans, Drawings and structural calculations shall be submitted to the Engineer on time so that no construction of such scaffoldings and forms shall take place before the Engineer's approval is accorded in writing. Such approval shall not relieve the Contractor of his responsibilities for the involved structure.

The Engineer shall have reasonable time for his examination of the Contractor's plans and calculations, if scaffoldings are introducing temporary loading on new structures in particular. For this purpose, the Contractor shall not be allowed any extension of time beyond the stipulated period of the Contract.

Before concrete is placed, the Engineer shall inspect all formworks and scaffoldings. No concrete shall be placed until inspection is made and approval is given by the Engineer. Such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion and the soundness of the structure.

2.2.11 Measurement

Formwork and false work shall not be measured separately but shall be deemed to be an integral part of the concrete items.

2.2.12 Payment

The Contractor's rates for concrete work, inter-alia, shall be inclusive of all costs of all formwork, falsework and centering and for their subsequent removal. No additional payment will be made to the Contractor for these works.

2.3 Water proofing polythene sheet**2.3.1 Description**

Works covered under this item shall consist of supplying and laying in place one layer of polythene sheet of weight in accordance with the applicable Drawings, BOQ and these specifications and/or as directed by the Engineer.

2.3.2 Construction requirement

Sheets shall be laid covering the entire inside area under the Cement Concrete. Before laying the sheets, the surface shall be cleaned to give a surface free from damage, tear or other imperfections and shall be laid such that there is a minimum of 300mm overlap of the adjacent strips.

2.3.3 Measurement

Measurement shall be taken for payment in square meter of the actual area covered by the sheets and accepted by the Engineer. No allowance shall be made for overlaps.

2.3.4 Payment

The amount of completed and accepted work measured as provided above shall be made at the Contract unit price per square meter and the payment shall constitute full compensation for furnishing all materials, equipment including their storage, handling and transport and all labours, cleaning, preparing, cutting, laying, fixing and all incidentals necessary to complete the work. No additional payment shall be made for the overlaps.

Pay Items shall be:

Clause	Description	Unit of measurement
2.3	Supplying and laying of polythene sheet	Square meter

2.4 JOINTS IN CONCRETE

2.4.1 Construction joints

General

Construction joints are defined as concrete surfaces upon or against which concrete is to be placed and to which new concrete is to be placed, that have become so rigid that the new concrete cannot be incorporated integrally with that previously placed. Construction joints shall be formed wherever there is a discontinuity in placing concrete in external elements of concrete structures. Formed vertical or inclined construction joints as well as unformed joints, which are due to interruption of concrete placement, shall be made only where located on the Drawings or shown in the pouring schedule or as directed by the Engineer. All exposed faces of construction joints shall be made absolutely straight, leveled or plumbed and normal to the finished surface.

Spacing of construction joints shall be in accordance with good concreting practice as defined in BS 8110 or equivalent and enabling adequate precautions to be taken against shrinkage cracking. Placing of concrete shall be carried out continuously. The joints shall be at right angle to the general direction of the member and shall take due account of shear and other stresses.

All planned reinforcing steel shall extend uninterrupted through joints. Additional reinforcing steel dowels shall be placed across the joints, if and when directed by the Engineer. Such additional steel shall be furnished and placed at the Contractor's expenses.

Bonding

Unless otherwise shown on the Drawing, horizontal joints may be made without keys and vertical joints shall be constructed with shear keys. Surfaces of fresh concrete at horizontal construction joints shall be rough floated sufficiently to thoroughly consolidate the surface and intentionally left in a rough condition. Shear keys shall consist of formed depressions in the surface covering approximately one-third of the contact surface. The forms for keys shall be beveled so that removal will not damage the concrete.

Surfaces of construction joints shall be prepared as early as possible after casting. The preparation shall consist of the removal of all laitance, loose or defective concrete coatings, sand and other deleterious materials. Preparation shall be carried out preferably when the concrete has set but not hardened by jetting with a fine spray of water or brushing with a stiff brush, just sufficient to remove the outer mortar skin and to expose the larger aggregate without it is being disturbed. Where this treatment is impracticable and work is resumed on a surface, which has set, the whole surface shall

be thoroughly roughened or scrapped with suitable tools so that no smooth skin of concrete that may be left from the previous work is visible.

The prepared joint face shall be thoroughly cleaned by compressed air and water jets or other approved means and brushed and watered immediately before depositing concrete. The cleaned and saturated surfaces that also include vertical and inclined surfaces, shall first be thoroughly covered with a thin coating of mortar or neat cement grout against which the new concrete shall be placed before the grout has attained its initial set.

The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints, which are exposed to view, shall be carefully finished true to line and elevation.

Construction joints in floors shall be located within the middle third of spans of slabs, beams and girders. Joints in girders shall be offset a minimum distance of two times the width of intersecting beams.

Bonding and doweling to existing structures

When reinforcing dowels grouted into the holes drilled in the existing concrete is required at such construction joints, the holes shall be drilled by methods that will not damage the concrete around the holes. The diameters of the holes shall be 6mm larger than the nominal diameter of the dowels unless shown otherwise on the Drawings. The dowel bars shall be round mild steel bar of the diameter and length as indicated on the Drawings and/or as per the directions of the Engineer. The grout shall be a neat cement paste of Portland cement and water or an epoxy. Immediately prior to placing the dowel bars, the holes shall be cleaned off dust and other deleterious materials, shall be thoroughly saturated with water, have all free water removed and shall be dried to a saturated surface dry condition. Sufficient grout or an epoxy shall be placed inside the holes so as not to remain any void after the dowels are inserted. Grout shall be cured for a period of at least 3 (three) days or until dowel bars are encased in concrete. When an epoxy is used, the mixing and placing shall conform to the manufacturer's recommendations.

Forms at construction joints

When forms at construction joints overlap previously placed concrete, they shall be re-tightened before depositing new concrete. Exposed face edges of all joints shall be neatly formed with straight bulkheads or grade strips, or otherwise properly finished true to line and elevation.

2.4.2 Expansion and contraction joints

2.4.2.1 Expansion joints

General

Expansion joints are intended to accommodate relative movement between adjoining parts of a structure.

Compressible filler shall be placed between the joint faces to provide freedom for expansion for the two adjacent concrete masses. Care shall be taken to ensure that the material fills the joint completely and that no concrete or hard material is left in the joint after the second face of the joint has been cast.

Material

One of the following specifications shall be used as pre-mould fillers:

- ☐ Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction, ASTM 1751.
- ☐ Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction ASTM D 1752. Type-II (cork) shall not be used when resiliency is required.

- ☐ Specification for Preformed Expansion Joint Filler for Concrete, ASTM D 994.

The bitumen sheet, laid on the horizontal top surface of the expansion joint keys, shall be a 10mm thick material approved by the Engineer.

Metal armour

Expansion joint armour assemblies shall be fabricated from steel with the following materials:

- ☐ Steel bars, plates and shapes shall conform to the requirements of ASTM A 36.
- ☐ Bolts and nuts shall conform to the requirements of ASTM A 307.
- ☐ High strength bolts, nuts and washers shall conform to the requirements of ASTM A 325.
- ☐ Steel castings shall conform to the requirements of ASTM A 486 or ASTM A 27.
- ☐ Grey iron castings shall conform to the requirements of ASTM A 48.
- ☐ Sheet metal shall be of commercial quality.

Armour assemblies

All assemblies shall be accurately fabricated and straightened at the workshop, as necessary to conform to the concrete sections. The assemblies shall be installed so that their top surface matches the plane of the adjacent finished concrete surface throughout the length of the assembly. Appropriate methods shall be followed in placing the assemblies to keep them in correct position during the placing of concrete. The opening at expansion joints shall be that designated on the Drawings at normal temperature or as directed by the Engineer for other temperatures. Cares shall be taken to avoid impairment of the clearance in any manner.

2.4.2.2 Contraction joints

General

Joints placed in structures or slabs to provide for volumetric shrinkage of monolithic unit or movement between monolithic units are defined as contraction joints. Contraction joints shall be constructed so that there will be no bond between the concrete surface forming the joints.

Material

Material placed in contraction joints shall consist of asphalt saturated felt paper or other approved bond-breaking materials.

2.4.2.3 Pourable joint sealants

Pourable sealants shall be placed along the top edges of contraction or filled expansion joints. It shall conform to the following considerations:

- ☐ Unless otherwise shown on the Drawings and/or ordered by the Engineer, joint sealants shall be a hot poured rubber bitumen compound for horizontal joints and either a bituminous compound or an elastomeric two parts polysulphide sealant for sloping, vertical and soffit joints.
- ☐ Bituminous compounds shall comply with BS 2499 for horizontal joints and BS 2499 Type A1 for sloping or vertical joints. Polysulphide compound shall comply with BS 4254.
- ☐ Joint sealants and the requisite priming materials shall be obtained from manufacturers approved by the Engineer. The application of joint sealant shall not be commenced without the Contractor obtains its approval by the Engineer.

2.4.2.4 Compressive filler

Unless otherwise specified, the joint filler shall be of resin or bituminous bonded corks such as 'Hydrocor' manufactured by Expandite Ltd. The filler shall be obtained from a manufacturer approved by the Engineer and shall be stored and fixed in accordance with the manufacturer's instructions.

2.4.2.5 Water stops

General

Water stops shall be of the type, size and shape shown on the Drawings and/or as directed by the Engineer. They shall be dense, homogeneous and without holes or other defects.

Types

Water stops to be used may be of the following types:

- ☐ Polyvinyl chloride (PVC) water stops

Where shown on the Drawings, construction (as required and approved by the Engineer), contraction and expansion joints shall be made watertight by the provision of a continuous Water Stop strip of Poly Vinyl Chloride (PVC) manufactured by the extrusion process from an elastomeric plastic compound, the basic resin of which shall be Poly Vinyl Chloride. Unless otherwise specified or ordered, a two bulb dumbbell section PVC. Water Stop shall be used in construction joints and a three bulb section PVC Water Stop shall be used in expansion joints.

Water Stops shall be of high grade PVC, containing no filler or reclaimed or scrap material. PVC shall comply with the requirements of BS 2571 for PVC Type A, Class 1. The quality of Water Stops shall comply with the following major requirements:

- ☐ Specific gravity 1.30 (maximum)
- ☐ Hardness 80 (minimum) duro
- ☐ Tensile strength 138 kg/cm² (minimum)
- ☐ Elongation 225% (minimum)
- ☐ Rubber water stops

Rubber Water Stops shall be manufactured with synthetic rubber made exclusively from neoprene, reinforcing carbon black, zinc oxide, polymerization agents and softeners. The quality shall conform the following major requirements:

- ☐ Neoprene content 70% by volume (minimum)
- ☐ Hardness 50-60 duro
- ☐ Tensile strength 193 kg/cm² (minimum)
- ☐ Elongation 600% (minimum)

Rubber Water Stops shall be formed with an integral cross section in suitable moulds so as to produce a uniform section with a permissible variation in dimension of 0.8mm plus or minus. No splices will be permitted in straight strips. Strips and special connection pieces shall be well cured in a manner such that any cross section shall be dense, homogeneous, and free from all porosity. Junctions in the special connection pieces shall be full moulded. During the vulcanizing period, the joints shall be securely held by suitable clamps. The material at the splices shall be dense and homogeneous throughout the cross-section.

2.4.2.6 Installation

Open joints

Open joints shall be constructed by the insertion and subsequent removal of a wood strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. When not protected by metal armour, open joints in

slabs shall be finished with an edging tool. Upon completion of concrete finishing work, all mortars and other debris shall be removed from the open joints.

Filled joints

When filled joints are shown on the Drawings or asked by the Engineer, pre-mould type fillers shall be used unless Poly Styrene board is specifically called for. Filler for each joint shall consist of as few pieces of material as possible. Abutting edges of filler material shall be accurately held in alignment with each other and tightly fit or taped as necessary to prevent the intrusion of grout. Joint filler material shall be anchored to one side of the joint by waterproof adhesive or other methods so as to prevent it from working out of the joint but not interfere with the compression of the material.

Sealed joints

Prior to installation of the pourable joint sealants, all foreign materials shall be removed from the joint. The filler material shall be cut back to the depth shown or approved and the surface of the concrete, in contact with the sealant, be cleaned by light sand blasting. When required, a Poly Ethylene foam strip shall be placed in the joint to retain the sealant and isolate it from the filler material. The sealant materials shall then be mixed and installed in accordance with the manufacturer's directions. Any material that fails to bond the sides of the joint within 24 hours after placement shall be removed and replaced.

Water stops

Water Stops shall be obtained from a manufacturer approved by the Engineer, and shall be fixed and joined according to the manufacturer's instructions. All strips shall be stored in a place as cool as practicable and shall in no case be exposed to the direct sun light.

Water Stops shall be installed with approximately half of the width of the material embedded in the concrete on either side of the joint. It shall be firmly supported by split stop-end shuttering and in no case shall Water Stop be pierced to assist in fixing. Special care shall be taken to ensure that the concrete is well worked against the embedded parts of the strips and is free from honeycomb. Precautions are to be taken to protect any projected portions of the strips from damage during the progress of the works and from sunlight and heat.

If, after placing concrete, Water Stops are moved out of position or shape, the surrounding concrete shall be removed, the Water Stop reset, and the concrete replaced at the Contractor's own expenses. Two 9mm diameter reinforcing bars shall be provided to support the Water Stops and shall be securely held in position by the use of spacers, supporting wires, or other approved devices.

Flexible Water Stops shall be fully supported in the formwork, free from nails and clear of reinforcement and other fixtures. Damaged Water Stops shall be replaced and care shall be taken to place the concrete so that Water Stops do not bend or distort.

Splicing of Poly Vinyl Chloride Water Stop shall be performed in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt but not to char the plastic. Splices shall develop at least 90% of the tensile strength of un-spliced materials and shall withstand bending 180° around a 50mm diameter pin without cracking or separating.

The Contractor, at least before the commencement of concrete work, shall submit to the Engineer for his approval details of the Contractor's proposals for the installation of water stops. These shall show where joints in the Water Stops are to be located and details of the intersections and changes of direction to a scale that shows the position of any joint or shape of any mould section.

As far as possible, jointing of PVC Water Stops on Site shall be confined to the making butt joints in straight runs of Water Stops. Where it is agreed with the Engineer that it is necessary to make an intersection or change of direction of any joint other than a butt joint in a straight run, a preliminary joint, intersection or change of direction piece shall be made and subjected to such tests as the Engineer may require.

Precautions shall be taken so that the Water Stops shall neither be displaced nor damaged by construction operations or other means. All surfaces of the Water Stops shall be kept free from oil, grease, dried mortar or any other foreign matters while the Water Stop is being embedded in concrete. Means shall be used to ensure that all portions of the Water Stop designed for embedding shall be tightly enclosed by dense concrete.

2.4.3 Measurement

Construction Joints shall not be measured. Expansion and Contraction joints shall be measured in linear meter of the joints considered satisfactory by the Engineer and accepted by him. There will be no additional measurement for joint fillers, sealed joints, Water Stops, miscellaneous metal devices etc.

2.4.4 Payment

Payment for construction joints shall be deemed included in the items of concrete and there will be no extra payment for it. For expansion and Contraction joints the amount of completed and accepted works measured as provided above shall be paid at the Contract Unit Price per linear meter and the payment shall constitute the full compensation for furnishing and placing joint fillers, sealed joints, Water Stops, drains, vents, miscellaneous metal devices including all labour and incidentals for full completion of the Work as per Specifications.

Pay Items shall be:

Clause	Description	Unit of measurement
2.4	Expansion joints	Linear meter
2.4	Contraction joints	Linear meter

2.5 REPAIR OF EXISTING CONCRETE STRUCTURES

2.5.1 Description

This work shall consist of re-construction of the existing localized defective concrete (including that associated with small extensions of existing concrete structures), rehabilitation of existing concrete facing, repair of minor cracks in structural concrete and anchoring and tying of existing structural members.

The work shall be carried out in accordance with these Specifications and to the locations, lines and dimensions shown on the Drawings and/or as required by the Engineer.

Any extension work associated with repair of existing localized defective concrete is covered under Sections titled 'Concrete Work' and 'Reinforcing Steel' of this Specification and the extension work shall be measured and paid for under those Sections.

2.5.2 Materials

Concrete shall conform to the specifications contained in the Sub-section on 'Concrete for structures' of this Specification.

Cement mortar shall comply with the specifications contained in the Sub-section on 'Brick masonry work' of this Specification except that the mix may vary as shown on the Drawings and/or as directed by the Engineer.

2.5.3 Construction methods

General

The Contractor and the Engineer shall jointly survey structures to be repaired and the location of all repairs shall be permanently marked in paint on each structure. The repair works shall be carried out by skilled and experienced personnel well conversant with this work.

Repair of existing localized defective concrete

Where existing defective concrete is to be repaired or extended, the existing concrete shall be carefully broken to ensure that all defective materials are removed and that, where necessary, sufficient reinforcement is exposed.

All loose concrete shall be removed, the exposed reinforcement shall be carefully cleaned and the exposed concrete shall be cleaned of all dusts. A construction joint shall be prepared on the exposed face to ensure a good feature between the existing section and the repaired/extension works.

The prepared faces shall be inspected and approved by the Engineer before new work commences.

Repair to concrete surfaces

Defective concrete on the face of substructure walls, in soffits to beams, slabs and other superstructure and on the web faces of main beams and other superstructures shall be carefully removed in a sequence and in accordance with the strict instructions of the Engineer. Such works shall be permanently supervised by a representative of the Engineer and the Contractor shall ensure that technical staffs are permanently available at the Site to receive instructions. The structural integrity of the existing members shall not be impaired and the Contractor shall be fully responsible to ensure that strict procedures are followed. Defective concrete shall be carefully and cleanly removed by manual methods using hammers and chisels. The concrete exposed shall be cleaned of all dust and loose materials. Any reinforcement shall be carefully cleaned using wire brushes unless otherwise instructed by the Engineer.

The removed concrete shall be replaced by a method proposed by the Contractor and approved by the Engineer after inspection of the exposed work. The Contractor shall demonstrate that the method he proposes to adopt, is capable of giving a face equivalent to the workmanship standard that would be accepted in new works.

Repair of minor cracks in concrete

Minor cracks shall be cleaned to remove all loose materials to expose a sound surface. On approval by the Engineer of the cleared crack, it shall be grouted to full depth with cement mortar and trimmed flush with the face of the concrete.

Anchoring and tying

Structural concrete members that exhibit cracking and relative movement may be anchored or tied as instructed by the Engineer. Prior to commencing work, the Contractor shall obtain the approval of the Engineer of the methods to be followed. This shall cover the provision of temporary stages, the drilling methods, safety measures, anchoring methods and subsequent testing for ground anchors to ensure tie bars capable of carrying twice the working load, stressing methods and ultimate grouting of anchor bars. The Contractor shall take instructions from the Engineer on the precise requirements for the provision, installation and anchoring of all tie bars incorporated in the Work.

2.5.4 Measurement

Measurement for repair of defective concrete shall be taken in cubic meters of volume actually marked up, replaced to original lines and accepted by the Engineer.

Measurement of concrete surface repaired shall be taken in square meters of surface areas marked up, repaired and accepted by the Engineer.

Repair of minor cracks shall be measured as the length in linear meters marked up, grouted and accepted by the Engineer.

Anchoring and tying shall be measured as the weight in Kg of anchors and tie bars ordered, installed and accepted by the Engineer.

2.5.5 Payment

The works measured as provided above shall be paid at the relevant Contract unit prices per cubic meter, per square meter, per linear meter and per Kg as applicable. The payment shall constitute the full compensation for all works including all materials, preparatory works and removal of defective materials, temporary works, all labour, equipment, tools and incidentals necessary to complete the Work meeting the prescribed specifications and to the entire satisfaction of the Engineer. For anchoring and tying, the payment shall also be the full compensation for fixing or drilling, installation, grouting in stages and stressing.

Pay Items shall be:

Clause	Description	Unit of measurement
2.5	Repair of existing defective concrete	Cubic meter
2.5	Repair of existing concrete surfaces	Square meter
2.5	Repair of minor cracks in existing concrete	Linear meter
2.5	Supplying and fixing anchors and tie bars	Kg

2.6 REINFORCING STEEL

2.6.1 Reinforcement for RCC

2.6.1.1 Description

Works covered by this item shall consist of supplying and placing of steel reinforcement in different types of concrete structures including board cast-in-situ piles and pre-cast concrete piles but not includes reinforcement for pre-stressed concrete. The works shall conform to the specifications, the types, sizes and positions of reinforcement requirements shown on the Drawings and this specification.

2.6.1.2 Materials

Reinforcement

Reinforcing bars discussed under this Section shall be made of Mild Steel or High yield Steel, plain or deformed, for all Reinforced Concrete Works but excluding Pre-stressing Concrete.

Bars shall be rolled and produced from steel in the form of new and clean billets directly reduced from ingot of properly identified heats of open hearth, basic oxygen or electric arc furnace steel or lots of acid besmear steel.

Reference standards

Deformed reinforcement

Steel Bars and Wires for the Reinforcement of Concrete – BDS 1313

Rolled Deformed Steel Bars (intermediate grade) for Concrete Reinforcement – BDS 580

Deformed and Plain Billet Steel Bars for Concrete Reinforcement – ASTM A 615

Rail Steel Deformed and Plain Bars for Concrete Reinforcement – ASTM A 616

Axle Steel Deformed and Plain Bars for Concrete Reinforcement – ASTM A 617

Low Alloy Steel Deformed Bars for Concrete Reinforcement – ASTM A 706

Deformed Steel Wire – ASTM A 496

Welded Deformed Steel Wire Fabric – ASTM A 497

Zinc Coated (Galvanized) Steel Bars – ASTM A 767

Epoxy – Coated Reinforcing Steel – ASTM A 775

Plain reinforcement

BDS 1313, ASTM A 615 M, ASTM A 616 M, ASTM A 617 M, ASTM A 185

Smooth steel wire

Cold – Drawn Steel Wire - ASTM A 82

Cold – worked steel reinforcement

IS 1786: 1985, BS 4461: 1978

Mild steel plain round bar

This is a type of bar plain and round in shape of a structural or intermediate grade with yield strength of not less than 280 MPa (N/mm²) i.e. 40 grade.

Deformed bars

Reinforcing steel under this type comprises Mild Steel Grade 40 and High Strength Grade 60 Deformed re-bars with yield strength of not less than 280 MPa (N/mm²) in case of Grade 40 and with yield strength of not less than 410 MPa (N/mm²) in case of Grade 60.

Other bars

Steel welded wire, fabric plain reinforcement conforming to ASTM A 185 may be used, except that for wire with specified yield strength f_y exceeding 410 MPa (N/mm²), f_y will be the stress corresponding to a strain of 0.35 percent.

Smooth steel wire conforming to ASTM A 82 may be used in concrete except that for a wire with a specified yield strength f_y exceeding 410 MPa (N/mm²), f_y will be the stress corresponding to a strain of 0.35 percent.

Fabricated deformed steel bar mats conforming to ASTM A 184 and deformed steel wire complying with ASTM A 496 may be used. Deformed wire for concrete reinforcement shall not be smaller than a

nominal diameter of 5.72mm, and for a wire with specified yield strength (f_y) exceeding 410 MPa (N/mm²), f_y shall be the stress corresponding to a strain of 0.35 percent.

Welded deformed steel wire fabric conforming ASTM A 497 may be used for a wire with specified yield strength exceeding (f_y) 410 MPa (N/mm²), f_y will be the stress corresponding to a strain of 0.35 percent.

2.6.1.3 Chemical composition

The structural grade shall be made from billets. The ends of the bar shall be machine sheared perpendicular to the axis of the bar. The bars shall be free from injurious defects and shall have a workman like finish.

The chemical composition should conform to the requirements of ASTM 706-82.

2.6.1.4 Process

The steel shall have been made by one or more of the following processes:

- ☐ open-hearth
- ☐ basic oxygen
- ☐ electric furnace
- ☐ acid besmear

2.6.1.5 Dimensional requirements

The nominal diameter, cross sectional areas and perimeter of a deformed bar are equivalent to that of a plain bar having the same standard weight per unit length. Dimensional requirements of such bars have been shown in the Table given below:

Bar Designation No.*	Nominal Dimensions**			Nominal weight, lb/ft [Nominal mass, kg/m]
	Diameter, in. [mm]	Cross Sectional Area, in. ² [mm ²]	Perimeter, in. [mm]	
3 [10]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.376 [0.560]
4 [13]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.668 [0.994]
5 [16]	0.625 [15.9]	0.31 [199]	1.963 [49.9]	1.043 [1.552]
6 [19]	0.750 [19.1]	0.44 [284]	2.356 [59.8]	1.502 [2.235]
7 [22]	0.875 [22.2]	0.60 [387]	2.749 [69.8]	2.044 [3.042]
8 [25]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	2.670 [3.973]
9 [29]	1.128 [28.7]	1.00 [645]	3.544 [90.0]	3.400 [5.060]
10 [32]	1.270 [32.3]	1.27 [819]	3.990 [101.3]	4.303 [6.404]
11 [36]	1.410 [35.8]	1.56 [1006]	4.430 [112.5]	5.313 [7.907]
14 [43]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	7.65 [11.38]
18 [57]	2.257 [57.3]	4.00 [2581]	7.09 [180.1]	13.60 [20.24]

* Bar numbers are based on the number of eighths of an inch including in the nominal diameter of the bars [bar numbers approximate the number of millimeters of the nominal diameter of the bar]..

** The nominal dimension of a deformed bar are equivalent to those of a plain round bar having the same weight [mass] per foot [metre] as the deformed bar.

2.6.1.6 Tensile properties

The tensile properties of the Grade 40 and Grade 60 steel have been shown in the Table given below:

Item	Requirements	
	Grade 40 [300]*	Grade 60 [420]
Tensile strength, min, psi [MPa]	70,000 [500]	90,000 [620]
Yield strength, min, psi [MPa]	40,000 [300]	60,000 [420]
Elongation in 8 in. [203.2 mm], min, %		
Bar Designation No.		
3 [10]	11	9

Item	Requirements	
	Grade 40 [300]*	Grade 60 [420]
4, 5 [13, 16]	12	9
6 [19]	12	9
7, 8 [22, 25]	-	8
9, 10, 11 [29, 32, 36]	-	7
14, 18 [43, 57]	-	7

* Grade 40 [300] bars are furnished only in sizes 3 through 6 [10 through 19].

2.6.1.7 Bend test requirement

The pin diameter required for performing bend tests shall conform to ASTM A 615. The following table contains such requirements:

Bar Designation No.	Pin Diameter for Bend Tests *	
	Grade 40 [300]	Grade 60 [420]
3, 4, 5 [10, 13, 16]	3.5d	3.5d
6 [19]	5d	5d
7, 8 [22, 25]	-	5d
9, 10, 11 [29, 32, 36]	-	7d
14, 18 [43, 57] (90°)	-	9d

* Test bends 1800 unless noted otherwise.

d = Nominal diameter of specimen

Permissible variation

For lots from standard weights.	+ 5% for 6mm dia
+ 3.5% for 10mm dia and above	
Individual	+ 6% for all sizes

Length

Length of the bar shall be maximum possible, but each bar shall not be less than 12m in length or 45.36 kg in weight whichever is greater.

2.6.1.8 ASTM code requirements for deformations

Deformations shall be spaced along the bar at substantially uniform distances. The deformations on the opposite sides of the bar shall be similar in size and shape.

The deformations shall be placed with respect to the axis of the bar so that the included angle is not less than 45°. Where the line of deformation forms an included angle with the axis of the bar from 45° to 70° inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the line of deformation is over 70°, a reversal in direction is not required.

Average spacing or distance between deformations on each side of the bar shall not exceed 17 (seventeen) times of the nominal diameter of the bar.

Overall length of deformations shall be such that the gap between the ends of the deformations on the opposite sides of the bar shall not exceed 12.5% of the nominal perimeter of the bar. Where the ends terminate in a longitudinal rib, the width of the longitudinal rib shall be considered as the gap. Where more than two longitudinal ribs are involved, the total width of all longitudinal ribs shall not exceed 25% of the nominal perimeter of the bar. Furthermore, the summation of gaps shall not exceed 25% of the nominal perimeter of the bar. Nominal perimeter of the bar shall be 3.14 times the nominal diameter (db).

Spacing, height and gap of deformations as to be conformed have been shown in the following table:

Deformation requirements, in. [mm]

Bar designation	Maximum average spacing	Minimum average height	Maximum gap (Chord of 12.5% of Nominal Perimeter)
3 [10]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
5 [16]	0.437 [11.1]	0.028 [0.71]	0.239 [6.1]
6 [19]	0.525 [13.3]	0.038 [0.97]	0.286 [7.3]
7 [22]	0.612 [15.5]	0.044 [1.12]	0.334 [8.5]
8 [25]	0.700 [17.8]	0.050 [1.27]	0.383 [9.7]
9 [29]	0.790 [20.1]	0.056 [1.42]	0.431 [10.9]
10 [32]	0.889 [22.6]	0.064 [1.63]	0.487 [12.4]
11 [36]	0.987 [25.1]	0.071 [1.80]	0.540 [13.7]
14 [43]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	1.58 [40.1]	0.102 [2.59]	0.864 [21.9]

Note: Any bar that fails to satisfy the aforementioned all requirements is to be treated as plain reinforcement.

2.6.1.9 Binding Wire

Reinforcement binding wire shall be the best black annealed mild steel wire and not less than 1.6mm in diameter in approximation/18 - 22 BWG or 26 BWG galvanized iron wire.

2.6.1.10 Wire mesh

Wire mesh shall conform to the requirements of AASHTO Standard Specification M 55 Welded Steel Wire Fabric for Concrete Reinforcement.

2.6.1.11 Ordering material

The name of the proposed supplier of the reinforcement shall be submitted as soon possible to the Engineer for his approval. The Contractor shall submit necessary information concerning the supplier as requested by the Engineer.

Copies of orders placed shall be submitted to the Engineer.

The manufacturer shall submit all requested relevant data on the steel, i.e. breaking strength, yield strength, characteristics on elongation, chemical composition etc., to the Engineer for his approval.

No steel shall be delivered without a certificate guaranteeing the yield stress.

The steel shall be stored and marked in a way that it enables identification of the steel corresponding to each certificate later on.

2.6.1.121 Tests

Test results in addition to those to be submitted by the Contractor and specified above shall be required.

The Contractor shall cut out samples as directed by the Engineer.

The samples shall be tested according to the Engineer's instructions by an approved Testing Institution, provided that the testing facilities are not available in the LGED Laboratories. Approximately three samples shall be tested from each 10 tons of reinforcement delivered at the Site. Expenses incurred in connection with cutting, carrying and testing the samples shall be borne by the Contractor at his own costs.

2.6.1.13 Construction methods of reinforcing bar

Storage and care

All reinforcing steel when received at the Site, prior to its use, shall be stacked off the ground on platforms, skids or any other support and shall be kept free from dirt, oil and grease. All cares shall be taken to prevent the steel reinforcement from any mechanical injury and surface loss resulting from its

exposition to weather conditions that produce rust. It shall be clean and kept free from loose rust and loose mill scale at the time of fixing in position and subsequent pouring of concrete. However, reinforcement steel may not be rejected on the ground of bonded rust, surface seams, surface irregularities and mill scale so long minimum dimensions, cross-sectional area and tensile properties of a hand wire brushed specimen meet the specified physical requirements for the size and grade of steel.

Reinforcement shall be handled and stored in a manner that will prevent bending out of the desired shape and any accumulation of dirt, oil and paint. When placed in the works, it shall be free from dirt, oil, grease, paint, mill scale and loose or thick rust.

Bar reinforcement shall be shipped in standard bundles, tagged and marked in accordance with the Codes of Practice of the Concrete Reinforcing Steel Institute.

Fabrication

All bars shall be fabricated following Specifications, methods and procedures stated below. Fabrication tolerances shall be in accordance with ACI 315.

Cutting and bending

All reinforcement bars shall be cut and bent cold to the specified shape and pertinent dimensions shown on the Drawings using a proper bar bender, operated by hand or power to attain proper radii of bends. The equipment used and methods followed for this purpose shall get the approval of the Engineer.

Bars shall not be bent or straightened in a manner that will injure the material.

Bars partially embedded in concrete shall not be field bent unless otherwise shown on the Drawings or directed by the Engineer.

Errors in alignment of reinforcement partially embedded in hardened concrete shall not be corrected by bending in place, except as permitted by the Engineer.

Bars bent during transportation or handling shall be straightened before being used in work. It shall not be heated to facilitate bending.

Fabrication tolerances shall be in accordance with ACI 315.

All plain bars shall have standard hooks at the end, which shall meet the following requirements unless otherwise specified on the Drawings. When the dimensions of hooks or the diameter of bends are not prescribed, they shall be in accordance with ACI 318 'Building Code requirements for Reinforced Concrete'. Some of the standard requirements have been specified below:

- ☐ 180° turn plus an extension of at least 4 bar diameters but not less than 60mm at the free end of the bar.
- ☐ 90° turn plus an extension of at least 12 bar diameters at the free end of the bar.
- ☐ For stirrup and the anchorage only:
 - For 16mm ϕ bar and smaller : 90° bend plus an extension of at least 6 bar diameters or 75mm whichever is greater at the free end of the bar.
 - For 20mm ϕ and 25mm ϕ bar : 90° bend plus an extension of at least 12 bar diameters or 150mm whichever is greater at the free end of the bar.
 - For 25mm ϕ bar and smaller : 135° bend plus an extension of at least 6 bar diameters at the free end of the bar.
 - For closed ties and continuously wound ties : 135° bend plus an extension of at least 6 bar diameters, but not less than 75mm.

The minimum diameter of bend measured on the inside of the bar, for standard hooks other than for stirrups and ties in sizes 10mm □ thorough 16mm □, shall not be less than the values shown in the table given below.

Minimum diameters of Bend

Bar size	Minimum diameter of bend
$10\text{mm} \leq d_b \leq 25\text{mm}$	$6d_b$
$25\text{mm} < d_b \leq 40\text{mm}$	$8d_b$
$40\text{mm} < d_b \leq 55\text{mm}$	$10d_b$

* d_b is the nominal diameter of bar, mm

For stirrups and tie hooks, inside diameter of bend shall not be less than 4 bar diameters for 16mm □ bar and smaller. For bars larger than 16mm □, diameter of bend shall be in accordance with the specifications shown in the above table.

Bends for other bars, where full tension in the bar may occur, shall be made around a pin having a diameter not less than 20 bar diameters. Hooks shall conform to American Concrete Institute Standard Building Code Requirements for reinforced concrete ACI 316-89, or as shown on the Drawings or as directed by the Engineer.

Placing, supporting and fastening

All bar reinforcement shall be accurately placed, supported and secured in position as shown on the Drawings using approved spacer blocks and chairs prior to any concrete pouring. Displacement tolerance may be allowed within the permissible tolerance limit as shown in the table given below unless otherwise specified by the Engineer. The reinforcement shall be checked and approved by the Engineer before pouring of concrete.

Tolerances for Placing Reinforcement

	Tolerance for depth (d)	Tolerance for Minimum Concrete Cover
$d < 200\text{mm}$	+ 10mm	- 10mm
$d > 200\text{mm}$	+ 12mm	- 12mm

Notwithstanding the above provisions, tolerance for the clear distance to formed soffits shall be minus 6mm and tolerance for cover shall not exceed minus one-third the minimum concrete cover required in the design Drawings or specifications.

Tolerance for longitudinal location of bends and ends of reinforcement shall be + 50mm, except at discontinuous ends of members where tolerance shall be + 12mm.

Welding of crossing bars shall not be permitted for assembly of reinforcement unless authorized by the Engineer.

The Contractor shall be responsible for the accuracy of cutting, bending and placing of the reinforcement. Reinforcement will be inspected for compliance with the requirements as to grade, size, shape, length, splicing locations, overlapping length and position after it has been placed.

Before the reinforcement is placed, the surfaces of the bars and the surfaces of any metal bar supports shall be cleaned of heavy rust, loose mill scale, dirt, grease and other objectionable foreign substances. Heavy flaky rust, which can be removed in firm rubbing with hessian or equivalent treatment, shall be considered objectionable. After being placed, the reinforcing bars shall be maintained in a clean condition until they are completely embedded in the concrete.

Reinforcement shall be accurately placed in the position shown on the Drawings and/or as directed by the Engineer and shall be securely held by blocking against the forms, by supporting on concrete or approved metal or plastic chairs or by using metal hangers and by wiring together at intersections using annealed wire of specified diameter with the ends turned in to the main body of concrete. Bars shall be tied at all intersections except where spacing is less than 300mm in any direction when alternate intersections shall be tied. Wire ties shall be securely tied and folded so that they do not

project beyond the planes formed by the reinforcing bars. The adequacy of the supports and ties to secure the reinforcement properly shall be subject to the approval of the Engineer.

Reinforcement supports shall be strong enough to withstand the imposed loads without movement of the reinforcement. They shall be positively attached to the reinforcement and of such size and number as to maintain the specified cover.

There shall be a clear distance of at least 25mm between the bars and any adjacent embedded metal works. The Contractor shall ensure that there is no disturbance of the reinforcing bars in concrete that has already been placed.

Reinforcement binding wire shall be best black annealed mild steel wire and not less than approximately 1.6mm in diameter/18 - 22 BWG galvanized iron wire.

Cover blocks required for ensuring that the reinforcement is correctly positioned shall be as small as possible, consistent with their purpose, or a shape and material acceptable to the Engineer and designated so that they will not overturn when the concrete is placed. The concrete cover blocks or space blocks shall be made of concrete having 1 part cement, 1 part sand and 2 part coarse aggregate. The coarse aggregate would be 6mm down graded. The blocks would be cast in mould and continuously cured for 21 days before use. Wire shall be cast in the block for the purpose of tying it to the reinforcement. The wire must not be closer than 30mm from the concrete surface. The use of small stones or wood blocks shall not be permitted.

If concrete cylinder blocks are used for proper spacing of vertical bars in column, the height shall be 2.54cm and radius shall be equal to the distance of the centre line of the bar from column face.

Top reinforcement in slabs shall be maintained in position by means of chairs made out of ferrous metal and shall conform to industry practice as described in the Manual on 'Standard Practice of the Concrete Reinforcing Steel Institute'. The diameter and quantity being sufficient to ensure security of the reinforcement shall be used to support access ways, working platforms, or the placing equipment or for conducting of an electric current.

Platforms for the support of workers and equipment and machines shall be placed directly on the forms without any disturbance of the reinforcing steel during concrete placement.

Before any steel reinforcement is embedded in the concrete, any loose mill scale, loose rust and any oil, grease or other deleterious matter shall be removed. Partially set concrete, which may adhere to the exposed bars during concrete placing operations, shall also be removed.

2.6.1.14 Lateral reinforcement for columns

Spirals

Spiral reinforcement for columns shall conform to the following:

- a) Spirals shall consist of evenly spaced continuous bar or wire of such size and so assembled as to permit handling and placing without distortion from designed dimensions.
- b) Size of spirals shall not be less than 10mm diameter for cast-in-place construction.
- c) The minimum and maximum clear spacing between spirals shall be 25mm and 75mm respectively.
- d) Anchorage of spiral reinforcement shall be provided by 1.5 extra turns of spiral bar or wire at each end of a spiral unit.
- e) Splices in spiral reinforcement shall be lap splices of 48 spiral diameter, but not less than 300mm.
- f) Spirals shall extend from the top of footing or slab in any story to the level of the lowest horizontal reinforcement in members supported above.
- g) Spirals shall extend above termination of spiral to bottom of slab or drop panel, where beams or brackets do not frame in to all sides of a column.

- h) Spirals shall extend to a level at which the diameter or width of capital is 2 times that of the column, in case of columns with capitals.
- i) Spirals shall be held firmly in place and true to line.

Ties

Tie reinforcement for compression members shall conform to the following:

- a) All bars shall be enclosed by lateral ties, at least 10mm diameter in size for longitudinal bars 30mm diameter or smaller, and at least 12mm diameter in size for 35mm diameter to 55mm diameter and bundled longitudinal bars.
- b) Vertical spacing of ties shall not exceed 16 longitudinal bar diameters or 48 tie diameters, or the least dimension of the compression members.
- c) Ties shall be arranged such that every corner and alternate longitudinal bar shall have lateral support provided by the corner of a tie with an included angle of not more than 135°. No vertical bar shall be farther than 150mm clear on each side along the tie from such a laterally supported bar. Where longitudinal bars are located around the perimeter of a circle, a complete circular tie is allowed.
- d) The lowest tie in any story shall be placed within one-half the required tie spacing from the top most horizontal reinforcement in the slab or footing below. The uppermost tie in any story shall be within one-half the required tie spacing from the lowest horizontal reinforcement in the slab or drop panel above.
- e) Where beams or brackets provide concrete confinement at the top of the column on all (four) sides, the top tie shall be within 75mm of the lowest horizontal reinforcement in the shallowest of such beams or brackets.

Lateral reinforcement for beams

Compression reinforcement in beams shall be enclosed by ties or stirrups satisfying the size and spacing limitations as stated above. Such ties or stirrups shall be provided throughout the distance where compression reinforcement is required.

Lateral reinforcement for flexural framing members subject to stress reversals or to torsion at supports shall consist of closed ties, closed stirrups, or spirals extending around the flexural reinforcement.

Closed ties or stirrups shall be formed in one piece by overlapping standard stirrup or tie end hooks around a longitudinal bar, or formed in one or two pieces laps, spliced with a lap of development length.

2.6.1.15 Spacing of Reinforcement

The minimum clear spacing between parallel bars in a layer shall be equal to one bar diameter, but not less than 25mm.

Where parallel reinforcement is placed in two or more layers, bars in the upper layers shall be placed directly above those in the bottom layer with clear distance between layers not less than 25mm.

For compression members, the clear distance between longitudinal bars shall be not less than 1.5 bar diameters or 35mm.

Clear distance limitation between bars shall apply also to the clear distance between a contact lap splice and adjacent splices or bars.

In walls and one-way slabs, the maximum bar spacing shall be three times the wall or slab thickness (h) but not more than 450mm.

For two-way slabs, maximum spacing of bars shall be 2h but not more than 450mm.

For temperature steel only, maximum spacing shall be 5h but not more than 450mm.

2.6.1.16 Splicing

General

All reinforcement shall be furnished in the full lengths indicated on the Drawings unless otherwise permitted by the Engineer. Except for splices shown on the Drawings and splices for No. 5 or smaller bars, splicing of bars shall not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible.

Where the Drawings do not detail laps that will be necessary, the Contractor shall furnish working Drawings to the Engineer for his approval.

If such additional lap splices are approved, the extra weight occasioned by such lap splices shall not be included in the measurement of reinforcement for payment unless provided for in these Specifications.

Lapped splices

All splices for high yield strength steel bars shall have a lap length as shown on the Drawings or if not shown therein shall be in accordance with the American Concrete Institute Building Code Requirements for Reinforced Concrete (ACI 318-89).

All splices for mild steel shall have a lap length as shown on the Drawings or if not shown therein, of not less than 40 diameters of the smaller bar when hooks are used and 50 diameters for bars without hooks.

Lap splices shall not be used for 35mm diameter bars and larger, except when bars of different diameters are lap spliced in compression, the splice length shall be the larger development length of the larger bar, or the splice length of the smaller bar.

Lap splices of bundled bars shall be based on the lap splice length required for individual bars within the bundle, increased in accordance with development of bundled bars. Individual bar splices within a bundle shall not overlap. Entire bundles shall not be lap spliced.

Bars spliced by non-contact lap splices in flexural members shall not be spaced transversely farther apart than one-fifth the required lap splice length, nor 150mm.

Lap splices shall generally be located at points of minimum tension in bars. Except where otherwise shown on the Drawings, lap splices shall be made with the bars placed in contact and securely wired together.

Welded splices

Welding on Site shall be avoided wherever possible, but where suitable safeguards and techniques are employed and provided that the types of steel including high-yield steels to SS 2 have the required welding properties, it may be undertaken with the acceptance of the Engineer. Before welding any reinforcement, the Contractor shall supply to the Engineer a Welding Procedure Specification (WPS) and an example of the weld for the type of steel, connection and weld being proposed. If such evidence is not available, the Contractor shall demonstrate satisfactory performance by means of testing as agreed by the Engineer. Unless satisfactory performance of the proposed welded connection is established by either of the two methods described above, approval for use of the welded connection shall not be given.

In addition and as required by the Engineer, the competence of the operators shall be demonstrated prior to and periodically during welding operations by submission of independent Welder Qualification Records (WQR) for each welder to be used on Site.

Welding may be used in fixing reinforcement in position, for example, by welding between crossing or lapping reinforcement, or between bars and other steel members.

Welded intersections shall not be spaced farther apart than 300mm in the direction of calculated stress, except for wire fabric used as stirrups.

Structural welding shall not be carried out unless specifically shown on the Drawings.

Notwithstanding the above, the Engineer will not permit tack welding of bars, which will be subject to fluctuating stresses in the completed structure.

Welding shall conform to the Structural Welding Code, Reinforcing Steel, AWS D 1.4 of the American Welding Society and applicable special provisions.

Welded splices shall be butted and welded to develop in tension at least 125 percent of specified yield strength f_y of the bar. A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of specified yield strength f_y of the bar. Welded splices and mechanical connections not meeting the above requirements are allowed where area of reinforcement is at least twice that required by analysis shall meet the following:

- Splices shall be staggered at least 600mm and in such manner as to develop at every section at least twice the calculated tensile force at the section but not less than 140 N/mm² for total area of reinforcement provided.
- Spliced reinforcement may be rated at the specified splice strength, in computing tensile force developed at each section. Non-spliced reinforcement shall be rated at that fraction of f_y defined by the ratio of the shorter actual development required to develop the specified yield strength (f_y).

Splices of deformed bars in tension

The minimum length of lap for tension splices shall be as required for Class A or B splice, but not less than 300mm, where the classification shall be as follows:

Class A splice	1.0ld
Class B splice	1.30ld

* ld is the development length

Lap splices of deformed bars in tension, shall be Class-B splices except that Class-A splices are allowed when the area of reinforcement provided is at least twice that required by analysis over the entire length of the splice, and one-half or less of the total reinforcement is spliced within the required lap length.

Where area of reinforcement provided is less than twice that required by analysis, welded splices or mechanical connections used shall meet the following requirements. This is also applicable in case of splices in tension tie members those shall be made with a full welded splice or full mechanical connection.

- Welded splices shall be butted and welded to develop in tension at least 125 percent of specified yield strength f_y of the bar.
- A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of specified yield strength f_y of the bar.

Welded splices or mechanical connections used where area of reinforcement provided is at least twice that required by analysis shall meet the following:

- a) Splices shall be staggered at least 600mm and in such manner as to develop at every section at least twice the calculated tensile force at the section but not less than 140 N/mm² for total area of reinforcement provided.
- b) Spliced reinforcement may be rated at the specified splice strength, in computing tensile force developed at each section. Non-spliced reinforcement shall be rated at that fraction of f_y defined by the ratio of the shorter actual development length to ld required to develop the specified yield strength f_y .

Splices in adjacent bars shall be staggered at least 750mm.

Splices of deformed bars in compression

The minimum length of lap for compression splice shall be $0.07 f_y d_b$ for f_y equal to 410 N/mm² or less or $(0.13 f_y - 24)d_b$ for f_y greater than 410 N/mm², but not less than 300mm. For f'_c (specified compressive strength of concrete, N/mm²) less than 20 N/mm², length of lap shall be increased by one-third.

When bars of different diameters are lap spliced in compression, the splice length shall be the larger of the development length of the larger bar, or the splice length of the smaller bar.

Welded splices or mechanical connections used in compression shall also satisfy the following requirements:

- ☐ Welded splices shall be butted and welded to develop in tension at least 125 percent of the specified yield strength f_y of the bar.
- ☐ A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of the specified yield strength f_y of the bar.

End bearing splices

- a) Compression splices for bars required to transmit compressive stress only, may consist of end bearing of square cut ends held in concentric contact by a suitable device.
- b) Bar ends shall terminate in flat surfaces within $1.5d$ of a right angle to the axis of the bars, and shall be fitted within $3d$ of full bearing after assembly.
- c) End bearing splices shall be used only in members containing closed ties, closed stirrups or spirals.

Special splice requirements for columns

Lap splices, butt welded splices, mechanical connections, or end-bearing splices shall be used with the limitations as stated below. A splice shall satisfy the requirements for all load combinations for the column.

Lap splices in columns

- a) Lap splices shall conform to the first two requirements stated above under the Sub-section on 'Splices of Deformed Bars in Compression' and where applicable to (d) or (e) below where the bar stress due to factored loads is compressive.
- b) Where the bar stress due to factored loads is tensile and does not exceed $0.5f_y$ in tension, lap splices shall be Class B tension lap splices, if more than one half of the bars are spliced at any section, or Class A tension lap splices, if half or fewer of the bars are spliced at any section and alternate lap splices are staggered by l_d (development length).
- c) Where the bar stress due to factored loads is greater than $0.5f_y$ in tension, lap splices shall be Class B tension lap splices.
- d) If spiral reinforcement confines the splice, the lengths required may be multiplied by 0.75, but lap length shall not be less than 300mm.

Welded splices or mechanical connectors in columns

Welded splices or mechanical connectors in columns shall also meet the following requirements.

- ☐ Welded splices shall be butted and welded to develop in tension at least 125 percent of specified yield strength f_y of the bar.
- ☐ A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of specified yield strength f_y of the bar.

End bearing splices in columns

End bearing splices complying with the requirements stated above under Sub-section on "End Bearing Splices" may be used for column bars stressed in compression provided that the splices are staggered or additional bars are provided at splice locations. The continuing bars in each face of the

column shall have a tensile strength at least $0.25f_y$ times the area of the vertical reinforcement in that face.

Splices of plain bars

For plain bars, the minimum length of lap shall be twice that of deformed bars.

Mechanical anchorage

Any mechanical device capable of developing the strength of reinforcement without damage to concrete is allowed as anchorage.

Mechanical device may be used only when its adequacy can be proven by test results to the satisfaction of the Engineer.

Development of reinforcement may consist of a combination of mechanical anchorage plus additional embedded length of reinforcement between the point of maximum bar stress and the mechanical anchorage.

2.6.1.17 Substitutions

Substitutions of different size bars shall be permitted only with specific authorization by the Engineer and at no additional cost to the Employer. If bars are substituted, they shall have a cross sectional area equivalent to the design area or larger.

The Contractor shall also provide, also in the case of substitutions, at his own expenses and to the approval of the Engineer, such necessary detailing of the reinforcement as he require for the execution of the work to the Engineer's satisfaction.

2.6.1.18 Concrete cover to reinforcement

Unless specified on the Drawings, the clear concrete cover to reinforcement shall be as tabulated below:

Description of Concrete Element	Clear Cover (mm)	
	Normal Exposure	Saline Water
Wall and footing		
a) contact with earth	60	75
b) exposed to weather and water	50	60
Piles		
a) cast-in-place	75	100
b) pre-cast	40	50
Beam, Girder, Column	40	50
Building roof and floor slab	25	25

2.6.1.19 Protective coating

All exposed reinforcing steel at construction joints shall be protected with a brush coat of neat cement mixed to a consistency of thick paint within one week after the placing of the initial concrete, unless it is definitely known that the steel will be embedded within 30 days. This coating shall be entirely removed, by light tapping with a hammer or other tools, not more than one week before the placing of the final pour.

2.6.1.20 Bundled bars

- Groups of parallel reinforcing bars bundled in contact to act as one unit, shall be limited to four in any one bundle.
- Bundled bars shall be enclosed within stirrups or ties.
- Bars larger than 35mm diameter shall not be bundled in beams.
- Individual bars within a bundle terminated within the span of flexural members shall terminate at different points with at least 40 times the nominal diameter of bar staggered.

- e) Where spacing limitations and minimum concrete cover are based on nominal bar diameter, a unit of bundled bars shall be treated as a single bar of a diameter derived from the equivalent total area.
- f) Minimum concrete cover shall be equal to the equivalent diameter of the bundle, but need not be greater than 50mm.

2.6.1.21 Inspection

The Contractor shall notify the Engineer when the steel has been placed in position and ready for concrete placing. No concrete shall be placed until the Engineer inspected the steel and given his approval in writing.

2.6.1.22 Measurement

The quantity of reinforcement to be measured under this Section shall be the computed weight in kilogram of material used and accepted as shown on the Drawings provided that the quantity shall not include the reinforcement in any item of works. In computing the weight to be measured, the theoretical weights of bars of the cross section shown in this Specification shall be used.

The computed weight shall not include the extra materials incurred, when bars larger than those specified are used or the extra materials necessary for splices, when bars shorter than those specified are used even with the permission of the Engineer. It shall not also include the weight of any devices used to support or fasten the reinforcement in correct position.

2.6.1.23 Payment

This work measured as provided above, shall be paid for at the Contract unit price per kilogram of reinforcement for the particular Bill of Item. The payment shall be considered to be the full compensation for furnishing, fabricating, splicing and placing of the reinforcing steel, supports and binding wire, cutting and bending, all labours, equipment, tools and incidentals necessary to complete the works prescribed in this Section.

No separate payment shall be allowed for chairs, laps, splices, separators etc. The costs of these shall be considered included in the unit rate.

Pay Items shall be:

Clause	Description	Unit of measurement
2.6.1	Mild steel reinforcing bars	Kilogram
2.6.1	High yield steel reinforcing bars	Kilogram

2.6.2 Welding

2.6.2.1 General

All welding shall be performed by certified welders and in accordance with the American Welding Society (AWS) D1.1 'Structural Welding Code' or similar approved standard.

The principal forms of welding metals are as follows:

- ☐ Electric arc welding
- ☐ Gas welding

The electric arc welding process is the most important and is most extensively used for mild steels ranging from light articles with a wall or thickness of 16 gauge to heavy fabrications. This is a process whereby the metal of the two members to be welded is fused together through heat generated by an electric arc. Fusion should be complete over the whole area of the joint surface.

Gas welding is done using oxy-acetylene flame and is not adapted to structural steel works, but is generally used for small jobs. The flame produced by burning oxy-acetylene is fed through a blowpipe, which is ignited at its tip. The flame is played on the two pieces to be welded until the metal

becomes hot enough to fuse together adding additional metal to the joint as necessary by melting in to it a suitable electrode.

Unless otherwise specified, all welding shall be performed following the Shielded Metal Arc Process with low hydrogen electrodes for manual welding.

The Contractor shall be responsible for the quality of the welding performed by his welding organization. All welding by the Contractor shall be carried out by the electric arc method using coated electrodes or other means whereby the air is excluded from the molten metal and where applicable, automatic machines with correct procedure control shall be used.

2.6.2.2 Workmanship and visual quality requirements

In addition to conforming with the procedural and quality requirements set forth in the Structural Welding Code and/or these Specifications, all manual welding shall meet the following requirements for workmanship and visual quality.

- (a) Each weld shall be uniform in width and size throughout its full length and each layer of welding shall be smooth, free of slag, cracks, pinholes and undercut and shall be completely fused to the adjacent weld beads and base metal. In addition, the cover pass shall be free of coarse ripples, irregular surface, non-uniform bead pattern, high crown, deep ridges or valleys between beads and shall blend smoothly and gradually into the surface of the base metal.
- (b) Butt Welds shall be slightly convex, of uniform height and shall have full penetration.
- (c) Fillet Welds shall be of specified size with full throat and with each leg of uniform length.
- (d) Repair, chipping or grinding of welds shall be done in such a manner as not to gouge, groove, or reduce the base metal thickness.

2.6.2.3 Welding repairs

All weld defects which are determined unacceptable, shall be removed by chipping, grinding, arc or flame gouging, following which the area shall be properly prepared for welding, repaired by an approved qualified welding procedure and re-tested as necessary. The Contractor shall establish the cause of all defects and show that such defects have been corrected before welding will be permitted. All repairing shall be done by and at the expenses of the Contractor.

2.6.2.4 Peening

The Contractor shall not be allowed to peen welds without prior approval of the Engineer.

2.6.2.9 Electrodes

All electrodes shall be purchased in sealed containers and shall be thoroughly dry when used. Electrodes, taken from sealed containers, shall be used within four hours. Electrodes not used within four hours shall be stored in electrode storage ovens. The electrode storage oven temperature shall be in accordance with the electrode manufacturer's recommendations. Electrodes with wet or damaged coatings shall not be used.

A simple test indicate the quality of an electrode or welding or welding wire can be made by laying the wire flat on a clean surface and applying the welding flame to it for a distance of about 8 - 10cm by moving the flame backward and forward until the wire becomes red and then slowly melting the wire, moving the flame in such a manner so that the wire melts only half-way thorough its diameter. If the flame is withdrawn as soon as the rod metal begins to melt, the impurities can readily be seen being thrown off in the form of sparks, or a boiling action in the case of inferior metal. When cold, an inferior metal will contain numerous spongy, volcano-like irregularities. A good metal welding rod will melt and flow evenly without any disturbing actions.

Cracks may occur in welding alloy steels owing to the rapidity with which these harden. This may largely be avoided by preheating the parent metal at 300oC or above in advance of welding to lower the normal cooling rate.

The maximum diameter of electrodes for welding have been shown in the following table:

Average thickness of plate or section	Maximum gauge or diameter of electrode to be used
Less than 5mm	3.2mm – 10 SWG
5mm to less than 8mm	4mm – 8 SWG
8mm to less than 10mm	5mm – 6 SWG
10mm to less than 16mm	6mm – 4 SWG
16mm to less than 25mm	9mm
25mm and over	9mm

The maximum width of any bead of welding, other than a cover pass, shall not exceed 3 times the diameter of the electrode being used.

Subject to the approval of the Engineer, electrodes shall be carefully selected in order to provide metal welds with mechanical properties similar to those of the metal being welded, except that for welding higher strength steel to lower strength steel, the electrodes shall be chosen to provide metal welds with mechanical properties comparable to those of the lower strength material.

2.6.2.6 Cutting and edge preparation

Members of structural steel and miscellaneous metal works, which are to be joined by welding shall be cut accurately to size and where required, shall be rolled or pressed to the proper curvature in accordance with dimensions shown. The edges of these members shall be sheared, flame-cut or machined to suit the required type of welding and to allow thorough penetration. The cut surfaces shall expose sound metal, free from laminations, surface defects caused by shearing or flame-cutting operations, or other injurious defects. The surface to be welded shall be free from rust, grease, paint and other foreign matter for a distance of at least 150mm back from the edge of the weld.

2.6.2.7 Grinding wheels

Grinding wheels, which leave a deposit detrimental to subsequent welding will not be permitted. Grinding wheels, which are determined by the Engineer to be detrimental to welding shall not be used.

2.6.2.8 Qualification of welders and welding operators

All welders and welding operators assigned to the work shall have passed the qualification test for welding operators as specified in the AWS Structural Welding Code. If, as determined by the Engineer, the work of any welder appears questionable, such welder will be required to pass additional qualification tests to determine his ability to perform the type of work on which he is engaged. Such additional qualification tests for welders and the physical tests of the welded specimens shall be made in the presence of the Engineer. If required, the Contractor shall furnish to the Engineer a certified copy of reports of the results of physical tests of specimens welded in the qualification tests. Fulfillment of such qualification shall be at the expenses of the Contractor.

2.6.2.9 Welding methods

General

Methods which are essentially required to be followed while welding are as follows:

- ☐ Welds should be made in the flat position as far as practicable.
- ☐ Freedom of movement of one member should be allowed as far as possible.
- ☐ The work should be securely held in position by means of spot welds, service bolts, clamps or jigs before commencing welding so as to prevent any relative movement due to distortion, wind or other causes.
- ☐ The parts to be welded must be thoroughly cleaned and proper flux used. Any paint or rust and loose mill scales, etc. should be removed from the surfaces to be welded and surrounding materials for a distance of at least 12mm from the weld. A coating of boiled

linseed oil may be permitted. Steel to be welded should not be painted or oiled until after erection, unless all ends to be welded are left bare.

- ☐ The sequence of welding should be such that when possible the members, offering the highest resistance to compression, are welded first.

Extreme care shall be taken to ensure that correct welding sequences and procedures are observed to avoid any strains and internal stresses arising in welding.

Welding of stainless steel

Unless otherwise specified, all welding shall conform with AWD D1.1. Electrodes used for welding of stainless steel shall be Series E308 and electrodes used for welding of stainless steel to carbon steel shall be Series E309.

Welders and welding operators assigned to the work shall have passed the qualification test for welding operators as specified above under 'Qualification of Welders and Welding Operators' of this Sub-section.

Welding of reinforcement

Electric Arc Butt-welding is most suitable for bars of diameter greater than 20mm and lap welding for smaller diameters and lap welding with longitudinal beads for 6mm to 40mm diameters. However, reinforcement, specified to be welded, shall be welded by any process the Contractor can demonstrate by bend and tensile tests, which will ensure that the strength of the parent metal is not reduced and that the weld possesses a strength no less than that of the parent metal. The welding procedure established by the successful weld tests shall be maintained and no departure from this procedure shall be permitted. Following the establishment of a satisfactory welding procedures, each welder to be employed on the work shall carry out welder performance qualification tests on reinforcing bars of the same metal and size as those on the works.

Welds in positions other than those shown on the Drawings and/or as directed by the Engineer shall not be permitted.

2.6.2.10 Defects in welded joints

The usual defects in welded joints are :

- ☐ Lack of penetration or fusion of the metal to the bottom of the joint or welded members.
- ☐ Laps in the metal of the weld not properly fused together.

Defects are most likely to occur at the root of the weld and in this position they are liable to have the maximum effects in reducing the strength of the weld.

2.6.2.11 Inspection and testing of welds

The metal in a good weld when cold should show its original colour. If the metal has a rusty or dull red colour or appears crystallized, it is an indication that the heat has become too high and the metal has been burnt. A good weld will show an evenness of ripples or waves and well formed beads with good fusion along the edges of the welds. There should be no unfilled cavities, small pockets of slags or burnt metal and small air or gas pockets.

The strength of a welded joint may be taken only about 75 per cent of the stress usually allowed for common works, although tests have shown that if the welding is properly done it is possible to develop the full strength of the members jointed.

The following tests shall be carried out on the procedure, qualification, test plates and production test plates:

- ☐ Tensile and bend tests: all welds shall be subject to visual inspection.
- ☐ The procedures of visual examination shall conform to the requirements of the ASME Boiler and Pressure Vessels Code.

The following defects are unacceptable unless otherwise noted:

- ☐ Dimensional defects such as insufficient throat or leg length, excess convexity, excess or insufficient reinforcement.
- ☐ Undercuts, overlap, blowholes, slag inclusion, seams and excess weave.
- ☐ Any crack or liner indication.

Plates with laminations discovered during gas cutting, welding or any other time shall be rejected, unless approval to repair the plate is obtained from the Engineer.

Welds may also be subject to anyone or a combination of the examinations as may be required to establish the soundness of welds.

The inspection procedures for testing of all welds shall be prepared on the above basis by the Contractor and submitted to the Engineer for approval before any fabrication work is started.

2.6.2.12 Measurement and payment

Welding shall not be measured and no direct payment shall be made. All costs of welding shall be deemed included in the related items of the Bill of Quantities unless otherwise it has been specifically mentioned in the BOQ.

2.7 SUB-SOIL BORING AND TESTING

2.7.1 General

Confirmatory Sub-Soil investigation shall be carried out at the actual locations of each foundation. The objective of the subsoil investigation is to ascertain the actual soil strata at the location, the engineering properties at each stratum and to ascertain the level at which the foundation can be laid. The investigation shall be carried out as per the following specifications and as directed by the Engineer.

2.7.2 Boring

Boring shall be carried out in accordance with the specifications of ASTM D 1586 and D 1587. The bore holes shall have a minimum diameter of 100mm and shall be lined throughout. Minimum depths shall be 20m unless otherwise directed by the Engineer. The toe of the lining shall at no time be more than 1m above the level to which the soil has been removed from the bore hole.

Before taking any undisturbed sample or making any in-situ test, the lining shall be carried down to the bottom of the bore hole at the test depth.

Auger of proper size shall be used in very soft to soft clays and silts to avoid suction. The use of shell shall only be restricted to moderately stiff to very stiff and hard clays and also in sandy strata below water table. The use of a chisel would be permitted only in case of boulder or rock formation or through local obstructions or other situation demanding its use as would be decided by the Engineer.

Uncased bore holes may be permitted only upto a depth where the sides of the hole can stand unsupported. In case of side fall or squeezing, steps shall be taken immediately to stabilize the sides of the bore hole by casing pipes as directed by the Engineer. Use of Bentonite slurry of 5% concentration may be permitted to stabilize the bore hole.

No water shall be added while boring through cohesive soils and non-cohesive soils above the water table. While boring through non-cohesive soil below water table, water level in the casing shall always be maintained at or above the water table.

The cutting brought up by the auger shell or the split-spoon or undisturbed sampler shall be carefully examined and the soil description duly recorded after performing field identification tests.

On completion of boring at any bore hole, a bore log shall be prepared in an approved standard format in consultation with the Engineer and submitted to the Engineer in triplicate. Position of the

water table shall be observed after 24 hours and back filling of the bore hole shall be carried out with approved materials in a manner as directed by the Engineer.

2.7.3 Disturbed samples

Disturbed samples shall be taken from bore hole cuttings and split-spoon for visual classification tests at the Site. The samples shall be taken at 1.5m interval or at every identifiable change of strata, whichever is met earlier to give a reliable record of the variation in the conditions of the soils. Disturbed samples shall be sent to the laboratory in airtight plastic container with proper label for the purpose of record and laboratory testing.

2.7.4 Undisturbed samples

Collection of undisturbed samples from cohesive soil layers shall be conducted as per ASTM D 1587 and/or any other equivalent.

2.7.5 Handling and labeling of samples

The following conditions of handling and protection of undisturbed samples shall be undertaken on undisturbed sample.

- ☐ Immediately after being taken from the bore hole, the ends of the sample shall be cut and removed to a depth of about 2.5cm (or more in the top to cover any obviously disturbed soil). Several layers of molten wax should then be applied to each end to give a plug about 2.5cm thick. If the sample is very porous, a layer of waxed paper should first be placed over the ends of the sample.

Any space left between the end of the sample tube and the top of the wax should be tightly packed with saw dust or other suitable materials and a close fitting lid or screwed cap shall be placed on each end of the sample tube.

The lids should, if necessary, be held in position by adhesive tape.

- ☐ A label bearing the number of the sample, bore hole number, depth of sample, date, etc. preferably typed, shall be placed inside the container just under the lid. It shall be placed at the top of the sample. In addition, the number of the sample shall be painted on the outside of the container and the top or bottom of the sample shall be indicated.
- ☐ Undisturbed soil sample tubes shall be placed in a strong wooden box and packed with moist saw dust, paper, etc. to prevent damage during dispatch to the laboratory.

2.7.6 Standard penetration test

Standard penetration test shall be conducted as per ASTM D 1586 at an interval of 1.5m or at every identifiable change of strata, whichever is earlier.

The driving of split-spoon shall be recorded for every 150mm penetration till the total penetration is 450mm.

Driving of the split-spoon shall be terminated when standard penetration resistance value, $N > 100$ blows / 30cm of penetration is received, unless otherwise directed by the Engineer. The test shall be conducted after driving the casing to the bottom of the bore hole and after cleaning it. N-values, as observed in the field, shall be reported in the bore logs without any correction.

2.7.7 Dispatch of samples

Samples shall be dispatched to the laboratory as soon as possible after being obtained and shall not be allowed to accumulate at Site. In the event a danger of sample's deterioration through further storage is noticed, the Contractor shall dispatch such samples immediately on receiving direction from the Engineer.

2.7.8 Laboratory tests

General

Laboratory tests shall be carried out as per relevant ASTM or BS Procedures or by any other procedures approved under equivalent recognized standards. The results of all tests shall be submitted in the format as approved by the Engineer.

Preparation of the test specimens

Preparation of test specimens for the various tests shall be carried out as per the procedures laid down in the various relevant ASTM or BS Codes or by any other procedures approved under equivalent recognized standards.

In case of soft to firm cohesive undisturbed soil samples, test samples for all types of shear tests shall be prepared strictly by hand trimming on soil lathe. Care shall be taken against bending of soil samples at the time of horizontal ejection of the samples from the sampling tubes. Samples shall be ejected from the sampling tubes preferably in the same direction of travel in which the samples entered the sampling tubes.

Similarly test specimens for consolidation tests shall also be prepared to the required size by hand trimming only and the ring of the consolidation apparatus shall be inserted by pressing gently with the hands and carefully removing the material around the ring. In no case the ring should be forced into the soil. Great cares shall be taken during trimming of the sample from the top and the bottom of the ring. The test specimen shall be prepared in the same orientation as that to the actual strata so that the laboratory test load compresses the soil in the same direction relative to the soil strata as the applied load in the field.

Unconfined compression test

Unconfined compression test shall be conducted both on natural and remoulded soil samples. Remoulded soil specimen shall be prepared by the dynamic method of compaction.

Each unconfined compression test (natural or remoulded) shall comprise tests on minimum of three soil specimens, not less than 38mm diameter and a height to diameter ratio of 2 together with the determination of natural moisture content and density. Water content of the specimen shall be taken from the failure zone of the specimen. Test results shall be observed and reported as per the standard practice.

Triaxial test

Triaxial test shall be conducted on the undisturbed samples selected by the Engineer. Each test shall be conducted on a minimum of three specimens tested at different cell pressures (0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm²). The moisture content before and after the test and the density shall be determined.

The stress-strain diagrams as well as the Mohr circle envelop for these tests shall be submitted.

Consolidation test

Consolidation tests shall be conducted on undisturbed samples selected by the Engineer. The coefficient of consolidation (Cv.), the coefficient of volume compressibility (Mv.), Laboratory Compression Index (Ccl.), Field Compression Index (Ccf.) including field virgin slope and the coefficient of permeability (k) shall be determined and results shall be submitted.

The loading on the test specimens shall be applied at the stages of 0.1 kg/cm², 0.25 kg/cm², 0.5 kg/cm², 1.0 kg/cm², 2.0 kg/cm², 4.0 kg/cm² and 8.0 kg/cm².

Unloading of the test specimens shall be done at suitable stages.

Routine test

All routine tests like natural moisture content, bulk density, liquid and plastic limits, grain size distribution, specific gravity, shall be conducted on selected representative samples as directed by the Engineer.

Report and records

On completion of each bore hole, three copies of a bore hole log shall be submitted to the Engineer together with one copy of the list of disturbed and undisturbed samples taken from the bore hole.

These bore logs shall show:

1. Ground level referred to the reduced level.
2. Locations of the bore holes on a plan.
3. Detailed description of each stratum.
4. Position, type and identification of each sample and SPT value.
5. Any other Site test results available.
6. Levels at which each separate ground water level is first encountered and at which it comes to rest (standing water level).

On completion of all field and laboratory tests, all results shall be submitted to the Engineer in 3 (three) copies in the form of reports with comments and views.

2.7.9 Measurement

The work will be measured for payment as an item on a lump sum basis or as specified in the Schedule of Items and BOQ.

2.7.10 Payment

Payment shall only be admissible on implementation of the item as measured and provided above and on being certified by the Engineer that the investigations have been carried out as per specifications as contained herein. Payment shall be made as lump sum rate or as specified in the Schedule of Items and BOQ, which shall cover the full costs of boring, collection and dispatch of samples, standard penetration test and all necessary Laboratory tests, preparation and submission of records, cost of all labour, equipment, materials, tools, test fees and all incidentals required for undertaking the test and submission of requisite reports to the Engineer in its totality. No payment shall be made until the testing results and other information in the form of reports with requisite number of copies are submitted to the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
2.7	Sub-Soil investigation	Lump sum

2.8 FOUNDATION PILES

2.8.1 Bored cast in place piles

2.8.1.1 Description

This work shall comprise of boring and construction of bored cast in place piles for foundation of the building structures. The item includes the provisions of all labour, materials, equipment, boring and all incidentals necessary to complete the work in accordance with these Specifications, in conformity with the requirements of the Drawings, as required in the other places of the Contract Document and/or as per direction of the Engineer.

Piles through the water and soft upper soil layers shall be provided with permanent steel casing, if shown on the Drawings.

The pile boring shall be carried out using a temporary steel casing driven upto the pile toe or to a level approved by the Engineer. The temporary casing shall be withdrawn.

Under certain circumstances the Contractor may be permitted to bore all or part of the pile without casing under water or using drilling fluid to stabilize the bore hole.

Concrete and reinforcement of the piles shall be strong enough to resist pile loads and horizontal forces on the pile caps.

2.8.1.2 Accessories

Steel casing

Temporary steel casing

Temporary steel casing pipe of required diameter shall be used at least for the upper 6m from the ground level during drilling to stabilize the hole. The casing pipe shall be fabricated to the specified size and shape from mild steel. It shall be smooth, clean, water tight and sufficiently strong to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. It shall be free from significant distortion and shall have uniform cross-section throughout each continuous length. Size of the shaft shall be less than the inside diameter of the casing. However, it shall not be less than 10mm. During pouring of concrete, it shall be free from internal projections and encrusted concrete, which might prevent the proper formation of piles.

Permanent steel casing

The steel shall conform to the ASTM A 36 or approved equivalent having sufficient strength and rigidity to prevent distortion by soil pressure or for drilling of adjacent piles.

Minimum wall thickness of the permanent steel casing shall be 6mm. Minimum length shall be from 100mm above the bottom of the pile cap to 5m inside the ground or into firm strata or as shown on the Drawings or as directed by the Engineer. In the case the permanent casing is used in the boring operation and if the handling and transport require a greater thickness to avoid deformation or buckling, the increase in thickness shall be provided by the Contractor at his own expenses.

The steel casing shall be furnished in appropriate length and the joints shall be approved by the Engineer.

Casing pipes may be transported to the Site at suitable lengths in pieces and shall be welded as per specifications to fabricate the designed length. The casing shall be handled and stored in a manner that shall prevent buckling and other deformation as well as accumulation of dirt, oil and paint. When placed in the work, it shall be free from dirt, oil, grease, paint, mill scale and loose or thick rust or any deleterious substance that may affect the concrete.

Tremie pipe

A Tremie shall consist of a steel tube having a diameter of not less than 150mm, sufficiently long to reach the bed of water keeping its one end above the water level, constructed in sections having flanged couplings fitted with gaskets. The tube shall be fitted with a hopper at its upper end for pouring concrete inside the tube. The Tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work so as to permit rapid lowering when necessary to retard or stop the flow of concrete.

2.8.1.3 Materials

Concrete

The concrete for bored cast-in-place piles shall conform to all requirements as described under the Section on 'Concrete Work' of this Specification. Cement Type 1 shall be used and the characteristic cylinder strength shall be 250 kg/cm² at 28 days.

Concrete placed under water or drilling mud by Tremie shall have cement content of not less than 370 kg /m³.

The density and consistency of the concrete shall conform to the Tremie Casting Method. Sufficient workability (slump) of all concrete shall be maintained during the casting and casing handling period. Reasonable calculated delays shall be secured by a design mix (including the necessary retarders and plasticisers) which is tested by trial mixes prior to the pile construction.

All relevant concrete properties such as slump, time of setting, temperature and strength shall be measured on the trial mixes.

Reinforcement

Reinforcement bar and binding wires used in the construction of bored cast-in-place piles shall conform to the requirements stated under the Sub-section on 'Reinforcement for RCC' of this Specification.

Welding electrodes

Where welding is specified for fabrication of the reinforcement, the electrodes shall conform to the American Welding Society (AWS) Standards and shall be of the size and classification number recommended by the manufacturer.

Drilling fluid

The following instructions shall be complied with, if Bentonite mud is used to stabilize the bore hole.

☐ Supply

Bentonite, if required and supplied at the Site, shall be in accordance with the specifications conforming to DFCP 4 of the Oil Companies Materials Associations.

The Contractor shall obtain a certificate from the manufacturer of the Bentonite powder showing the properties of the consignment delivered at the Site. This certificate shall be made available to the Engineer on request. The properties to be given by the manufacturer are the apparent viscosity range and the gel strength range for solids in water.

Any other materials for the drilling fluid shall receive approval from the Engineer.

☐ Mixing

Bentonite and any other materials shall be mixed thoroughly with clean water to make a suspension, which shall maintain the stability of the pile excavation for a period necessary to pour concrete and complete construction. Where saline or chemically contaminated groundwater occurs, special precautions shall be taken to modify the Bentonite in fresh water so as to render it suitable in all respect for the construction of piles.

☐ Tests

The frequency of testing drilling fluid and the methods and procedures of sampling shall be proposed by the Contractor and approved by the Engineer prior to the commencement of the work. The frequency may subsequently be varied as required depending upon the consistency of the results obtained. The control tests shall cover the determination of density, viscosity, gel strength and pH values.

For average soil conditions, the results shall generally be within the ranges stated in the Table given below. The tests shall be carried out until a consistent working pattern has been established.

Property to be measured	Range of Results at 20°C	Test Method
Density	1.03 – 1.1 g/ml	Mud density balance
Viscosity	30-90s or less than 20 cP	Marsh cone method Fann viscometer
Shear strength (10 minute gel strength)	1.4 - 10.0 N/m ² or 4.0 - 40.0 N/ m ²	Shearometer Fann Viscometer
pH value	9.5 - 12.0	pH indicator paper strips or electrical pH meter

The Contractor shall supply all equipment and engage experienced operators required for carrying out tests on the drilling mud. No additional payment shall be made for these tests, which shall be considered as an essential part of the drilling operations.

2.8.1.4 Construction method

General

☐ Preparation

Before starting drilling operation, the Contractor shall plan the sequence and stages of operation for different piles and establish levels, grades and alignment of all piles with reference to Bench Mark (BM) previously established at Site. The Contractor shall have fabricated all casing pipes and reinforcing bars as per design and shall be ready for lowering the pipes on completion of drilling. All necessary equipment such as pump, welding set, etc. and materials for concrete work including Tremie pipe shall be made available before the start of drilling operation.

☐ Drilling

The Engineer shall approve the drilling method and the equipment to be used for this purpose. The Contractor shall prepare all suitable cofferdam/artificial island/staging or any other approved means, if required, for the drilling operation and pouring concrete of the piles in water. Bentonite slurry, if required, shall be used to stabilize the hole.

☐ Pile cluster

Where there are more than 4 (four) piles in a cluster, the centre pile shall be installed first. All piles in a cluster shall be of the same depth.

☐ Obstruction during drilling

When obstructions make it extremely difficult to drill certain holes in the location shown and upto the proper bearing strata, the Contractor shall take all usual methods to install piles as required including jetting, cutting, drilling or other feasible means. If in the judgment of the Engineer the Contractor is unable to complete properly any pile by resorting to such methods, the Engineer may order for an additional hole drilled at another selected location at the Contractor's own expenses.

☐ Depth of hole

The Engineer shall check the depth of hole by lowering suitable drop in order to determine the length of pile. Immediately after approval of the bore, the permanent steel casing pipe shall be installed upto the design depth, if provided in the BOQ and then the reinforcement cage shall be lowered.

Pile type and construction methods shall ascertain that the pile shaft shall not be weakened by contamination of the concrete, by sectional reduction, by washing out of cement, by breaking during pulling of temporary casings or by any other way including construction of neighbouring piles.

Assumed Procedure

The following construction procedures shall be assumed in the Design. The Engineer shall approve the final construction procedures or any subsequent modification prior to commencing piling operations.

- ☐ If required, placing the permanent steel casing in position and embedding the casing toe into the firm strata. If no permanent steel casing is specified, a sufficient length of temporary steel casing shall be used to stabilize the upper part of the bore hole.
- ☐ Boring and excavating the inside of the steel casing down to the casing toe level or to a level approved. Excavating upto the final pile tip level using either temporary casing under water or using drilling mud. Water level inside the casings shall, at all times, be at least 2m higher than the outside of the casings.
- ☐ Cleaning carefully all mud or sediments from the bottom of the bore hole.
- ☐ Placing reinforcement cage, inspecting pipes, etc.
- ☐ Pouring concrete continuously under water or drilling fluid following the Tremie method.
- ☐ Withdrawing the temporary casing concurrently with pouring of concrete upto the instructed level.
- ☐ Breaking the top section of the concrete pile after hardening in order to reach sound concrete.

Approval of construction method

In the Tender, the Contractor shall describe his proposed construction methods, which shall include information on boring equipment, materials, methods of work, quality control and bearing capacity and also the name of the Sub-contractor (as and when allowed). The Contractor shall submit references from similar jobs carried out by him or by the Sub-contractor.

Prior to making Contract, the Contractor shall submit all requested supplementary information in writing.

After the Contract has been awarded to the Contractor, he shall prepare a detailed programme and establish a procedure for the pile construction in accordance with the above information.

The detailed programme shall contain all information as requested on materials, equipment, methods of work, etc. and be approved in writing by the Engineer. Such approval shall not relieve the Contractor of his full responsibilities for the entire pile construction.

No boring equipment or material shall be imported at Site before the Contractor has received the approval of the Engineer as stated above.

Setting out piles

Before starting drilling operation the Contractor shall plan the sequence and stages of operation for different piles and establish levels, grades and alignment of all piles with reference to Bench Mark, previously established at Site. The Contractor shall have all casing pipes and reinforcing bars fabricated as per design and ready for lowering on completion of drilling. All necessary equipment and materials for concrete work including Tremie pipe shall be made available before the start of drilling operation.

The positions of the piles shall be set out in accordance with the Drawings from established Bench Mark. The position of each pile shall be approved by the Engineer before drilling commences.

Where there are more than four piles within a cluster, the center pile shall be constructed first. No concrete shall be placed until all drilling within a radius of 2.5m has been completed. If this is not possible, no drilling shall be done within 2.5m radius of a cast-in-situ pile until the concrete has set for at least 96 hours after pouring.

Diameter of piles

The diameter of a pile shall be not less than the specified diameter.

Tolerances

Bores shall be accurately drilled in the locations as shown on the Drawings. All piles shall be drilled with a lateral tolerance of not more than 75mm from the point specified. Pile that deviates by more than 75mm in lateral location or pile whose slope deviate from the vertical by more than 2%, shall be

rejected. Additional piles shall then be furnished and installed by the Contractor in such locations as the Engineer may direct. The Contractor shall provide suitable equipment, such as an inverted pendulum, to check the verticality of the bore holes at intervals during drilling and prior to pouring concrete. All costs for such additional piles as required to suit the changed pile locations, shall be borne by the Contractor at his own costs.

Boring

Method

Generally two methods are followed while excavation. One is Percussion Drilling Method and the other is Rotary Drilling Method. However, method of excavation shall be proposed by the Contractor and approved by the Engineer. Water or air jetting for boring of the piles shall not be allowed.

Boring near recently cast piles

Piles shall not be bored so close to other piles which have recently been cast and which contain workable or unset concrete so that flow of concrete could be induced from or damage caused to any of the piles. Boring and excavation for a pile shall not be commenced until 96 hours after completion of any pile within a radius of 2.5m center to center.

Steel casing

A temporary steel casing pipe of approved quality and specifications stated earlier shall be used and lowered simultaneously with the progress of drilling for the purpose of stabilizing at least the top 6m of the hole. Where a permanent steel casing pipe is specified in the Drawings, this shall either be lowered as drilling progresses instead of the temporary pipe, or installed immediately on completion of drilling. The inside of the casing pipe shall be cleaned of oil, grease, paint and other deleterious substances before lowering.

A pile constructed in a stable cohesive soil without the use of temporary casing or other form of support shall be bored and concreted without prolonged delay and in any case soon enough to ensure that the soil characteristics are not significantly impaired.

Stability of pile excavation using drilling fluid

Where a bore hole is formed without casing under water or using drilling fluid for maintaining the stability of a boring, the level of the water or fluid in the excavation shall be maintained so that the water fluid pressure always exceeds the pressure executed by the soils and external ground water. The water or fluid level shall be maintained at a level not less than 2m above the level of the outside water level or any artesian pressure level.

Drilling mud shall be used at least from the level of sub-soil water or from the level of the bottom of the guide casing depending upon the Site conditions and the hole shall then always be kept almost full with fluid, which should preferably be kept in motion. The density and composition of the fluid shall be such as to suit the requirements of the ground condition and to maintain the fine materials from the boring in suspension. A five percent Bentonite suspension would be generally suitable.

Where saline or chemically contaminated ground water occurs, special precautions shall be taken to modify the Bentonite suspension or pre-hydrate the Bentonite in fresh water so as to render it suitable in all respect for construction of the piles.

In the event of a rapid loss of water or Bentonite suspension from the pile excavation, the excavation shall be back-filled without any delay and the instructions of the Engineer shall be obtained before excavation at the location is resumed.

Disposal of excavated material

No excavated material shall be dumped into the river or any connecting waterway without the written approval of the Engineer. Excavated materials shall be removed from the Site and dumped either beyond areas affected by dredging, or taken to the Contractors dumping areas on land. The Contractor shall be fully responsible for all costs involved in removing the excavated materials to spoil.

Pumping from bore holes

Pumping from a bore hole shall not be permitted unless a casing has been placed into a stable stratum, which prevents the flow of water from other strata in significant quantities into the boring, or unless it can be shown that pumping will not have a detrimental effect on the surrounding soils and/or properties.

Obstructions

Where boulders or other obstructions render it impossible to bore the pile, excavation operations inside the pile casing, as directed by the Engineer, shall be carried out to remove the obstructions. The Contractor shall be reimbursed for such operations only when the largest dimension of the obstruction exceeds 200mm and the obstruction is found more than 2m below the ground level or water bed. However, the amount of compensation shall be proposed by the Contractor and agreed by the Engineer beforehand the removal works start.

Unexpected ground conditions

The Contractor shall report immediately to the Engineer any circumstances, which indicates that in the Contractor's opinion the ground conditions differ from those expected by him from his interpretation of the Site Investigation Reports.

Boring records

During the boring of the pile, the Contractor shall compile a boring log indicating depths and types of the various soil layers encountered. Disturbed samples shall be submitted to the Engineer, as per requests.

The Contractor shall carry out sampling and tests to check soil strengths and shall not be reimbursed for this work.

Final pile toe level

The final pile toe level shall be as indicated on the Drawing or as instructed by the Engineer after due consideration of the Contractor's proposals, boring logs and test results.

The final toe level of other piles may subsequently be altered according to the results of the test loading detailed under Section on 'Pile Load Testing' of this Specifications.

Inspection and cleaning of bottom of excavation

The time between final excavation and bottom cleaning and the start of pouring concrete shall be reduced as much as possible and shall not exceed six hours. To achieve this, the final 2m of excavation shall not start until all preparations for cleaning, reinforcing and pouring concrete are finished. In case of unexpected delay, the Contractor shall dump sand or gravel in the bore upto 2m above the toe level.

Immediately after excavation, the bottom of the excavation shall be carefully cleaned for mud and sediments and other soft materials. A short interruption is recommended to allow the fine materials to settle.

The cleaning shall be made by an approved method. Before cleaning of every pile, notice shall be given to the Engineer.

The Contractor shall carry out Sedimentation Tests in presence of the Engineer.

For boring without casing, the diameter of the bore hole for a representative number of piles shall be measured by a Caliper prior to the pouring of concrete. The verticality of the bore holes shall be maintained by the Contractor using approved equipment and no reimbursement shall be made in this regard.

Placing reinforcement

The reinforcing steel cage consisting of the steel shown on the Drawings along with cage stiffener bars, spacers, centralizers, and other necessary appurtenance shall be completely assembled and

placed as one unit immediately after the excavation is inspected and accepted and prior to concrete placement.

The reinforcement shall be placed as indicated on the Drawings. Reinforcement in the form of a cage shall be assembled with additional support, such as spreader forks and laciness, necessary to form one rigid cage. Hoops, links or helical reinforcement shall fit closely around the main longitudinal bars and be bound by approved wire, the ends of which shall be turned into the interior of the pile or pour. Hoops, links or helical reinforcement may also be placed and fitted with main longitudinal bars by staggered spot or line welding of approved quality.

The reinforcing steel shall be tied and supported so that it will remain within allowable tolerances until the concrete will support the reinforcing steel.

The cover to all reinforcement shall be not less than 75mm.

Joints in longitudinal steel bars shall be permitted unless otherwise specified. Joints in reinforcement shall be such that the full strength of the bar is effective across the joint and shall be made so that there is no relative displacement of the reinforcement during construction of the pile.

Joints in longitudinal steel bars in piles with tension (for instance for test loading) shall be carried out by welding unless another method has been approved by the Engineer.

In case the final pile toe level, instructed by the Engineer, is deeper than that indicated on the Drawings, the section of the pile, deeper than the toe level indicated on the Drawings, will not require any reinforcement.

Placing concrete

☐ Approval

No pouring of concrete shall take place before the bottom of the excavation has been cleaned, the bore hole inspected and approval has been obtained in writing from the Engineer.

☐ Methods

The method for mixing the concrete shall be as specified under the relevant Sub-section of the Section on 'Concrete Work' of this Specification. The concrete shall be placed using a Tremie pipe long enough to reach the bottom of the hole and having an internal diameter of not less than 150mm. The Tremie pipe shall be gradually withdrawn as the pouring of the concrete progresses but shall always be kept below the surface of the poured concrete.

The method of placing and the workability of the concrete shall be such that a continuous monolithic concrete pile of the full cross-section is formed.

The concrete shall be placed continuously and without such interruption as would allow the previously placed batch to have hardened. In this respect the Contractor shall submit details of his contingency plans, standby plant, etc. to be utilized in the event of any equipment breakdown.

The use of pumped concrete and the methods in its use shall be approved by the Engineer.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a casing. No spoil, liquid or other foreign matters shall be allowed to contaminate the concrete.

☐ Workability of concrete

Slump measured at the time of discharge in to the pile boring shall be minimum 100mm and maximum 150mm.

☐ Placing concrete under water or drilling fluid

Concrete to be placed under water or drilling fluid shall be placed by Tremie and shall not be discharged freely into the water or drilling fluid.

The internal diameter of the pipe of the Tremie shall be not less than 150mm for concrete made with 25mm aggregate and not less than 200mm for concrete made with 32mm aggregate. It shall be so designed that external projections are minimized allowing the Tremie to pass through reinforcing cages without causing damage. The internal face of the pipe of the Tremie shall be free from projections.

Before placing concrete, all measures shall be taken to ensure that there is no accumulation of silt or other materials at the base of the boring and the Contractor shall ensure that heavily contaminated Bentonite suspension that could impair the free flow of concrete from the pipe of the Tremie, has not accumulated at the bottom of the hole.

A sample of the Bentonite suspension shall be taken from the base of the boring by using an approved sampling device. If the specific gravity of the suspension exceeds 1.25, pouring of concrete shall not proceed. In this event, the Contractor shall modify the mud quality.

The concrete shall be a rich coherent mix of high workability as shown on the Drawing, in accordance with the provisions stated under the relevant Sub-section on 'Concrete Work' as stated in the BOQ and/or as directed by the Engineer.

The concrete shall be placed in such a manner that segregation does not occur.

During and after pouring concrete, all cares shall be taken to avoid damage to the concrete from pumping and de-watering operations.

The hopper and pipe of the Tremie shall be clean and watertight throughout. The pipe shall be sufficiently long to reach the base of the boring and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the pipe of the Tremie and the water or drilling fluid. The discharge end shall be sealed closed at the start of work so as to prevent water from entering the tube before the tube is filled with concrete. After placement of concrete has started the Tremie pipe shall be kept full of concrete upto the bottom of the hopper. The pipe shall, at all times, penetrate the concrete, which has previously been placed and shall not be withdrawn from the concrete until the concrete pouring is completed. The bottom of the Tremie pipe shall be kept at least 1.5m under the surface of the concrete. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water or drilling fluid. If water enters the tube after placement of concrete has started, the Tremie shall be withdrawn, the discharge end resealed and the placement restarted. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow shall be continuous until the work is completed.

The Contractor shall maintain a continuous record of the volume of the concrete used and the level of the concrete in the pile. Any deviation from the theoretical or expected volume/level relationship shall immediately be reported to the Engineer.

☐ Placing concrete in dry

When the top of the pile elevation is above the ground, portion of the pile above the ground shall be formed with a removable form or permanent casing when specified.

The concrete shall be vibrated or rodded to a depth of 1.5m below the ground surface except where soft uncased soil or slurry remaining in the excavation will possibly mix with the concrete.

After placement, the temporarily exposed surfaces of the shaft concrete shall be cured in accordance with the provisions of curing of concrete described under the Section "Concrete Work" of this Specification.

For at least forty-eight hours after concrete has been placed, no construction operation other than mild vibration shall be conducted that would cause soil movement adjacent to the shaft.

Portions of the pile exposed to a body of water shall be protected from the action of water by keeping the forms in place for a minimum of seven days after concrete placement.

2.8.1.5 Extraction of temporary casing

Workability of concrete

Temporary casing shall be extracted while the concrete within it remains sufficiently workable to ensure that the concrete is not lifted.

Concrete level

When the casing is being extracted, a sufficient quantity of concrete shall be maintained within it to ensure that pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in section nor contaminated. The toe of the temporary casing shall be kept minimum 2m under the outlet of the Tremie.

No concrete shall be placed in the boring once the bottom of the casing has been lifted above the top of the concrete. It shall be placed continuously as the casing is extracted until the desired head of concrete is obtained.

Adequate precautions shall be taken in all cases where excess head of water or drilling fluid could be caused as the casing is withdrawn because of the displacement of water or fluid by the concrete as it flows into its final position against the walls of the shaft.

The pile shall be concreted at least one pile diameter above the designed cut off level to allow for chiseling off the top concrete down to sound hard concrete.

The pile top shall, after clean cutting, be embedded 75mm in the foundation.

Vibrating extractors

The use of vibrating casing extractors shall be permitted.

Reinforcement cage

When concrete is placed by Tremie method, temporary hold-down devices shall be used to prevent uplifting of the steel cage during concrete placement. Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals not exceeding 1.5m along the drilled depth to insure concentric location of the cage within the boring. When the size of the longitudinal reinforcing steel exceeds 25mm, such spacing shall not exceed 3m.

Supervision

The execution of the pouring of concrete in the pile shall be supervised by a qualified person of the Contractor's staff in addition to the Engineer's representative, who will keep records on the relation between quantity of concrete used, level of concrete and withdrawal of casing.

2.8.1.6 Temporary support

The Contractor shall ensure that free standing piles are temporarily braced or stayed immediately after driving to prevent loosening of the piles in the ground and to ensure that no damage resulting from oscillation, vibration or movement of any free-standing pile length can occur.

2.8.1.7 Records

The Contractor shall keep records as indicated below for the installation of each pile and shall submit two signed copies of these records to the Engineer no later than noon of the next working day after the pile has been installed. The signed records shall form a record of the work.

- ☐ Contract
- ☐ Pile reference number (location)
- ☐ Pile type
- ☐ Nominal cross-sectional dimensions or diameter
- ☐ Date and time of boring

- ☐ Date and time of pouring of concrete
- ☐ Level of the ground at commencement of installation of pile
- ☐ Working level
- ☐ Pile toe level
- ☐ Pile head level
- ☐ Length of temporary casing
- ☐ Length of permanent casing
- ☐ Soils samples taken and in-situ test carried out
- ☐ Standing water level
- ☐ Length and details of reinforcement
- ☐ Concrete mix
- ☐ Volume of concrete supplied to pile and corresponding levels of concrete and casings
- ☐ All information regarding obstructions, delays and other interruptions to the sequence of work.

2.8.1.8 Measures in case of rejected piles

If any pile is found unsatisfactory in the opinion of the Engineer for utilization in the structure, it shall be cut off below the pile cap when so ordered by him.

The pile shall be replaced as directed by the Engineer. All additional expenses shall be borne by the Contractor, which would not be reimbursable.

When the safe bearing value of any pile is found by tests to be less than the design load, longer pile or additional piles shall be installed as ordered in writing by the Engineer.

2.8.1.9 Other requirements

Reinforcement cages of piles selected by the Engineer shall be fitted at the Contractors expenses with watertight 50mm diameter G.I pipe from datum level down to pile toe level. Bottom of the pipes shall be closed waterproof. Piles with diameter above 800mm shall have four G.I pipes while piles with diameter below or equal to 800mm shall have three G.I pipes.

The Contractor shall test piles by an electronic ultrasonic device as per the instruction of the Engineer. The Contractor shall submit a report in two samples within two days of testing. Ultrasonic testing will not be paid separately and the Contractor shall make provisions that piles shall be tested in several lots as required by the work.

The Contractor shall cut off pile heads carefully but shall not cut, bend or damage starter bars. If required, the Engineer may instruct the Contractor to cut starter bars to the top level indicated on the Drawings.

2.8.1.10 Measurement

The unit of measurement shall be the linear meter in case of boring. The payable length shall be measured from the bottom of the pile cap upto the toe level of each pile.

The unit of measurement for concrete shall be in cubic meter. The payable length of the satisfactory bored piles shall be measured from the toe level to pile to including the broken portion.

The mass measured for injection of grout material shall not include the mass of water.

Breaking of pile heads shall be measured in cubic meter.

Permanent casing shall be measured in linear meter for each size.

The above measurements shall be taken for payment only on completion of works in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the

Drawings and/or as accepted by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

2.8.1.11 Payment

The amount of completed and accepted boring works, as measured above, shall be paid at the Contract unit price per linear meter. The payment shall constitute the full compensation for furnishing all related accessories and equipment related to boring with all support arrangements like Rigs, Crane, Jets, Frames, Leads etc. including temporary casing, drilling and removal of obstruction in course of drilling, drilling fluid circulation, disposal of excavated materials, all labour and incidentals necessary to complete the Work as per requirements described under this item of work, the Bill of Quantities, as shown on the Drawings and/or as directed by the Engineer.

The amount of completed and accepted work, as measured above in cubic meter of concrete, shall be paid at the Contract unit price. The payment shall constitute the full compensation for all costs for furnishing all materials of concrete including setting out piles, placing of reinforcement cage and keeping it in proper position, placing concrete by Tremie casting method, testing of all construction materials all costs of labour, equipment and plants, inspection and control, all related tools and all incidentals necessary to complete the work as per requirements described under this item of work, the Bill of Quantities, as shown on the Drawings and/or as directed by the Engineer. The payment shall exclude the costs for reinforcement and the broken portion of pile head.

Breaking of Pile Heads shall include removal of the dismantled materials such as concrete to a safe distance including scrapping and removing concrete from steel/M.S. rods, preparation and making platform where necessary, leveling and dressing the Site and clearing as well, etc.

Permanent casing shall be paid for at the Contract unit price per linear meter for permanent casing. Such payment shall be the full compensation for furnishing and placing the casing above the costs attributable to the work paid for under associated pay items.

No payment shall be made for unauthorized, defective, unsound or unsatisfactorily piles or for any costs incurred by the Contractor for such piles.

Pay Items shall be:

Clause	Description	Unit of measurement
2.8.1	Bored cast in place piles (Percussion method) (diameter as stated in the Bill of Quantities/Drawings)	
	a) Boring	Linear Meter
	b) Concrete	Cubic Meter
2.8.1	Bored cast in place piles (Rotary Drilling method) (Diameter as stated in the Bill of Quantities/Drawings)	
	a) Boring	Linear Meter
	b) Concrete	Cubic Meter
2.8.1	Breaking of pile heads	Cubic Meter
2.8.1	Permanent casing	Linear Meter

2.8.2 Pre-cast reinforced concrete piles

2.8.2.1 Description

This work shall consist of the production and driving of pre-cast reinforced concrete piles in accordance with this Specification and of the types and dimensions designated on the Drawings or as directed by the Engineer.

General

Pre-cast piles shall be manufactured in a casting yard in accordance with the Drawings.

Concrete shall be placed in one continuous pour for each pile. Pouring of concrete shall begin at the head and be progressed to the driving end of the pile.

Each pile shall be indelibly marked with its sequential number and date of manufacture.

2.8.2.2 Materials

Concrete

The concrete for pre-cast piles shall conform to the requirements illustrated under the Section on 'Concrete Work' of this Specification with a minimum concrete strength (cylinder) of 250 - 300 kg/cm² at 28 days.

Reinforcement

Reinforcing bar and binding wire used in the production of pre-cast piles shall conform to the requirements illustrated under the relevant Sub-section of the Section on 'Reinforcing Steel' of this Specification.

The reinforcement shall be assembled before placing in the moulds and all hoops and links shall be of uniform length firmly wired into position. Ends of helical reinforcement shall be firmly secured. Diagonal fork spacers shall be of an approved pattern.

Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided at agreed centers, designed to develop the full strength of the bar across the joint provided with adequate links or stirrups and staggered in position from those of adjacent longitudinal bars, all to the acceptance of the Engineer.

The main longitudinal reinforcing bars in piles, not exceeding 12m in length, shall be in one continuous length unless otherwise specified. In piles exceeding 12m long, joints will be permitted in main longitudinal bars at 12m nominal intervals. Joints in adjacent bars shall be staggered at least 1m apart along the length of the pile.

Joints in reinforcement shall be such that the full strength of the bar is effective across the joint.

Welding of joints in main longitudinal bars will not be permitted unless agreed in writing by the Engineer.

Concrete cover shall be maintained at the joints.

2.8.2.3 Formwork

Formwork shall comply with the provisions under the item on 'Formwork' of the Sub-section 'False Work and Forms' of this Specification except as specified below.

- ☐ When the sides of adjacent piles are used as formwork, an approved method shall be used to prevent adhesion between concrete surfaces.
- ☐ Holes for toggle bolts shall be at right angles to the faces of the pile and lined with steel tubes or other approved materials. Holes for lifting, handling and pitching shall be formed in the positions and according to the details shown on the Drawings or otherwise approved by the Engineer and lined with steel tubes.
- ☐ Details of all pile shoes shall be submitted to the Engineer for approval prior to fabrication or supply. All shoes shall be fitted to the reinforcement as shown on the Drawings.

Pile shoe/helmet

Where applicable, pile shoes shall be manufactured by an approved supplier and consist of cast iron, cast steel or fabricated steel as shown on the Drawings.

Cast iron shoes shall be formed from chill hardened iron grade 10 in accordance with BS 1452 "Specification for Grey iron castings". Cast steel shoes shall be formed from steel to grade A of BS 3100 "Specification for steel castings for general engineering purposes". Fabricated steel shoes shall

be formed from steel to grade 43 A1 and steel straps and fastenings to Grade 43A of BS 4360 "Weldable structural steels". Other equivalent established standards will also be applicable in this case.

Castings shall be free from sand, honeycomb, porosity, blowholes or other defects. For cast shoes, straps and fastenings shall be of mild steel or wrought iron, cast in to and running continuously through the base.

2.8.2.4 Production of pre-cast reinforced concrete piles

Length of piles

The pile lengths shown on the Drawings are based on Site investigations prior to driving of test piles. The lengths of the piles shall be finally determined and ordered by the Engineer after driving of pilot piles. Pilot piles shall be produced to the lengths shown on the Drawings.

Pile dimensions

Piles shall be cast to the cross-sectional dimensions shown on the Drawings. The cross-section on dimensions shall not be less than those specified and shall not exceed them by more than 6mm.

The head of each pile shall be square to the longitudinal axis. The edges of the head and of the pile for a distance of 30mm from the head, shall be chamfered 25mm x 25mm. Any face of a completed pile shall not deviate by more than 1/1000th of the length of the pile from the straight line connecting the centroids of the end faces.

Casting of piles

All pre-cast concrete piles shall be cast on the Site or at the Contractor's pile casting yard. In case where piles are manufactured off-Site, the Contractor shall ensure that adequate notices have been given to the Engineer and he has been provided with appropriate facilities for inspection of the manufacturing process.

Piles shall be cast in a horizontal position on an accurately leveled casting platform. The formwork shall conform to the requirements defined under the relevant clause of this Specification.

May be deleted because of repetition reinforcing bar shall be of the types and dimensions and shall be placed, as shown on the Drawings. The construction method for reinforcement shall conform in all respect to the requirements defined under the relevant Sub-section (Reinforcing Steel) of this Specification.

The formwork and reinforcement for each pile shall be inspected and approved by the Engineer before pouring of concrete commences.

Concrete shall be placed continuously and shall be compacted by mechanical vibration. Special cares shall be taken to produce a pile free from air pockets or honeycomb.

The forms shall be slightly overfilled, the surplus shall be scraped off and the top surface shall be finished to a uniform texture similar to that specified to be produced by the forms. The pile surfaces shall be true, smooth and even.

Casting tolerances

The cross sectional dimensions of piles shall not be less than those specified or shown on the Drawings and shall not exceed such dimensions by more than 6mm.

Unless otherwise directed by the Engineer, any face of a pile shall not deviate by more than 6mm from a straight edge 3m long laid on the face and the centroid of any cross section of the pile shall not deviate by more than 10mm from the straight line connecting the centroid of the end faces of the pile.

Curing and removal of formwork

Curing shall conform to the requirements defined in the relevant portion of the Section on 'Concrete Work' of this Specification. Side forms may be removed not less than 24 hours after placing the

concrete, but the entire pile shall remain fully supported for at least seven days. When accelerated curing is used, the curing procedures shall have to be accepted by the Engineer.

2.8.2.5 Marking of piles

The head of each pile shall be permanently marked with its date of casting and reference number. The pile shall be indelibly marked at 1m interval along its length showing the distance from pile shoe. The top 3m of the pile shall be marked at 250mm interval.

2.8.2.6 Protection of finished piles

Protection of finished piles against aggressive soil conditions shall be provided by one of the following methods:

- (a) Impervious liners to LWL – 2m
- (b) Tanking/waterproofing of the piles to the depth referred under (a) above
- (c) Painting with an approved two parts coal tar epoxy paint product suitable for mixing at Site immediately before application.

2.8.2.7 Handling and storage of piles

Pre-cast piles shall be lifted, handled, transported and stacked so that no damage occurs. The lifting points for each size of pile shall be marked as shown on the Drawings and as stated above with waterproof paint and to be approved by the Engineer. The piles shall be transported and stacked with supports at the lifting points.

Piles are to be handled only when concrete has reached its characteristic strength as determined by field control test cylinders. Piles shall be handled carefully to avoid being dropped or severely jarred.

2.8.2.8 Pilot (Test) piles

The Contractor shall construct and drive pilot piles prior to commencement of piling for the permanent works. The permanent work piles shall not proceed until the testing of the pilot piles has been completed meeting all requirements of acceptance to the satisfaction of the Engineer

Pilot piles shall be furnished for the lengths ordered and driven at the locations and to the elevations directed by the Engineer. In general, the ordered length of pilot piles will be greater than the estimated length of production piles in order to provide for variation in soil conditions.

The driving equipment used for driving pilot piles shall be identical to that which the Contractor shall propose to use in case of production piling.

Pilot piles shall be driven in positions specified by the Engineer. The Contractor shall notify the Engineer in advance of driving and shall supply the Engineer daily with a detailed record of the driving of the pilot piles.

Pilot piles shall be driven to a hammer blow count established by the Engineer at the estimated tip elevation. Pilot piles which do not attain the hammer blow count specified above at a depth of 0.3m above the estimated tip elevation shown on the plants, shall be allowed to “set-up” for a period of 12 to 24 hours as determined by the Engineer, before being re-driven. If the specified hammer blow count is not attained on re-driving, the Engineer may direct the Contractor to drive a portion or all of the remaining pilot pile length and repeat the “set-up”– re-drive procedure.

Driving of a pilot pile shall continue until the Engineer directs that it shall cease, in order to demonstrate that driving resistance continues to increase.

2.8.2.9 Driving of piles

The Contractor shall establish all lines, levels and be responsible for the correct positioning of all piles. Setting out shall be carried out from the main grid lines of the proposed structure. Immediately before installation, the pile position shall be marked with suitable identifiable pins or markers.

The position of the piles shall be set out in accordance with the Drawing from the established Bench Mark.

The pre-cast piles shall be driven to a pre-planned sequence approved by the Engineer and in the presence of the Engineer's authorized representative in order to minimize the detrimental effects of heave and lateral displacement of the ground. No pile driving will be allowed at night unless prior permission is obtained from the Engineer.

Piles shall be protected with an approved cushion and cap while being driven. Pile driving shall be stopped when the maximum blows per 0.3m or the number specified on the Drawings are reached or if the pile head is damaged due to improper driving.

Piles shall be rigidly secured by leads or temporary guide structure against lateral movement during driving and shall be driven without interruption right from the first blow of the hammer until the required penetration has been attained.

Piles shall be driven to the positions, lines and elevations shown on the Drawings so that the pile center is within 75mm of the specified location point and with a deviation from the vertical of not more than two percent. If any pile is damaged or driven out of the specified tolerance, the Contractor shall immediately submit proposals for remedial measures to the Engineer for his written approval. Notwithstanding the Engineer's approval, the Contractor shall be solely responsible for the design and cost of the remedial measures.

The Contractor shall keep a pile driving register in a format approved by the Engineer, where he shall record all data covering dimensions, elevation of point, top elevation after cut off, type, make and weight of hammer, height of fall of hammer, average penetration per blow under the last 20 blows and blow count per 0.3m throughout the full length of that pile. Five copies of the report shall be submitted to the Engineer before any payment will be made for this work.

Driving equipment

Before any driving takes place, the Contractor shall submit to the Engineer, for his approval, full details of all pile driving equipment, including the driving hammer, hammer cushion, drive head, pile cushion and other appurtenances and the proposed methods to be followed. The Contractor's proposal shall not be on using water-jetting method.

Piles shall be driven by continuous vibratory percussion using steam, air, diesel or gravity hammers. The equipment shall have sufficient capacity to drive the pile to the design depth and set without damaging the pile.

Pile driving hammers, other than gravity hammers, shall be of the size needed to develop the energy required to drive piles at a penetration rate of not less than 2.5mm per blow at the required bearing value.

Gravity hammers shall not be used for concrete piles or for piles where design load capacity exceeds 30 Metric Tons. When gravity hammers are permitted, the ram shall weigh not less than 900 kg and the height of drop shall not exceed 4.5m. In no case the ram weight of a gravity hammer shall be less than the combined weight of the drive cap and pile. All gravity hammers shall be equipped with hammer guides to insure concentric impact on the drive head or pile cushion.

Open-end (single acting) diesel hammers shall be equipped with a device to permit the Engineer to determine hammer stroke at all times during pile driving operations. Closed-end (double acting) diesel hammers shall be equipped with a bounce chamber pressure gauge, in good working order and mounted near the ground level, to facilitate easy reading by the Engineer. The Contractor shall provide a correlation chart on bounce chamber pressure and delivered hammer energy.

Vibratory or other pile driving methods may be used only when specifically allowed by the special provisions or in writing by the Engineer. Except when pile lengths have been determined from load test piles, the bearing capacity of piles driven with vibratory hammers shall be verified. Such verification shall be carried out by re-driving the first pile driven in each group of 10 piles with an impact hammer of suitable energy to measure the pile capacity before driving the remaining piles in the group.

In case the required penetration is not obtained by the use of a hammer complying with the above minimum requirements, the Contractor shall be required to provide a hammer of greater energy or, when permitted, resort to supplemental methods such as jetting or pre-boring.

Driving appurtenances

Hammer cushion

All impact pile driving equipment, except gravity hammer, shall be equipped with a suitable thickness of hammer cushion material to prevent any damages to the hammer or pile and to insure uniform driving behaviour. Hammer cushions shall be made of durable manufactured materials, which will retain uniform properties during driving. Wood, wire rope, and asbestos hammer cushions shall not be used. The Contractor shall replace the hammer cushion before driving is permitted to continue whenever there is a reduction of hammer cushion thickness exceeding twenty-five percent of the original thickness.

Pile drive head

Pile, driven with impact hammer, shall be fitted with an adequate drive head to distribute the hammer blow to the pile head. The drive head shall be axially aligned with the hammer and the pile. The drive head shall be guided by the leads and not be free-swinging. The drive head shall fit around the pile head in such a manner as to prevent transfer of torsion forces during driving while maintaining proper alignment of hammer and pile. The pile head shall be plain and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts from the drive head.

Pile cushion

When the nature of the driving of a concrete pile is such as to unduly injure it, shall be protected by a pile cushion. When plywood is used, the minimum thickness placed on the pile head, prior to driving, shall not be less than 100mm. A new pile cushion shall be provided, if the cushion is either compressed more than one-half the original thickness or begins to burn during driving. The pile cushion dimensions shall be such, as to distribute the blow of the hammer throughout the cross-section of the pile.

Leads

Pile driving leads, which support the pile and the hammer in proper positions throughout the driving operation, shall be used. Leads shall be constructed in a manner that allows movement of the hammer while maintaining alignment of the hammer and the pile to insure concentric impact for each blow. The leads shall be of sufficient length to make the use of a follower redundant and shall be so designed as to permit proper alignment of battered piles.

Followers

Followers shall only be used when approved in writing by the Engineer, or when specifically allowed as special provision. The follower and pile shall be held and maintained in equal and proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the length determined necessary from the driving of the full-length piles.

Driving procedures

Pile heads shall be squared up prior to driving. In addition, pile shoes may be used to protect the piles when hard driving is anticipated. The pile shoes shall be of the types and quality as shown on the Drawings and as specified in this Specification and/or as directed by the Engineer. They shall be used at the locations specified or ordered by the Engineer either.

Each pile shall be driven continuously until the specified set or depth has been reached, except that the Engineer may permit the suspension of driving, if he is satisfied that the rate of penetration prior to the cessation will be substantially re-established on resumption or if he is satisfied that the suspension of driving is beyond the control of the Contractor.

Pile shall be driven to the minimum tip elevations and bearing capacity shown on the plans, specified in the special provisions or approved by the Engineer. Piles that heave more than 6mm upward during the driving of adjacent piles shall be re-driven.

Piles shall be driven with a variation of not more than 6mm per 0.3m from the vertical or from the batter shown on the Drawings, except that piles for trestle bents shall be so driven that the cap may be placed in its proper location without inducing excessive stresses in the piles. Foundation piles shall not be out of the position as shown on the Drawings by more than one-fourth of their diameter or 150mm, whichever is greater after driving. Any increase in footing dimensions or reinforcing due to out-of-position piles shall be at the Contractor's own expenses.

At the start of work and in new sections, sets shall be taken at intervals during the last 3m of the driving to establish the behavior of the piles.

The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check the driving resistance. A set shall be taken only in the presence of the Engineer unless otherwise approved.

The final set of each pile shall be recorded either as the penetration in millimeter per 10 blows or as the number of blows required to produce a penetration of 250mm. The exposed part of the pile and the driving equipment shall be in good condition when the final set is measured.

The Contractor shall inform the Engineer immediately in the event of an unexpected change in driving characteristics is noted.

When required, levels and measurements shall be taken to determine the movement of the ground or any pile resulting from the driving process.

When problems are encountered in the resistance to the pile being driven or with a pile rising as a result of driving of an adjacent pile, the Contractor shall seek and comply with the instructions of the Engineer on methods and procedures to overcome the problem. One of the methods may be that the Contractor shall provide a heavier hammer as decided by the Engineer or resort to jetting at his own expenses. The drop hammers shall be equipped with proper leads and hoisting equipment to handle the work efficiently. The fall of hammer shall not be more than 2.43m.

Jets

Jetting shall only be carried on, if the Engineer approves it in writing or when specifically allowed under the special provisions. The Contractor shall be responsible for all damages caused to the Site by the jetting operations.

When water jetting is followed, the number of jets along with the volume and pressure of water at the jet nozzles shall be adequate to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times a minimum pressure of 293 kg/cm² at two number 20mm jet nozzles. In either case, unless otherwise indicated by the Engineer, jet pipes shall be removed when the pile tip remains at a minimum of 1.52m above the prescribed tip elevation and the pile shall be driven to the required bearing capacity with an impact hammer to secure the final penetration.

All jet water shall be controlled, treated if necessary and disposed of by the Contractor in a manner satisfactory to the Engineer.

Driving records

The Contractor shall keep a record of the installation of each pile and shall submit two signed copies to the Engineer, not later than noon of the next working day after the pile is installed. The record shall include the following data:

- (a) Pile location
- (b) Pile reference number
- (c) Pile type
- (d) Nominal cross-sectional dimensions

- (e) Length of preformed pile
- (f) Date and time of driving or re-driving
- (g) Ground level at the commencement of installation of pile
- (h) Working level
- (i) Pile toe level
- (j) Type, weight, drop and mechanical condition of hammer and similar information for other equipment
- (k) Numbers and type of packing and type and condition of dolly used.
- (l) Final set of pile
- (m) If required, the sets taken at interval during the last 3m of driving
- (n) If required, temporary compression of ground and pile from the time of a marked increase in driving resistance until the pile reaches its final level
- (o) All information regarding obstructions, delays and interruptions to the sequence of work.

2.8.2.10 Repair of pile heads

When repairing the head of a pile, the head shall be cut off square at sound concrete and all loose particles shall be removed by wire brushing followed by washing with water.

If the pile is to be subjected to further driving, the head shall be replaced with concrete of an approved grade. Repaired piles shall not be driven until the added concrete has reached the specified strength of the concrete of the pile.

If the driving of a pile has been accepted but the sound concrete remained below the cut-off level, the pile shall be made good up to the cut-off level with concrete of a grade not inferior to that of the pile.

2.8.2.11 Extension of piles

Where it becomes necessary to extend a pile, the concrete at the end of the pile shall have to be broken in order to expose the reinforcing bars for a length of 40 bar diameters. Additional reinforcement shall be used in line with the pile axis as per the relevant Section/Sub-section of this Specification and/or in the way the Engineer directs. The additional concrete shall be of the same quality as that used in the pile. Prior to placing concrete, a construction joint shall be made in accordance with the specifications of the relevant Section/Sub-section of this Specification. Forms shall remain in place for a minimum of seven days.

2.8.2.12 Defective piles

The driving procedures shall not subject the piles to excessive abuse producing crushing and spalling of the concrete or deformation of the steel. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, shall not be permitted. Any piles, being damaged from internal defects or improper driving or driven out of its proper location or below the specified elevation, shall be corrected at the Contractor's own expenses by one of the following methods approved by the Engineer.

- (1) The pile shall be withdrawn and replaced by a new and if necessary, a longer pile.
- (2) A second pile shall be driven adjacent to the defective or low pile.
- (3) The pile shall be spliced or built up or a sufficient portion of the footing shall be extended to properly embed the pile.
- (4) All piles, pushed up by the driving of adjacent piles or by any other causes, shall be driven down again.

2.8.2.13 Cutting off pile heads and bonding

On completion of installation of piles, they shall be cut off to the required level as shown on the Drawings and to a tolerance of + 20mm or otherwise instructed by the Engineer. For pre-cast reinforced concrete piles, the main reinforcement shall be exposed and left reasonably straight for bonding into the pile cap. The minimum bond length of main reinforcement to be exposed shall be as given in the following table.

Grade of Pile Cap Concrete	30	40 or more
High Tensile Steel ($f_y = 460 \text{ N/mm}^2$)	37D	32D
Mild Steel ($f_y = 250 \text{ N/mm}^2$)	30D	25D

D = nominal diameter of bar.

In the stripping of pile heads, the concrete shall be stripped upto such a level that the remaining concrete will project 75mm into the pile cap.

Where a pile has been formed below the required cut-off level, it shall be built-up and the reinforcement shall project for such length as given above.

The method of cutting the pile heads shall have to be accepted by the Engineer.

2.8.2.14 Measurement

This work shall be measured separately for production of piles, pile driving and providing pile shoe.

Measurements of production of piles for concrete shall be taken for payment in cubic meters of pre-cast reinforced concrete produced in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer on the basis of specified pile length. Only the completed works as accepted by the Engineer will be eligible for payment.

Driving of pile shall be measured in linear meters of the length of pile driven complete and accepted. Cut off length shall not be measured for payment. The length of pile driven shall be measured from the pile toe to the cut-off level.

Pile shoe shall be measured by number that has been produced in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

2.8.2.15 Payment

The amount of completed and accepted concrete work measured as provided above shall be paid for at the Contract unit prices per cubic meter of pile produced and linear meter of pile driven, as shown in the Bill of Quantities. The payment shall constitute the full compensation for the production of concrete, transportation of piles, all materials used, arranging all equipment, machinery and all labour, tools and incidentals necessary to complete the work satisfactorily true to the Specifications but excluding the cost of reinforcement with its fabrication and pile shoe. Reinforcement and pile shoe shall be paid separately as shown in the Bill of Quantities. No payment shall be made for pre-cast pile concrete until concrete test results demonstrate that the piles have achieved the specified strength.

The amount of completed and accepted pile driving work measured as provided above shall be paid for at the Contract unit prices per linear meter of pile driven. The payment shall be the full compensation for the driving of the piles including, pile head breaking and repair, squaring up pile heads, construction and removal of any cofferdam, arranging rigs, cranes, hammers, leaders and all other necessary driving equipment, driving and all labour, tools and incidentals necessary to complete the work satisfactorily true to the Specifications but excluding the cost of reinforcement with its fabrication and pile shoe. No payment shall be made for driving piles until and unless the piles have been driven to the specified depth.

The pile shoe as accepted and measured as provided above shall be paid for at the Contract unit price per number, as contained in the Bill of Quantities and the payment shall constitute fabrication, furnishing and filling of the pile shoes according to prescribed Specification.

When pilot piles are incorporated in the foundation as working piles, no additional payment shall be made for the piles so utilized other than as for a pilot pile.

No payment shall be made for unauthorized, defective, unsound or unsatisfactory driven piles for any costs incurred by the Contractor for such piles.

Pay Items shall be:

Clause	Description	Unit of measurement
2.8.2	Supply of pre-cast reinforced concrete piles(excluding cost of reinforcement and pile shoe)	Cubic meter
2.8.2	Driving of pre-cast reinforced concrete piles including pile head breaking and repair	Linear meter
2.8.2	Supply and fitting of pile shoe for pre-cast piles	Each

2.8.3 Sand compaction piles

2.8.3.1 General

Sand compaction pile shall generally be used for improvement of sandy as well as clayey soil in alluvial plain, mostly plains, reclaimed land and marshy land.

The equipment used for sand compaction piles are:

- ☐ Derrick/winch
- ☐ Casing pipe
- ☐ Drop hammer

Drop hammer weighing 1 ton and above shall be of solid cylinder and sectional area shall be such that it can play within the casing pipe. Diameter of hammer section shall be about 6mm to 8mm lower than the opening of the casing pipe. The casing pipe shall be of Mild Steel.

2.8.3.2 Construction process

A small hole of about 50mm depth shall be made on the ground with the hammer. Casing pipe shall be installed at that point and kept vertical. The casing pipe shall be held in position with the wire rope connected to the winch i.e. downward movement of the casing pipe shall be restrained.

Coarse sand of F.M. between 1.5 and 2.5 or sand gravel mix as provided in the design shall be placed within the casing pipe (250mm to 300mm dia) upto a depth of about 1.0 to 1.5m.

The coarse sand or sand gravel mix placed at the tip of casing pipe shall then be compacted to form a solid mass by the hammer holding the casing pipe in position.

Casing pipe shall then be allowed to go downward with application of hammer blows on the shoe formed at the tip and shall be penetrated to the desired depth.

As the casing pipe reaches the desired depth, the pipe shall be pulled back by about 30cm from the lowest position and then held firmly from the winch. Artificial shoe shall then be detached from the casing pipe with the hammer blows.

The casing shall be drawn to a desired height and sand be discharged into the casing pipe upto a depth of about 1.5 to 2 times the drawn up height of the casing pipe.

The discharged sand shall be compacted by the hammer and the process of compaction shall continue until the casing pipe reaches the ground surface.

The removed volume of sand or sand gravel mix, measured on the ground, shall be between 120% and 130% of the designed volume.

Effect of improvement of the foundation soil shall be confirmed by SPT, CPT or any other method as approved by the Engineer between and at the centre of piles so as to satisfy the desired bearing capacity.

2.8.3.4 Measurement

Measurement shall be taken for payment in linear meter of pile constructed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

2.8.3.4 Payment

Sand compaction pile as measured above shall be paid at the Contract unit price per linear meter. The rate shall constitute the full compensation of furnishing all materials like sand, gravel and other materials, driving pile holes, lowering casing pipe, placing of materials and their compaction, SPT/CPT or any other method and tests for determining the improvement in the bearing capacity, arranging all equipment and machinery, labour, tools and incidentals necessary to complete the Work as per requirements described under this item of work, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

No payment shall be made for unauthorized, defective, unsound or unsatisfactorily piles or for any costs incurred by the Contractor for such piles.

Pay Items shall be:

Clause	Description	Unit of measurement
2.8.3	Driving and production of sand compaction pile	Linear meter

2.8.4 Timber piles

2.8.4.1 Description

This work shall consist of supplying and driving foundation piles made of timber of the type and dimension in accordance with these Specifications and as shown on the Drawings and/or as directed by the Engineer.

2.8.4.2 Materials

Timber piles shall adhere to the requirements of the Specifications for Wood Products, AASHTO M 168. The grades of timber to be used shall be as shown in the Plans or in the BOQ or in the special provisions. They should be matured, sound and free from large or loose knots, cracks sharp crooks and bends or decay or other defects and sufficiently straight so that a line drawn from the centre of the butt to the centre of the tip shall be contained entirely within the pile.

2.8.4.3 Preservatives and treatments

Timber piles shall be treated or untreated. When Specifications demand treatment of timber piles it should follow strictly the requirements and methods conforming AASHTO M 133 or BDS 819 : 1975. Unless and otherwise specially required on the design Drawings, timber piles those are required to be treated should be impregnated with solignum, creosote or treated with some such anti-rot compounds. Timber piles those are required to be painted may be treated with pentachlorophenol with a Type C solvent or with a water-borne preservative. Preservative treatment may not be necessary for piles, which will be completely and permanently submerged in waterlogged ground. In this case seasoning is not necessary and piles may be stored in water prior to use.

2.8.4.4 Handling and storage of piles

Timber piles shall be lifted, handled, transported and stacked in a way, which will keep the damages to the piles at minimum.

Untreated material shall be open-stacked on supports at least 300mm above the ground surface to avoid absorption of ground moisture and allow free circulation of air. When necessary, the Contractor shall provide shade or appropriate protection from weather by a suitable covering. The storage area shall be such that no water shall collect under or near the stored timber piles.

2.8.4.5 Pile driving

Pile driving equipment shall secure that it will not damage the pile during driving. List of all driving equipment and appurtenances shall be furnished by the Contractor, which shall be approved by the Engineer in advance of any driving taking place. However, approval of pile driving equipment shall not relieve the Contractor of his responsibilities of driving piles without damage.

Collars, bands or other devices shall be provided to protect piles against splitting and brooming as and when it would be necessary under the driving conditions.

The Contractor shall establish all lines, levels and be responsible for the correct positioning of all piles. Setting out shall be carried out from the main grid lines of the proposed structure. Immediately before installation of the pile, the pile position shall be marked with suitable identifiable pins or markers.

The positions of the piles shall be set out in accordance with the Drawings from the established Bench Mark.

The bark of the piles shall be removed before driving. The bottom is shaped conically for a length of 1½ to 2 times the diameter or about 0.3m and where the ground is hard it is protected with an iron shoe of 'V' shape or it should be of a design as specified on the Drawings and/or approved by the Engineer. Piles protected by shoes should have a blunt end 100mm to 200mm in diameters. The points of the piles shall be carefully shaped to secure an even and uniform bearing of the shoes.

The piles shall be driven to a pre-planned sequence approved by the Engineer and in presence of the Engineer's authorized representative in order to minimize the detrimental effects of heave and lateral displacement of the ground. No pile driving shall be allowed at night without prior permission from the Engineer.

Piles shall be rigidly secured by leads or temporary guide structure against lateral movement during driving and shall be driven without interruption right from the first blow of the hammer until the required penetration has been attained.

Each pile shall be driven continuously until the specified set or depth has been reached except that the Engineer may permit the suspension of driving, if he is satisfied that the rate of penetration prior to the cessation will be substantially re-established on resumption or if he is satisfied that the suspension of driving is beyond the control of the Contractor.

Piles shall be driven to the positions, lines and elevations shown on the Drawings and/or as per the direction of the Engineer so that the pile centre remains within 75mm of the specified location point and with a deviation from the vertical of not more than 2%. If any pile is damaged or driven out of the specified tolerance, the Contractor shall submit his proposed remedial measures to the Engineer for his written approval. Notwithstanding the Engineer's approval, the Contractor shall be solely responsible for the design and all costs of the remedial works.

At the start of work and in new sections, sets shall be taken at intervals during the last 3m of the driving to establish the behavior of the piles.

The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check the driving resistance. A set shall be taken only in the presence of the Engineer, unless otherwise approved.

The final set of each pile shall be recorded either as the penetration in millimeter per 10 blows or as the number of blows required to produce a penetration of 250mm. The exposed part of the pile and the driving equipment shall be in good condition when the final set is measured.

Piles should never be driven to "refusal". Piles shall be considered sufficiently driven, when five blows fail to drive more than 12mm or when the last blow does not sink the head more than 7mm.

The Contractor shall inform the Engineer immediately in the event of an unexpected change in driving characteristics is noted.

When required, levels and measurements shall be taken in order to determine the movement of the ground or any piles resulting from the driving process.

When problems are encountered in the resistance to the pile being driven or with a pile rising as a result of driving of an adjacent pile, the Contractor shall seek and comply with the instructions of the Engineer on methods and procedures to overcome the problem.

The Contractor shall keep a pile driving register in a format approved by the Engineer recording all data covering dimensions, elevation of point, top elevation after cut off, type, make and weight of hammer, height of fall of hammer, average penetration per blow under the last 5 blows. Five copies of the report shall be submitted to the Engineer before any payment will be made for this work.

2.8.4.6 Pile cut-off

Timber piles shall be cut-off to a true plane at the elevations required and anchored to the structure, as shown on the Drawings. All cut-off lengths of piling shall remain the property of the Contractor and shall be properly disposed of.

Timber piles, which support timber caps or grillage, shall be sawed to conform to the plane of the bottom of the superimposed structure. In general, the length of piles above the elevation of cut-off shall be sufficient to permit the complete removal of all materials injured by driving, but piles driven to very nearly the cut-off elevation shall be carefully adzed or otherwise freed from all broomed, splintered, or otherwise injured materials.

Immediately after making final cut-off on treated timber foundation piles, the cut area shall be given two liberal applications of preservative followed by a heavy application of approved sealer. Treated timber piles which will have the cut-off exposed in the structure shall have the cut area treated with three coats of a compatible preservative material meeting the requirements of AWWA Standard M4-A minimum time period of 2 hours shall elapse between each application.

If concrete cap is provided, the piles should be embedded for a depth sufficient to ensure transmission of load. The concrete should be at least 150mm outside the piles and be suitably reinforced to prevent splitting.

2.8.4.7 Measurement

This work shall be measured separately as the length in linear meters of timber pile supplied and accepted and the length in linear meters of pile driven complete upto the required depth in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment. The length of pile furnished shall be measured in accordance with the specified length. The length of piles driven shall be measured from the pile toe to the cut-off level.

2.8.4.8 Payment

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit prices per linear meter of pile furnished and linear meter of pile driven, as shown in the Bill of Quantities. The payment shall constitute the full compensation for the supply, treatment, handling and driving of piles including all driving, arranging all required equipment and machinery and all incidentals to complete the Work as per requirements described under this item of work, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer. Pile shoe shall be paid separately as shown in the Bill of Quantities.

No payment shall be made for unauthorized, defective, unsound or unsatisfactorily piles or for any costs incurred by the Contractor for such piles.

Pay Items shall be:

Clause	Description	Unit of measurement
2.8.4	Supply of timber piles	Linear meter
2.8.4	Driving of timber pile	Linear meter
2.8.4	Supply and fitting of pile shoe	Each

2.9 PILE LOAD TESTING

2.9.1 Description

In carrying out the Initial Test, the works shall consist of the application of compression load tests to pre-cast and driven or cast in-situ piles selected by the Engineer to determine the potential bearing capacity and adequacy of the piles by measurement of their settlement behavior under the test loads.

2.9.2 General

This Section deals with the testing of a pile by the application of an axial load or force. It covers vertical piles tested in compression.

2.9.3 Definitions

Allowable load

The load which may be safely applied to a pile after taking into account its ultimate bearing capacity, negative friction, pile spacing, overall bearing capacity of the ground below and allowable settlement.

Compression pile

It is a pile, which is designed to resist an axial force that would cause it to penetrate further into the ground.

Kentledge

The dead weight used in a load test.

Maintained load test

A loading test in which each increment of load is held constant either for a defined period of time or until the rate of movement (settlement or uplift) falls to a specified value.

Pilot pile

A pile installed before the commencement of the main piling works or a specific part of the works for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimensions and bearing capacity. Pilot piles may be utilized as working piles, subject to the Engineer's approval.

Proof load

A load applied to a selected pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed 200% of the working load on a pile except under the

circumstances where special provisions are provided for the testing of pre-cast piles driven to a set. In these circumstances 300% is specified.

Reaction system

The arrangement of kentledge, piles, anchors or rafts that provides a resistance against which the pile is tested.

Tension pile

It is a pile, which is designed to resist an axial force that would cause it to be extracted from the ground.

Test pile

Any pile to which a test loading is or is to be applied.

Ultimate bearing capacity

It is the load at which the resistance of the soil becomes fully mobilized.

Working load

It is the load, which the pile is designed to carry.

Working pile

It is one of the piles forming the foundation of a structure.

2.9.4 Supervision

All tests shall be carried out under the direction of an experienced and competent supervisor conversant with the test equipment and test procedures. All personnel, operating the test equipment, shall have been trained in the use.

2.9.5 Safety precautions

General

When preparing for conducting and dismantling a pile test, the Contractor shall carry out the requirements of the various regulations and other statutory requirements those are applicable to the work for the provision and maintenance of safe working conditions. In addition, it shall make such other provisions as may be necessary to safeguard against any hazard that is involved in the testing or preparations for testing.

Kentledge

Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any crib work, beams or other supporting structure in such a manner that there will be no differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it falling apart or becoming unstable because of deflection of the supports.

The weight of kentledge shall be greater than the maximum test load. If the weight is estimated from the density and volume of the constituent materials, an adequate factor of safety against error shall be allowed.

Tension piles and ground anchors

Where tension piles or ground anchors are used, the Contractor shall ensure that the load is correctly transmitted to all the rods or bolts. The extension of rods shall not be permitted by welding, unless it is known that the steel will not be reduced in strength by welding. The bond stresses of the rods in tension shall not exceed normal permissible bond stresses for the type of steel and grade of concrete used.

Testing equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring devices are mounted on the pile head, the whole system shall be stable upto the maximum load to be applied. Means shall be provided to enable dial gauges to be read from a position clear from the kentledge stack or test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure and so on might constitute a hazard to personnel.

The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum working pressure without leaking.

The maximum test load or test pressure, expressed as a reading on the gauge in use, shall be displayed and all operators shall be aware of this limit.

2.9.6 Construction of a pilot pile to be test loaded

Notice of construction

The Contractor shall give the Engineer at least 48 hours notice of the commencement of construction of any pilot pile, which is to be test loaded.

Method of construction

Each pilot test pile shall be constructed in a manner similar to that to be used for the construction of the working piles and by the use of similar equipment and materials. Any variation shall only be permitted with prior approval of the Engineer.

Extra reinforcement and concrete of increased strength shall be permitted in the shafts of pilot pile at the discretion of the Engineer.

Boring or driving record

For each pilot pile that is to be tested, a detailed record of the soils encountered during boring or of the progress during driving shall be made and submitted to the Engineer daily not later than noon on the next working day.

Cut-off level

The pile shaft shall terminate at the normal cut off level or at a level required by the Engineer.

The pile shaft shall be extended where necessary above the cut-off level of working piles so that gauges and other apparatus to be used in the testing process are not damaged by water or falling debris.

Pile for compression tests

A pile shall not be tested until the curing period is over. In the case of a driven pile, the period shall not be earlier than 72 hours after the driving of the pile is complete.

For a pile that is tested in compression, the head of the test pile shall be cut off, leveled and capped with a steel plate to produce a level bearing surface square to the axis of the pile and sufficiently large to accommodate the loading and settlement measuring equipment. It shall also be adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment.

2.9.7 Preparation of a working pile to be tested

If a test is required on a working pile, the Contractor shall cut down or otherwise prepare the pile for testing as required by the Engineer in accordance with the provisions of the relevant Sub-sections of this Specification.

2.9.8 Reaction system

Compression tests

Compression tests shall be carried out using kentledge, tension piles or specially constructed anchorage.

Where kentledge is to be used, it shall be supported on crib work disposed around the pile head so that its centre of gravity is on the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack. Kentledge shall not be carried directly on the pile head, except when directed by the Engineer.

Working piles

Where working piles are used as reaction piles, their movement shall be measured to within an accuracy of 0.5mm.

Spacing

Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall be not less than 1.3m.

The center to center spacing of vertical reaction piles including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2m, whichever is the highest.

Adequate reaction

The size, length and number of the piles or anchors, or the area of rafts shall be adequate to transmit the maximum test load to the ground in a safe manner without excessive movement or influence on the test pile.

Care of piles

The method employed in the installation of any reaction pile, anchor or raft shall be such as to prevent damage to any test pile or working pile.

Loading arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out at the Site.

2.9.9 Equipment for applying load

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The total capacity of the jacks shall be at least equal to the required maximum load. The jack or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test load required for the test.

2.9.10 Measurement of load

The Contractor shall supply measuring devices to determine the load on the pile, which shall require the Engineer's approval. Certificates of calibration shall be supplied to the Engineer.

In addition, large diameter (exceeding 1.2m) test piles shall be instrumented at 5 (five) different depths to measure the load distribution along the piles. The instrumentation shall consist of both a mechanical system and strain gauges for measuring the pile deformation. The mechanical system shall consist of 6mm steel rods or high tensile steel wires (Gauge No. 23) placed in steel tubes down to the various depths and connected to dial gauges at the top. The strain gauges shall be of a stable type, wholly protected by a steel capsule. They shall be welded to the steel reinforcement, 2 (two) gauges at each depth.

The approval of the Engineer shall be obtained on the type of gauges to be used and other details on the instrumentation.

2.9.11 Adjustment of loading equipment

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of a maintained loading test.

2.9.12 Measuring of pile head movement

General

In a maintained load test, movement of the pile head shall be measured by two of the methods as described below. One method for settlement measurements and the other for control.

Leveling method

An optical or any other leveling method by reference to an external datum may be used.

Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made within an accuracy of 0.5mm. A scale attached to the pile or pile cap may be used instead of a leveling staff. At least two datum points shall be established on permanent objects or other well-founded structures, or deep datum points shall be installed. Each datum point shall be situated so that only one setting up of the level is needed.

No datum point shall be affected by the test loading or other operations at the Site.

The written approval of the Engineer shall be required in the case any other method of leveling is proposed.

Independent reference frame

An independent reference frame may be set up to permit measurement of the movement of the pile. The supports for the frame shall be founded in such a manner and at such a distance from the test pile, kentledge support cribs, reaction piles, anchorage and rafts so that movements of the ground in the vicinity of the equipment do not cause movement of the reference frame during the testing. Observations of any movement of the reference frame shall be made and a check shall be made on the movement of the pile head in relation to an external datum during the progress of the test. In no case shall the supports be less than 3 (three) test pile diameters or 2m, whichever is greater, from the center of the test pile.

The measurement of pile movement shall be made by two dial gauges rigidly mounted on the reference frame that bear on surfaces normal to the pile axis fixed to the pile cap or head. Alternatively, the gauges may be fixed to the pile and bear on the surfaces on the reference frame. The dial gauges shall be placed in diametrically opposite positions and be equidistant from the pile axis. The dial gauges shall enable the readings to be made within an accuracy of 0.1mm.

The reference frames shall be protected from sun and wind.

Other methods

The Contractor may submit for approval of the Engineer any other method for measuring the movement of pile heads.

2.9.13 Protection of testing equipment

Protection from weather

Throughout the test period, all equipment for measuring load and movement shall be protected from weather.

Prevention of disturbance

Construction equipment and persons who are not involved in the testing process shall be kept away at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

2.9.14 Supervision

Notice of test

The Contractor shall give the Engineer at least 24 (twenty-four) hours notice of the commencement of the test.

Records

During the progress of a test, the testing equipment and all records of the test, required under this Specification, shall be made available for inspection by the Engineer.

2.9.15 Test procedures

Loading procedures

The test load shall be concentrically applied to the pile by such a method that the load acting on the pile at any time may be determined, adjusted and controlled. The load shall be applied to the pile as near to the ground surface as possible.

The load shall be applied and removed in increments based on the anticipated working load of the pile with the following schedule.

Load as percentage of working load		Minimum time of holding load
Board piles	Driven piles	
25	50	1 hour
50	100	1 hour
75	125	1 hour
100	150	1 hour
75	125	10 minutes
50	100	10 minutes
25	50	10 minutes
0	0	1 hour
100	150	6 hours
125	200	1 hour
150	250	6 hours
175	275	1 hour
200	300	24 hours - Proof load
175	275	10 minutes
150	250	10 minutes
125	225	10 minutes
100	200	10 minutes
75	150	10 minutes
50	100	10 minutes
25	50	10 minutes
0	0	1 hour

Following application of each increment of load, the load shall be held for not less than the period shown in the Table and until the rate of settlement is less than 0.25mm per hour and is slowing. Readings of settlement and of the time at which they are made, shall be taken immediately before and after the application of each load increment and at intermediate intervals 20 (twenty) minutes apart for the first four hours and 60 (sixty) minutes apart thereafter.

Each stage of unloading shall proceed to the schedule shown in the Table. During unloading, readings of rebound and of the time at which they are made, shall be taken immediately after each increment of load is removed and at intermediate intervals of 20 (twenty) minutes. A final rebound reading shall be taken 24 (twenty-four) hours after the entire test loads have been removed.

A check for the accuracy of the measurement of settlement shall be made from a fixed reference point on a permanent object or well founded structure. This reference point shall be at least 3m off from the nearest point of the test pile.

During the progress of the test, all readings taken shall be available for inspection by the Engineer.

Safe load through initial test (Single pile)

The safe load on single pile shall be the smallest of the following:

Part-6: Buildings (Specification for Structure of Building)

- (a) Two-thirds of the final load at which the total settlement attains a value of 12mm, unless it is established that a total settlement different from 12mm is permissible in a given case on the basis of nature and type of structure. In the later case, the actual total settlement permissible shall be used for assessing the safe load instead of 12mm.
- (b) Two-thirds of the final load at which the net settlement attains a value of 6mm.
- (c) 50 percent of the final load at which the total settlement equals one-tenth of pile diameter.

Pile foundation design and construction

The safe load on groups shall be the smallest of the following:

- (a) The final load at which the total settlement attains a value of 25mm, unless a total settlement different from 25mm is specified in a given case on the nature and type of structure.
- (b) Two-thirds of the final load at which the total settlement attains a value of 40mm.

Presentation of results

Within 24 hours of completion of the test, the Contractor shall submit a summary of results to the Engineer stating, for each stage of loading and unloading, the period for which the load was held and the maximum settlement or rebound.

Within seven days of completion of the test, the Contractor shall submit a full schedule of test data to the Engineer, which shall include the following:

- a) General
 - ☐ Project.
 - ☐ Contract identification.
 - ☐ Proposed structure.
 - ☐ Date of test.
- b) Pile details
 - ☐ Date of casting.
 - ☐ Pile reference number and location.
 - ☐ Type of pile.
 - ☐ Length on ground.
 - ☐ Level of toe.
 - ☐ Ground level at pile position.
 - ☐ Head level at which test load applied.
 - ☐ Condition of pile head.
 - ☐ Details of permanent casing.
- c) Installation details
 - ☐ Dates and times of boring, driving and pouring concrete of test pile and adjacent piles.
 - ☐ Date and time of casting concrete.
 - ☐ Driven length of pile or temporary casing at final set.
 - ☐ Hammer type, size or weight.
 - ☐ Dolly and packing, type and condition before and after driving.
 - ☐ Driving length (depth, blows per 250mm, interruptions or breaks in driving).

- ☐ At final set and at re-drive set, for drop of single action hammer the length of the drop or stroke, for diesel hammer the length of the stroke and the blows per minutes, for double-acting hammers the number of blows per minute.
 - ☐ Condition of pile head or temporary casing after driving.
- d) Test procedure
- ☐ Weight of kentledge
 - ☐ Tension pile, ground anchor or compression pile details
 - ☐ Plan of test arrangements showing position and distances of kentledge supports
 - ☐ Rafts, tension or compression piles and reference frame to test pile
 - ☐ Jack capacity
 - ☐ Method of Load measurement
 - ☐ Method of penetration measurement
 - ☐ Relevant dates and times
- e) Full test results
- ☐ In tabular and graphical form detailing loads, time and movement. The graphical presentation shall consist of:
 - ☐ Load verses Time
 - ☐ Load verses gross settlement and rebound for each cycle of loading
 - ☐ Load verses net settlement and rebound for each cycle of loading.

2.9.16 Completion of a test

Measuring equipment

On completion of a test, all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in further tests or removed from the Site.

Kentledge

Kentledge and its supporting structure shall be removed from the test pile and stored so that they are available for use in further tests or removed from the Site.

Temporary piles

On completion of a preliminary test, temporary tension piles shall be cut off below ground level, removed from the Site and the ground made good with approved materials as specified.

2.9.17 Measurement

Measurement shall be taken for payment as the number of pile compression load tests satisfactorily conducted and completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

2.9.18 Payment

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit prices per load test as shown in the BOQ. The payment shall constitute the full compensation for conducting the test including staging, all test equipment, provision for kentledge, carrying out tests, dismantling of equipment and removal from Site, cleaning of Site, preparation of all reports, materials, personnel, tools and all incidentals necessary to complete the entire tests.

Pay Items shall be:

Clause	Description	Unit of measurement

2.9	Load test on piles	Each

3.0 SPECIFICATIONS FOR MISCELLANEOUS ITEMS OF BUILDINGS

3.1 FLOOR

3.1.1 Patent stone floor

3.1.1.1 Description

Works covered under this item shall consist of constructing steel-trowelled concrete topping of specified thickness, prepared with stone/picked jhama brick chips, sand and cement in specified proportion in panels not exceeding 900mm on floor slabs and elsewhere including finishing the top with neat cement in accordance with these specifications or as contained in the BOQ or as shown on the Drawings and/or as directed by the Engineer.

3.1.1.2 Materials

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C150 Type 1 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Coarse aggregate

Coarse aggregate shall conform to the requirements of ASTM C 330 or BDS 243 and to the requirements specified in the relevant Section titled 'Construction Materials' of this Specification.

Coarse aggregate shall be hard, durable, clean, free from dust and other deleterious materials prepared from stone chips (or picked jhama bricks conforming BDS 208 when specifically allowed) and 10mm down graded.

Fine aggregate

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a Fineness Modulus obtained by mixing 50% sand of FM 1.2 and 50% of minimum FM 2.5. It shall conform to the requirements of ASTM C 33 or BDS 243 and those stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substances and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

3.1.1.3 Construction methods

Preparation of concrete mixture shall also be similar to what have been stated under the relevant Sub-sections of the Section on 'Concrete Work' of this Specification. The concrete mixture shall be prepared with one part cement, two parts sand and four parts stone chips/brick chips.

Before proceeding with the work, a sample panel of artificial Patent Stone Floor shall be prepared with specifications as required under the item of the work of the BOQ for approval of the Engineer.

The flooring shall be laid preferably no later than 24 hours after the floor slab is installed.

When the floor is to be laid on an old sub-floor, the base surface shall be thoroughly cleaned of laitance and all other loose foreign materials by stiff wire brush, roughened, if deemed necessary and washed and soaked with clean water. All excess water shall be removed ahead of the application of the bonding slurry so that the concrete surfaces become uniformly damp but not glisten-wet.

Creamy bonding slurry of neat cement shall be applied and well scrubbed on to the surface with stiff bristle brush. Bonding slurry shall be mixed and applied in a quantity as will be required to cover by

the succeeding coat before the slurry dries out. In general, slurry shall be made in a quantity sufficient for an area not over 10 square meter at one time in order to maintain a "Live Glue" for bonding. The slurry shall be applied by brush in small areas not exceeding 0.5 square meter. Excess or dead slurry shall be constantly removed from the base by broom.

The ingredients of the artificial Patent Stone Floor should be mixed in a similar way as have been described in the relevant Sub-sections of the Section on 'Concrete Work' of this Specification. The concrete mix of the specified proportion shall be applied promptly with the specified thickness after putting the cement slurry and before the slurry becomes hard and dry.

All constituents shall be thoroughly mixed. No re-tampered materials and no partially set materials shall be used in the work.

The floor shall be divided into panels of specified size by means of wooden battens. The top of the battens shall be at the level of the finished floor surface.

The mixture shall be laid evenly between the battens in alternate panels and shall be uniformly consolidated and leveled by a strike off. When the moisture has disappeared from the surface, the surface shall be steel-trowelled under firm pressure to produce a dense uniform smooth surface free from trowel marks.

The dividing battens shall be removed carefully after 16 hours and the remaining panels shall be completed in the aforesaid manner.

The neat cement application shall be minimum 2mm thick. A little extra thickness shall be allowed for polishing. The floor shall be polished on expiry of at least 7 days after it is laid and a perfectly smooth glazed surface is obtained. The work shall be cured and protected for 21 days on finishing.

3.1.1.4 Measurement

Artificial Patent Stone Floor including neat cement finishing in place completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.1.1.5 Payment

The amount of completed and accepted works measured as provided above shall be paid for at the Contract unit prices per square meter of Patent Stone Floor as shown in the BOQ. The payment shall be the full compensation for the cost of furnishing, transportation and storage of all materials and equipment, all labours for mixing and laying concrete in alternate panels, compacting, curing and all other works and incidentals necessary to complete the Work as per requirements described under this item of Work, the BOQ, as shown on the Drawings and as directed by the Engineer. The item shall also include all costs of materials, labours and equipment for neat cement finishing for which no separate claim from the Contractor will be entertained.

Pay Items shall be:

Clause	Description	Unit of measurement
3.1.1	Patent Stone Floor including neat cement finishing	Square meter

3.1.2 Mosaic floor

3.1.2.1 Description

Works covered under this item shall consist of providing in-situ terrazzo topping of required thickness in accordance with these specifications over an artificial patent stone floor constructed beforehand or on any locations as required in the Bill of Quantities or as shown on the Drawings and/or as directed by the Engineer.

3.1.2.2 Materials

Marble chips

Best quality machine crushed marble chips of Chinese, Pakistani or Indian origin as specified.

White cement

White cement shall be 'Onoda' brand or of an equivalent standard approved by the Engineer.

Grey cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C150 Type 1 or BDS 232 or of an equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substances and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

Glass strips

Glass dividers shall be of 5mm thickness and 20mm deep.

3.1.2.3 Construction methods

Terrazzo or mosaic floor shall be prepared with best quality Chinese/Pakistani/Indian origin marble chips of requisite grades and colour as required (generally 90% white and 10% coloured), gray cement and white cement. The cement and marble mixture shall be in the proportion of one part marble chips and one part cement or as specified in the Bill of Quantities or as directed by the Engineer. The cement mix shall consist of nine parts white cement and one part gray cement. The requisite quantity of aggregates shall be thoroughly mixed. However, the required proportions of the mixes shall be determined at Site by the Engineer.

White cement shall be 'Onoda' brand or an approved equal. Colouring materials shall be of best quality of mineral pigment of high purity and shall be finely grounded, sun-proof and with specific gravity not exceeding 5% by weight of cement used.

The Contractor shall submit three sets of samples of all type of marble chips to the Engineer for his approval before procuring the materials. One set will be kept at the office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

The terrazzo work shall be polished by machine and carborundum stone of 80 grit followed by 120 and 200 grits and polishing stone until the finished surface becomes acceptable to the Engineer.

The Contractor shall prepare sample terrazzo work, which must receive the approval of the Engineer. Before such approval is received, no full-scale work shall start. The floor layout shall fully conform to the design as shown on the Drawing or as instructed by the Engineer.

The thickness of terrazzo topping shall be as shown on the Drawing or as specified in the Bill of Quantities or as directed by the Engineer. The setting bed shall be 25mm thick artificial patent stone floor prepared with one part ordinary Portland cement, two parts coarse sand and four parts 12mm down graded coarse aggregate obtained from picked jhama chips/pea gravel/stone chips or in accordance with the specifications of the BOQ.

Terrazzo floors shall be laid over previously roughened and wetted patent stone. The panels for terrazzo floor shall be of the size as indicated in the relevant item of the BOQ, or as directed by the Engineer. Glass dividing strips shall be used, if required under the items of the BOQ.

The sub-floors, over which the terrazzo flooring will be laid, shall be prepared in the same way as have been stated under the Sub-section on 'Patent Stone Floor', but it will exclude the portion of the neat cement finishing.

Following the preparatory works, a creamy bonding cement paste, prepared with ordinary Portland cement, shall be applied and scrubbed with stiff bristle brushes on the surface, not exceeding an area

of about 0.4 square meter. In general, slurry shall be prepared in a quantity sufficient for an area not over 100 square meter at one time in order to maintain live-glue for bonding.

The terrazzo-topping layer shall then be well trowelled and compacted into the setting bed in the required thickness with desired camber and levels.

A layer of cement paste of same composition as used in topping shall be well trowelled next to leave a smooth surface.

The curing must be done after laying the mosaic work by wet sacking for 7 days.

After terrazzo topping has hardened enough to withstand any dislodgment, polishing works shall commence, which shall be started with first grinding the surface by an approved type of grinding machine with carborundum stone of 80 grits to expose the marble chips. The floors shall be kept wet during grinding. Sweeping and flushing with clean water shall be done to remove all grind-off materials.

Air holes, pits and other blemishes shall than be filled with a thin grout of cement paste of same composition as used in the topping.

On hardening of patch fillers, the floor shall receive successive grinding with carborundum stone upto 240 grit in a final finish. It shall then be cleaned and washed of all surplus materials.

The floor shall be kept undisturbed for a period of 2 weeks on even exposure of marble chips. On expiry of this period the floor shall be cleaned of dirt and dust by rubbing gently with pumic stone (No. 40, No. 80, No. 120) using sufficient water. Stains shall be removed by moistening with Oxalic Acid and rubbing with warm water, if required. No acid solutions shall be used.

The surface shall receive bee wax polishing on drying.

All materials shall be mixed in dry state and shall be protected from harmful effects of moisture. Water shall be added to only such amounts as may be consumed in quantities in less than 30 minutes as required to produce workability. Mixing shall be done on watertight platform.

3.1.2.4 Measurement

Measurement shall be taken for payment in square meter of finished visible floor surface in place completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.1.2.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which shall constitute the full compensation for furnishing all materials, equipment and labour, including transport, storage and handling of materials, batching, mixing, pouring, compacting and curing of terrazzo, providing glass divider strips, grinding, polishing of terrazzo and all incidentals necessary to complete the Work in all respect as per requirements described under this item of work, the BOQ, as shown on the Drawings and as directed by the Engineer. However, this item shall not include the costs for the item on Artificial Stone Floor.

Pay Items shall be:

Clause	Description	Unit of measurement
3.1.2	Cast-in-situ mosaic floor	Square meter

3.1.3 Non-skid floor tiles

3.1.3.1 Description

Works covered under this item shall consist of supplying, fitting and fixing approved foreign/local made homogeneous quartz/embossed, non-skid floor tiles or special quality fibrous floor tiles laid on cement mortar base of proportion in accordance with the applicable Drawings, requirements of the BOQ, and these Specifications and/or as directed by the Engineer.

3.1.3.2 Materials

Tiles

Tiles shall be either homogeneous quartz/embossed non-skid or special quality fibrous. The tiles shall be local/foreign made and of the sizes as shown on the Drawings, described in the Schedule of Works and/or as directed by the Engineer. They should be free from all wrapage blemishes and dimensional defects.

Mortar

Mortar for installation shall consist of 1 part cement and 2 parts sand (FM 1.2). The specification for cement and sand shall conform to those stated under the relevant Sub-sections of the Section on 'Construction Materials' of this Specification and/or as directed by the Engineer.

Grout

All grout for tile joints be prepared with white cement or coloured with inert pigments as and where specified. The specification for white cement shall conform to those stated under the relevant Sub-sections of the Section on 'Construction Materials' of this Specification and/or as directed by the Engineer.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substances and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

3.1.3.3 Construction methods

The Contractor shall submit three sets of samples of all types of tiles to the Engineer for his approval before procuring the materials. One set will be kept in the office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

The Contractor shall prepare sample tile work and he should obtain its approval from the Engineer. Before such approval is received, no full-scale work shall start. The design of the floor layout shall conform to what have been shown on the Drawing and/or as directed by the Engineer.

The tiles shall be laid over previously roughened and wetted patent stone floor. The panels shall be of the size as shown on the Drawings and/or as indicated in the relevant item of the BOQ and/or as directed by the Engineer.

The sub-floor on which the tiles will be laid, shall be prepared in the same way as have been stated under the Sub-section on 'Patent Stone Floor' of this Section, but it will exclude the portion of neat cement finishing.

The tiles are to be fitted and fixed on the floor on a base of 20mm thick cement mortar prepared with 1 part ordinary Portland cement and 2 parts sand of FM 1.2. The mortar bed shall be cut through horizontally and vertically every 425mm to 600mm.

If the surface needs leveling, a scratch coat of plaster shall be applied, leveled and scratched for key and be allowed to dry out for 12 hours before installing tiles. The setting mortar shall be applied evenly and a neat cement paste to a thickness of about 2mm shall be trowelled to the back of the tiles. The tiles will then be set on firmly tapped into place to ensure full contact. The joints shall be in

specified pattern and shall not exceed 2mm in width. The joints shall be raked with grout prepared with white cement and coloured pigment and damp-cured for at least 3 days.

The tiles shall be soaked in water for at least 6 hours before laying. Installation shall be controlled by strings, pages, spacers, levels or other suitable methods so as to ensure their correct laying and uniform leveled joints.

3.1.3.4 Measurement

Measurement shall be taken for payment in square meter of finished tiled surface in place completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.1.3.5 Payment

The amount of completed and accepted works measured as provided above shall be paid at the Contract unit price per square meter, which shall constitute the full compensation for furnishing all materials, equipment and labour, including transport, storage and handling of materials, cleaning, preparing and laying bed with cement mortar and cutting and laying the tiles with neat cement paste, grouting and curing tiles ranking our joints, high quality finishing and all other works and all incidentals necessary to complete the Work as per requirements described under this item of work, the requirements of the BOQ, as shown on the Drawings and as directed by the Engineer. However, this item shall not include the costs for the item on Artificial Stone Floor.

Pay Items shall be:

Clause	Description	Unit of measurement
3.1.3	Non-skid floor tiles	Square meter

3.2 CEMENT PLASTER, POINTING AND WALL TILES

3.2.1 12mm thick cement - sand plaster on brick masonry wall

3.2.1.1 Description

This item of work shall consist of making 12mm thick cement plaster on brick masonry wall surfaces and at any other appropriate locations in cement mortar with specified proportion. The Work shall consist of furnishing all materials, its transportation and storage, supply of all labours, tools and equipment and the performance of all other allied works that would be required to complete the Work in all respect. All works shall be carried out in accordance with these specifications and conforming to the levels, dimensions and designs as shown on the Drawings, provisions of the BOQ and/or to carry out the Work following the directions of the Engineer.

3.2.1.2 Materials

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C 150 Type 1 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a Fineness Modulus not less than what will be specified for a particular type of plastering and conform to the requirements of ASTM C 33 or BDS 243 and those stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification. Sand, to be used for plastering work, will be normally of F.M. 1.2 or as directed by the Engineer.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substances and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

3.2.1.3 Construction methods

Preparation of mortar

Unless otherwise specified on the Drawings or in the BOQ or instructed by the Engineer, cement mortar for plaster works on brick masonry walls shall consist by volume of one part Ordinary Portland cement and six parts screened sand of specified F.M. In each mortar, requisite quantity of water shall be added and the components mixed and thoroughly incorporated together to give a workability, appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding mixing water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform. Cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture. Water shall then be added sparingly, only to the minimum as would be necessary to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after water is added. The adding of additional water to and re-tempering (cement mortar that stiffened because of evaporation of water), shall be permitted only within 30 minutes from the time of adding water at the time of initial mixing.

Mortar that has taken initial set shall not be used in the work with or without addition of fresh materials.

Preparation of surface

Before application of plaster, all joints in brick masonry walls shall be adequately raked out with a hooked tool made for the purpose whilst the mortar is still green and not later than 48 hours of the time of lying and smooth concrete surfaces shall be roughened to provide key. Joints should not be raked out with a trowel or a hammer to avoid the edges of the bricks getting chipped. The brickwork should be brushed down with stiff wire brush so as to remove all loose dust from the joints. Surfaces to be rendered shall also be scrubbed clean of all loose materials and be made free from all dust, grease, etc. and be well wetted with water and kept dampen for 24 hours before applying plaster (the walls should not be soaked but only damped evenly). On old walls it would be required to ensure a good key for the new rendering, to destroy the smooth surface of the brick masonry work with appropriate tools.

Application of plaster

Plaster shall consist of two coats when applied over brick masonry i.e. under and finish. The under and finish coats shall be applied without an interval.

The undercoat shall have a minimum thickness of 6mm and shall be leveled with straight edge and scratched for key. The finish coat shall be troweled over with care and leveled with a straight edge to obtain a flat smooth surface. All edges and corners, unless otherwise shown on the Drawings, shall be rounded or chamfered as directed by the Engineer. All moulds shall be neat, clean and true to template.

Plaster shall be floated and troweled to a true and plumbed surface and tested frequently during the progress of the work with a straight edge sufficiently long. There shall be no overlaps or construction joints in single unbroken surface unless the area is over 28 square meter or prior permission is taken from the Engineer for a deviation. Plaster shall be stopped only at corners, construction or expansion joints.

If any crack appears in the plaster or any part sound hollow when tapped, or found to be soft or otherwise defective after the plaster has dried, the defects shall be mended by cutting out and re-plastering at the Contractor's own costs. Such works should not leave any visible impression on the places mended.

The methods and equipment used for transporting and placing mortar shall be such, as not to damage or delay the use of mixed mortar. All equipment and tools used for mixing or vehicles used for transporting mortar shall be kept clean and free from set mortar, dirt or other deleterious foreign substances.

All plastering works shall be placed only after all brick masonry surfaces have been prepared satisfactorily in accordance with the specifications and the Engineer's instructions.

The plaster shall not be applied during rain sufficiently heavy or prolonged to wash the mortar. Mortar already applied, but becomes diluted by rain, shall be removed and replaced at the expenses of the Contractor before continuing any further works.

3.2.1.4 Scaffolding

The scaffolding shall be sound and strong enough to withstand all loads likely to be imposed upon it and subject to the Engineer's approval. Pole, going into the masonry should be at a place, which can be filled with a header brick. The holes, which provide resting space for horizontal members shall not be left in masonry under 1m in width or immediately near the skewbacks of arches. The holes left in the masonry work for supporting the scaffolding shall be filled, made good and to be properly finished with plaster.

3.2.1.5 Protection and curing

All plasters shall be kept moist throughout the progress of work and protected for a minimum 10 days immediately following completion against harmful effects of weather by suitable covering. During hot weather, all finished or partly completed works shall be covered or wetted in such a manner as will prevent rapid drying of the plaster.

On completion of works, all visible surfaces shall be free from damage or debris and shall look clean. All cares shall be taken so that the plaster surfaces are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

3.2.1.6 Measurement

Measurement shall be taken for payment in square meter of the surface of the finished plaster works completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.2.1.7 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter of plaster which price shall constitute full compensation for furnishing all materials including their transportation and storage, mixing of mortar, plastering surfaces and corners, rounding and/or chamfering preparing, cleaning and watering the surfaces to be plastered, watering and protecting the plaster after completion, providing scaffolding and its erection and removal, all other works and all incidentals necessary to complete the Work as per requirements described under this item of work, the BOQ, as shown on the Drawings and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.2.1	12mm thick cement-sand plaster	Square meter

3.2.2 6mm thick cement - sand plaster on R.C.C surfaces

3.2.2.1 Description

This item of work shall consist of making 6mm thick cement plaster on R.C.C surfaces and at any other appropriate locations in cement mortar with specified proportion. The Work shall consist of supply of all materials, labour, tools and equipment, carriage and the performance of all other allied works. All works shall be carried out in accordance with these specifications and conforming to the levels, dimensions and designs as shown on the Drawings, provisions of the BOQ and/or to carry out the Work following the directions of the Engineer.

3.2.2.2 Materials

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C 150 Type 1 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a Fineness Modulus not less than what will be specified for a particular type of plastering and conform to the requirements of ASTM C 33 or BDS 243 and those stated under the relevant Sub-section of the Section on 'Construction Materials' of this Specification. Sand, to be used for plastering work, will be normally of F.M. 1.2 or as directed by the Engineer.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substances and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

3.2.2.3 Construction methods

Preparation of mortar

Unless otherwise specified on the Drawings, or in the BOQ or instructed by the Engineer, cement mortar for plaster works on R.C.C surfaces shall consist of one part Ordinary Portland cement and four parts screened sand of specified F.M. by volume. In each mortar, right quantity of water shall be added and the components mixed and thoroughly incorporated together to give a workability, appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding mixing water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform, Cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture. Water shall then be added sparingly, only the minimum necessary to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after water is added. The adding of additional water to and re-tempering (cement mortar that stiffened because of evaporation of water), shall be permitted only within 30 minutes from the time of adding water at the time of initial mixing.

Mortar that has taken initial set shall not be used in the work with or without addition of fresh materials.

Preparation of surface

Before application of plaster, smooth concrete surfaces shall be roughened to provide key. The surfaces shall be scrubbed clean of all loose materials and soaked with water and kept dampen for 2

hours before plastering. A neat cement coat shall be applied on all concrete surfaces before application of plaster.

Application of plaster

Plaster shall consist of a grout application and a finish coat, when applied direct to concrete surface. The under and finish coats shall be applied without an interval.

All edges and corners, unless otherwise shown on the Plans, shall be rounded or chamfered as directed by the Engineer. All moulds shall be neat, clean and true to template.

Plaster shall be floated and troweled to a true surface and tested frequently during the progress of the work with a straight edge sufficiently long. There shall be no overlaps or construction joints in single unbroken surface unless the area is over 28 square meter or prior permission is taken from the Engineer for a deviation. Plaster shall be stopped only at corners, construction or expansion joints.

If any crack appears in the plaster or any part sound hollow when tapped or found to be soft or otherwise defective after the plaster has dried, the defect shall be mended by cutting out and re-plastering at the Contractor's own costs.

The methods and equipment used for transporting and placing mortar shall be such, as not to damage or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar shall be kept clean and free from set mortar, dirt or other deleterious foreign substances.

All plastering works shall be placed only after all R.C.C surfaces have been prepared satisfactorily in accordance with the specifications and the Engineer's instructions.

The plaster shall not be applied during rain sufficiently heavy or prolonged to wash the mortar when the works are carried out under open sky. Mortar already applied, but becomes diluted by rain, shall be removed and replaced before continuing the work at the expenses of the Contractor.

3.2.2.4 Scaffolding

The scaffolding shall be sound and strong enough to withstand all loads likely to be imposed upon it and subject to the Engineer's approval. If any place is left out or the plaster gets damaged by resting of poles, the places shall be made plastered or repaired before/on removal of the scaffolding at the expenses of the Contractor.

3.2.2.5 Protection and curing

All plaster shall be kept moist throughout the progress of work and protected for a minimum 10 days immediately following completion against harmful effects of weather by suitable covering when the location is exposed under the open sky. During hot weather, all finished or partly completed works shall be covered or wetted in such a manner as will prevent rapid drying of the plaster.

On completion of works, all visible surfaces shall be free from damage or debris and shall look clean. All cares shall be taken that the plaster surfaces are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

3.2.2.6 Measurement

Measurement shall be taken for payment in square meter of the surface of the finished plaster works completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.2.2.7 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter of plaster which price shall constitute full compensation for furnishing all materials including their transportation and storage, mixing of mortar, plastering surfaces and corners, rounding or chamfering preparing, cleaning and watering the surface to be plastered, watering and protecting the plaster after completion, providing scaffolding and its erection and removal, all other works and all incidentals necessary to complete the Work as per requirements

described under this item of work, the Bill of Quantities, as shown on the Drawings and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.2.2	6mm thick cement-sand plaster	Square meter

3.2.3 12mm thick cement - sand skirting/dado

3.2.3.1 Description

This item of work shall consist of providing 12mm thick cement-sand plaster with neat cement finishing in skirting/dado on brick masonry wall surfaces and at any other locations where necessary in cement mortar with specified proportion. The Work shall include supply of all labour, materials, tools and equipment, carriage and the performance of all necessary works. All works shall be carried out in accordance with these specifications and conforming to the levels, dimensions and designs as shown on the Drawings, provisions of the BOQ and/or to carry out the Work following the directions of the Engineer.

3.2.3.2 Materials

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C 150 Type 1 or BS 12 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a Fineness Modulus not less than what will be specified for a particular type of plastering and conform to the requirements of ASTM C 33 or BDS 243 and those stated under the relevant Sub-section(s) of the Section on 'Construction Materials' of this Specification. Sand, to be used for plastering work, will be normally of F.M. 1.2 or as directed by the Engineer.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious and shall not contain any visibly solid material. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. All other requirements shall be similar to what have been stated under the relevant Sub-sections of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

3.2.3.3 Construction methods

Preparation of mortar

Unless otherwise specified on the Drawings or in the BOQ or instructed by the Engineer, cement mortar for skirting/dado works on brick masonry walls shall consists by volume of one part Ordinary Portland cement and four parts screened sand of specified F.M.. In each mortar, requisite quantity of water shall be added and the components mixed and thoroughly incorporated together to give a workability, appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding mixing water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform, Cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture. Water shall then be added sparingly, only the minimum necessary to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after addition of water. The adding of additional water to and re-tempering (cement mortar that stiffened because of evaporation of water), shall be permitted only within 30 minutes from the time of addition of water at the time of initial mixing.

Mortar that has taken initial set shall not be used in the work with or without addition of fresh materials.

Preparation of surface

Before application of skirting/dado, wall plaster, if there be any, shall be removed along the floor to the required height and the joints in brick-walls shall be adequately raked out to provide key. The surfaces shall be scrubbed clean of all loose materials and soaked with water and kept damped for 24 hours before skirting/dado works start.

Application of skirting/dado

Skirting/dado shall consist of two coats i.e under and finish. The under and finish coats shall be applied without an interval to permit the undercoat to set.

The undercoat shall have a minimum thickness of 6mm and the total built-up thickness will be same as that of the plaster on the wall. A 3mm groove shall be formed where skirting/dado meets wall plaster.

The skirting/dado shall be installed flushed with the finished wall surface. The intersection with the floor shall be right-angled and the top of the skirting/dado shall be straight and sharp.

The under-bed shall be laid as uniformly as possible and allowed to become firm before scratching for key and subsequently allowed to become thoroughly dry before applying the second under-coat. A neat cement paste of 3mm thickness shall be spread evenly over the second coat and shall be steel troweled under firm pressure to produce a dense uniform smooth surface free from trowel marks.

The finish coat shall be troweled over with care and leveled with a straight-edge to obtain a flat smooth surface including neat cement finishing. All edges and corners unless otherwise shown on the Drawings shall be rounded or chamfered as directed by the Engineer. All moulds shall be neat clean and true to template.

Skirting/dado shall be floated and troweled to a true and plumbed surface and tested frequently during the progress of the work with a straight edge sufficiently long. There shall be no overlaps or construction joints in single unbroken surface unless the area is over 28 square meter or prior permission is taken from the Engineer. Skirting/dado shall be stopped only at corners, sieves, construction or expansion joints.

If any crack appears in the skirting/dado, or any part sound hollow when tapped or found to be soft or otherwise defective after the skirting/dado has dried, the defect shall be made good by cutting out and re-plastering at the Contractor's own costs.

When the skirting/dado is applied on the plinth wall, it shall be plastered up to 150mm below the ground level.

The methods and equipment used for transporting and placing mortar shall be such, as not to damage or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar shall be kept clean and free from set mortar, dirt or other deleterious foreign substances.

All skirting/dado works shall be placed only after all brick-wall surfaces have been prepared satisfactorily in accordance with the specifications and the Engineer's instructions.

The skirting/dado shall not be applied during rain sufficiently heavy or prolonged to wash the mortar. Mortar already applied, but becomes diluted by rain shall be removed and replaced before continuing the work at the expenses of the Contractor.

3.2.3.4 Protection and curing

All skirting/dado shall be kept moist throughout the progress of work and protected for a minimum 10 days immediately following completion against harmful effects of weather by suitable covering. During hot weather, all finished or partly completed works shall be covered or wetted in such a manner as will prevent rapid drying of the skirting/dado.

On completion of works, all visible surfaces shall be free from damage or debris and shall look clean. All cares shall be taken that the skirting/dado surfaces are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

3.2.3.5 Measurement

Measurement shall be taken for payment in square meter of the surface of the finished skirting/dado works completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.2.3.6 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter of skirting/dado which price shall constitute full compensation for furnishing all materials, mixing of mortar, plastering surfaces and corners, rounding and/or chamfering, preparing, cleaning and watering the surface to be skirted, watering and protecting the skirting/dado after completion, all other works and all incidentals necessary to complete the Work as per requirements described under this item of Work, the BOQ, as shown on the Drawings and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.2.3	12mm thick skirting/dado	Square meter

3.2.4 Rule pointing on brick masonry wall joints

3.2.4.1 Description

This item of work shall consist of making rule points in the joints of the brick masonry wall surfaces and at any other locations where necessary in cement mortar with specified proportion. The Work shall include supply of all labour, materials, tools and equipment, carriage and the performance of all necessary works. All works shall be carried out in accordance with these specifications and conforming to the levels, dimensions and designs as shown on the Drawings, provisions of the BOQ and/or to carry out the Work following the directions of the Engineer.

3.2.4.2 Materials

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C 150 Type 1 or BS 12 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a Fineness Modulus not less than what will be specified for a particular type of rule pointing and conform to the requirements of ASTM C 33 or BDS 243 and those stated under the relevant Sub-section(s) of the Section on 'Construction Materials' of this Specification. Sand, to be used for plastering work, will be normally of F.M. 1.2 or as directed by the Engineer.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious and shall not contain any visibly solid material. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. All other

requirements shall be similar to what have been stated under the relevant Sub-sections of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

3.2.4.3 Construction methods

Preparation of mortar

Unless otherwise specified on the Drawings or in the BOQ or instructed by the Engineer, cement mortar for rule pointing works on brick masonry wall joints shall consists by volume of one part Ordinary Portland cement and two parts screened sand unless otherwise required by the Drawings or instructed by the Engineer. In each mortar, requisite quantity of water shall be added and the components mixed and thoroughly incorporated together to give a workability, appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding mixing water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform. Cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture. Water shall then be added sparingly, only the minimum necessary to produce a workable mixture of normal consistency. The water cement ratio in no case shall exceed 0.50 by weight, or as directed by the Engineer.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after addition of water. The adding of additional water to and re-tempering (cement mortar that stiffened because of evaporation of water), shall be permitted only within 30 minutes from the time of addition of water at the time of initial mixing.

Mortar that has taken initial set shall not be used in the work with or without addition of fresh materials.

Preparation of surface

Before rule pointing, the joints in brick-walls shall be adequately roughened. The surfaces shall be scrubbed clean of all loose materials and soaked with water and kept damped for 24 hours.

Making rule points

Unless otherwise specified, mortar for rule pointing shall be prepared with one part of Portland cement and two parts of sand generally of F.M. 1.2. Lime in powder form passing 100 mesh in the proportion of 2% by weight of cement shall also constitute an ingredient of the mortar.

The methods and equipment used for transporting and placing mortar shall be such, as not to damage or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar shall be kept clean and free from set mortar, dirt or other deleterious foreign substances.

When all brick wall surfaces including the joints are well prepared as described earlier, mortar of specified proportion shall be applied at the joints and finished in rule or concave pointing as mentioned in the 'BOQ' or indicated on the Drawings or directed by the Engineer. The concave pointing shall be done with the help of rebars wooden template to prepare semi-circular pointing intruding inside the brick wall joints. The Contractor shall remain very careful in maintaining the type of pointing as asked for in the Contract.

All rule-pointing works shall only start when all brick-wall surfaces have been prepared satisfactorily in accordance with the specifications and the Engineer's instructions.

The rule pointing works shall not be undertaken during rain sufficiently heavy or prolonged to wash the mortar. Mortar already applied, which becomes diluted by rain shall be removed and replaced before continuing the work at the expenses of the Contractor.

3.2.4.4 Scaffolding

The scaffolding shall be sound and strong enough to withstand all loads likely to be imposed upon it and subject to the Engineer's approval. Pole, going into the masonry should be at a place, which can

be filled with a header brick. The holes, which provide resting, space for horizontal members shall not be left in masonry under 1m in width or immediately near the skewbacks of arches. The holes left in the masonry work for supporting the scaffolding shall be filled and made good.

3.2.4.5 Protection and curing

All works shall be kept moist throughout the progress of work and protected for minimum 10 days immediately following completion against harmful effects of weather by suitable covering. During hot weather, all finished or partly completed works shall be covered or wetted in such a manner as will prevent rapid drying of the plaster.

On completion of works, all visible surfaces shall be free from damage or debris and shall look clean. All cares shall be taken that the plaster surfaces are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

3.2.4.6 Re-pointing of existing brick masonry work joints

The extent of re-pointing of existing brick masonry works shall be jointly surveyed by the Contractor and the Engineer at the start of the work and the location of all repairs needed shall be recorded and permanently marked in paint.

The defective mortar shall be carefully removed from the joints and the joints shall be cleaned immediately prior to re-pointing. The re-pointing shall be done with cement mortar of specified proportion to full depth, penetration and trimmed flush with the face of the brick masonry works.

Cracks in the existing brick masonry works shall be treated in the same way. Defective materials shall be carefully removed and the cracks shall be filled with cement mortar of specified proportion.

3.2.4.7 Measurement

Measurement shall be taken for payment in square meter of the surface of the brick masonry works with all joints have been finished by rule pointing in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.2.4.8 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter of brick masonry wall which price shall constitute full compensation for furnishing all materials, mixing of mortar, rule pointing of joints, cleaning and watering the surface to be rule pointed, watering and protecting the work after completion, providing scaffolding and its erection and removal, all other works and all incidentals necessary to complete the Work as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.2.4	Rule pointing of joints of the brick masonry wall	Square meter

3.2.5 Terrazzo skirting

3.2.5.1 Description

Works covered under this item shall consist of providing 10mm or 12mm thick in-situ terrazzo skirting over a cement sand mortar under-bed on walls or other locations as required in the BOQ and in accordance with these Specifications and/or as per the direction of the Engineer.

3.2.5.2 Materials

Marble chips

Best quality machine crushed marble chips of Chinese, Pakistani or Indian origin as specified.

White cement

White cement shall be 'Onoda' brand or of an equivalent standard approved by the Engineer.

Grey cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C150 Type 1 or BS 12 or BDS 232 or of an equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious to concrete or reinforcement and shall not contain any visibly solid materials. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer. All other requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

3.2.5.3 Construction methods

Terrazzo or mosaic floor shall be prepared with best quality Chinese/Pakistani/Indian origin marble chips of No. 2 size and colour as required (generally 90% white and 10% coloured), gray cement and white cement. The cement and marble mixture shall be in the proportion of one part marble chips and one part cement as specified in the BOQ or as directed by the Engineer. The cement mix shall consist of nine parts white cement and one part gray cement. The marble chips and the cement mix shall be thoroughly mixed in specified proportion. However, the required proportion of the mixes shall be determined at Site by the Engineer.

White cement shall be 'Onoda' brand or an approved equal. Colouring materials shall be of best quality of mineral pigment of high purity and shall be finely grounded, sun-proof and with specific gravity not exceeding 5% by weight of cement used.

The Contractor shall submit three sets of samples of all type of marble chips to the Engineer for his approval before procuring the materials. One set will be kept at the office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

The terrazzo work shall be polished by machine and carborundum stone of 80 grit followed by 120 and 200 grit and polishing stone until the finish becomes acceptable to the Engineer.

The Contractor shall prepare sample terrazzo work, which must receive the approval of the Engineer. Before such approval is received, no full-scale work shall start.

The thickness of terrazzo topping shall be at least 20mm. The setting bed shall be minimum 12mm thick using Portland cement and sand in proportion as mentioned in the BOQ.

The surface receiving situ terrazzo work shall be cleaned thoroughly and if necessary the joints will be racked. The surface shall be scarified properly. It shall then be moistened with water adequately to make the surface damp.

Following preparatory work, the setting bed as specified above shall be applied in such away that it provides a plumb and true surface, which will be scratched with broom and allowed to be cured for at least 24 hours.

A coat of bonding paste of neat cement (Portland Cement) shall then be trowelled on the setting bed. The setting bed shall be moistened before application of bonding slurry in such a way that it is damp only and not glisten-wet.

The next step is to well trowell the terrazzo topping layer in 20mm thickness over the live bonding paste. The ingredients of terrazzo topping layer shall be mixed in proportion and in manner as specified under the Sub-section on 'Mosaic Floor' and approved by the Engineer.

Layer of same cement paste of same composition as used in topping shall be well trowelled next leaving a smooth surface.

The curing must be done after laying the terrazzo work by wet sacking.

After terrazzo topping has hardened enough to withstand any dislodgment, polishing works shall commence, which shall be first started with grinding the surface by an approved type of grinding machine with carborundum stone of 80 grits to expose the marble chips. The wall shall be kept wet during grinding. Sweeping and flushing with clean water shall be done to remove all grind-off materials.

Air holes, pits and other blemishes shall than be filled with a thin grout of cement paste of same composition as used in topping.

On hardening of patch fillers, the wall shall receive a successive grinding with carborundum stone up to 240 grit in a final finish. It shall then be cleaned and washed of all surplus materials.

The wall shall be kept undisturbed for a period of 2 weeks on even exposure of marble chips. On expiry of this period the wall shall be cleaned of dirt and dust by rubbing gently with pumice stone (No. 40, No. 80 and No. 120) using sufficient water. Stains shall be removed by moistening with Oxalic Acid and rubbing with warm water, if required. No acid solutions shall be used.

The surface shall receive bee wax polishing on drying.

All materials shall be mixed in dry state and shall be protected from harmful effects of moisture. Water shall be added to only such amounts as may be consumed in less than 30 minutes, in quantities required to produce workability. Mixing shall be done on watertight platform.

3.2.5.4 Measurement

Measurement shall be taken for payment in square meter of the finished terrazzo skirting in place completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.2.5.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which shall constitute the full compensation for furnishing all materials, equipment and labour, including transport, storage and handling of materials, mixing, placing, compacting, curing, grinding, polishing and all other works and all incidentals as would be necessary to fully complete the Work in all respect as per requirements described under this item of work, the BOQ, as shown on the Drawings and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.2.5	Terrazzo skirting	Square meter

3.2.6.1 Description

Works covered under this item shall consist of supplying, fitting and fixing approved glazed ceramic tiles laid on walls or any other places as specified on a cement mortar base of proportion in accordance with the applicable Drawings and these Specifications. The tiles may be of local or foreign origin as would be specified in the BOQ.

3.2.6.2 Materials

Glazed ceramic tiles

Glazed ceramic tiles, unless otherwise specified, shall be of the standard size of 150mm x 150mm x 6mm or as approved by the Engineer, white or coloured, free from war-page, blemishes and dimensional defects and conforming to the standards of Federal Specification SS-T-308p. In case of foreign made tiles, the places of origin are normally Sri Lanka/Thailand/England/Italy.

Mortar

Mortar for installation shall consist of 1 part cement and 3 parts sand (FM 1.2). The specification for cement and sand shall conform to those stated under the relevant Sub-sections of the Section on 'Construction Materials' of this Specification and/or as directed by the Engineer.

Grout

All grout for tile joints shall be prepared with white cement, coloured cement and with inert pigments, where specified. The specification for white cement shall conform to those stated under the relevant Sub-sections of the Section on 'Construction Materials' of this Specification and/or as directed by the Engineer.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious to concrete or reinforcement and shall not contain any visibly solid materials. The Contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer. All other requirements shall be similar to what have been stated under the relevant Sub-section of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

3.2.6.3 Construction methods

The Contractor shall submit three sets of samples of all types of tiles to the Engineer for his approval before procuring the materials. One set will be kept at the office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

The Contractor shall prepare a sample work, which must receive the approval of the Engineer. Before such approval is received, no full-scale work for tile setting shall start.

Preparation of wall surface and application of mortar bed shall comply with the provisions of the item on 'Terrazzo Skirting' as stated in the preceding Sub-section of this Specification.

The tiles are to be fitted and fixed on wall on a base of 20mm thick cement mortar prepared with 1 part ordinary Portland cement and 3 parts sand of FM 1.2. The mortar bed shall be cut through horizontally and vertically every 425mm to 600mm.

If the surface needs leveling, a scratch coat of plaster shall be applied, leveled and scratched for key and be allowed to dry out for 12 hours before installing tiles. The setting mortar shall be applied evenly and a neat cement paste to a thickness of about 2mm shall be trowelled to the back of the tiles and the tiles to be set on firmly tapped in to place to ensure full contact. The joints shall be in specified pattern and shall not exceed 2mm in width.

The tiles shall be soaked in water for at least 6 hours before setting. Installation shall be controlled by strings, pages, spacers, levels or other suitable methods that will ensure correct layout and uniform leveled joints.

The joints shall be grouted with white cement, cleaned and damp-cured for at least 3 days.

3.2.6.4 Measurement

Measurement shall be taken for payment in square meter of the finished tiled surface completed in accordance with the Specifications stated herein and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.2.6.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which shall constitute the full compensation for furnishing all materials, equipment and labour, including transport, storage and handling of materials, cleaning, preparing and laying bed and cutting and laying the tiles, grouting, curing and all other works and all incidentals as would be necessary to fully complete the Work in all respect as per requirements described under this item of work, the BOQ, as shown on the Drawings and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.2.6	Glazed wall tiles	Square meter

3.3 LIME TERRACING AND DAMP PROOF COURSE

3.3.1 Lime Terracing

3.3.1.1 Description

This item of work shall consist of placing a waterproofing and drainage course on roof slabs by providing lime concrete of specified thickness and proportion in accordance with the requirements as shown on the Drawings, as stated in the BOQ and these Specifications or and as directed by the Engineer.

3.3.1.2 Materials

Lime

Lime to be used for lime terracing shall be slaked lime and shall conform to the requirements of ASTM C 5 and ASTM C 207.

Lime shall not contain more than 5% of impurities. It shall dissolve in soft water when water is added in sufficient quantity. Stone lime available in Sylhet, meeting the above requirements, may be used.

A good hydraulic lime shall have an ultimate tensile strength of at least 7kg/cm² for a mortar prepared with 1 part of lime and 3 parts of sand. A pure surki mortar gives a breaking strength of about 5.6 to 6.3 kg/cm² when left in dry air and 21 to 25 kg/cm² when left immersed under water.

Surki

Surki shall be made only by grinding 1st class well-burnt (but not vitrified) bricks or brickbats. Surki shall not be made from under-burnt or over-burnt bricks nor bricks containing high proportion of sand. Surki shall be perfectly clean and free from dust, sand or any other particles and shall be ground to such a fineness as would pass through 3.35mm sieve with at least 50% of it passing through 1.7mm sieve.

Brick chips

Brick chips (khoa) shall consist of 20mm down-graded angular fragments of broken or crushed well burnt (but not vitrified) 1st class bricks. Porous brick chips or showing signs of salt petre shall not be used for lime terracing.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious and shall not contain any visibly solid material. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. All other requirements shall be similar to what have been stated under the relevant Sub-sections of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

3.3.1.3 Construction methods

Mixing

The approximate proportion of the mixture shall be 2 parts lime to 2 parts surki to 7 parts brick chips, all having specifications as stated above and as stated under the relevant Sub-sections of the Section on 'Construction Materials' of this Specification.

The mixing shall be done on a clean platform. The lime and surki, in specified quantities, shall be first mixed dry till it takes a uniform colour. The mixture then shall be laid on the top of stack of specified quantity of previously wetted brick chips. The whole shall be turned over once without adding water and twice by gradually adding small quantities of water for tempering itself for 24 hours. The mix shall then be allowed to age for at least 7 days. During this period the mixture shall be turned by spading twice a day by adding further lime water to prevent drying up. The lime water shall be prepared with 1 part lime and 10 parts water. The process shall be repeated throughout the period of aging until the mix attains the desirable consistency.

The mixing shall be done invariably on the ground on a brick platform at the designated place.

The mixing shall not be allowed on the roof deck whatever may the case arises.

Installation

The roof slab, on which the mixture will be laid, shall be cleaned and washed accompanied by scrubbing, if necessary. The prepared mixture shall then be laid evenly on the cleaned roof slab to proper slope and grade in thickness 25mm more than the required compacted thickness as shown on the Drawings, as required by the Bill of Quantities or as directed by the Engineer.

Beating of the laid mixture shall then be undertaken which shall be done by two rows of workers sitting in rows that will traverse the length of the roof backward and forward beating with wooden mallets. Beating shall continue until the mixture has almost set and the mallets rebound from the surface. Beating shall usually be continued for 5 or 6 days. Before beating starts, a lime slurry shall be sprinkled on the top and allowed to soak well. The lime slurry shall be continually sprinkled on the concrete to keep it wet while being beaten. The surface shall never be allowed to dry. The mortar, which comes to the surface during the beating is to be rendered smooth and finished off with a grout prepared with 1 part lime and 2 parts surki, but no plaster shall be given to the surface.

The work shall be cured for 3 weeks by covering with a 50mm layer of moist earth mixed with 3% straw or hay. This layer shall be moistened from time to time as required. On expiry of the curing period, the layer of earth shall be removed and the entire roof area shall be swept clean.

Good care shall be taken not to clog roof drains.

Where lime concrete roofing cannot be placed all in one day, each day's work shall be terminated on a straight line with 1:2 slope. Joining of new work to previous day's work shall be accomplished by applying a bonding paste of lime-surki mortar to the slope before placing the new lime concrete. The composition of the lime-surki mortar shall be 1 part of lime and 1 part of surki mixed with requisite quantity of water.

Turn-up along parapet shall be provided as per the requirements of the Drawings and finished in a manner similar to roof.

3.3.1.4 Measurement

Measurement shall be taken for payment in cubic meter of volume actually built by computing the actual area multiplied by the average thickness of the lime concrete installed in position as per specifications of this item and/or as per the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.3.1.5 Payment

The amount of completed and accepted work as measured above shall be paid for at the Contract unit price per cubic meter. The payment shall constitute the full compensation for furnishing all materials, equipment and labour including storage, handling and transport of all materials, slaking of lime, making platform, mixing, laying and consolidating of lime concrete, making "ghoondi" neat finishing with lime mortar and all incidentals necessary to complete the Work as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.3.1	Finished lime terracing on the roof slab	Cubic meter

3.3.2 Damp proof course (DPC)

3.3.2.1 Description

Works covered under this item shall consist of constructing a layer of cement concrete with specified proportion and in required thickness with top surface painted with Asphalt/Coal tar.

3.3.2.2 Materials

Cement

Cement used in the works shall be ordinary Portland cement complying with the requirements of ASTM C150 Type 1 or BS 12 or BDS 232 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification.

Coarse aggregate

Coarse aggregate shall conform to the requirements of ASTM C 330.

Coarse aggregate shall be hard, durable, clean, free from dust and other deleterious material to be obtained by crushing 1st class/picked jhama bricks. The grading of the coarse aggregate shall be such that when combined with the approved fine aggregate and cement, it shall produce a workable concrete of maximum density which has been considered to be 10mm down graded in this case.

Materials shall also conform to the requirements specified in the relevant Sub-section of the Section titled 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a Fineness Modulus not less than what will be specified for a particular type of DPC and conform to the requirement of ASTM C 33 or BDS 243 and those stated under the relevant Sub-section(s) of the Section on 'Construction Materials' of this Specification. Sand, to be used for Damp Proof Course, will be of FM normally not below 1.8 or as directed by the Engineer.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious to concrete or reinforcement and shall not contain any visibly solid material. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. All other requirements shall be similar to what have been stated under the

relevant Sub-sections of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

Asphalt

Asphalt shall conform to the requirements of ASTM D 312. Type-1 shall be used below ground and Type-2 shall be used above ground.

3.3.2.3 Construction methods

25mm to below 40mm thick cement concrete mixture prepared with 1 part cement, 2 parts sand and 4 parts brick chips is to be installed following the procedures stated under the Section on 'Concrete Work' of this Specification. In case of DPC designed with a 40mm thickness, the cement concrete mixture may be prepared with 1 part cement, 1½ parts sand and 3 parts brick chips. Two coats of hot asphalt should be applied over the cement concrete when the concrete has been fully cured and dried. The surface to be damp-proofed shall be primed and thoroughly mopped with asphalt. When the first mopping of asphalt has set sufficiently, the entire surface shall be mopped with second coating of hot asphalt. Special care shall be taken to see that there are no skips in the coatings and that all surfaces are thoroughly covered. The asphalt used should not melt or soften in the hottest days and should not get squeezed due to pressure of the masonry over it.

All concrete surfaces, which are to be damp-proofed shall be reasonably smooth and free from foreign material that would prevent bond. The surface shall be dry and immediately before the application of the primer, the surface shall be thoroughly cleaned of dust and loose materials.

The damp-proof course should be laid flush with the floor surface and should not be carried across doorways or other openings. The upper layer of cement concrete floors should be continued over such openings and should be laid at the same time as the floors. The asphalt or tar layer should be laid under the concrete at the openings. Where concrete is laid on bitumen or tar, the surface of the bitumen or tar must be sprinkled with dry sand.

The position of the damp proof course is also an important factor and it should be laid at such a height that it is above the normal level to which water splashes from the ground when it is raining. A damp proof course should not be less than 15cm above the highest level of the ground.

3.3.2.4 Measurement

Damp proofing shall be measured in square meter of the works completed in place, in accordance with the Specifications stated herein and/or with the provisions of the Bill of Quantities and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.3.2.5 Payment

The amount of completed and accepted work as measured above shall be paid for at the Contract unit price per square meter. The payment shall constitute the full compensation for the cost of furnishing all equipment, materials, labour for preparation of concrete mixture and its casting, compacting, curing, including, asphalt painting including all storage, handling and transport and all incidentals necessary for the satisfactory completion of the damp-proofing as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.3.2	Damp-proofing	Square meter

3.4 PAINTING AND WHITEWASH

3.4.1 Synthetic enamel paint

3.4.1.1 Description

Works covered under this item shall consist of painting metallic surface or wooden surface where water proofing is required or the places as directed by the Engineer. Synthetic enamel paint of any approved brand and colour shall be used in minimum 3 coats in accordance with these specifications, as per the provisions in the BOQ and/or as directed by the Engineer or as specified by the manufacturers. Painting shall be done in a manner to obtain an even, smooth finish of confirm shade and without any mark of brush and joint.

3.4.1.2 Materials

Paint shall consist of ready-mixed synthetic enamel of approved type supplied in original sealed containers bearing the name of the manufacturer of the paint.

All painting materials shall be of the best quality and be delivered at the Site in sealed original containers bearing manufacturer's labels and seals.

Materials to be used in the work shall conform to the reputed manufacturer's specifications and to the satisfaction of the Engineer.

Storage of materials

Materials and tools shall be stored in a single place at the Site as designated by the Engineer.

Storage area shall be maintained in a neat and clean condition with surroundings protected from damage.

Inflammable materials shall be stored in sealed containers. Waste shall be removed from the premises at the end of each day's work. Every precaution shall be taken to prevent fire.

Storage area shall be all time accessible to the Engineer.

3.4.1.3 Construction methods

General

Before purchasing materials, the Contractor shall submit to the Engineer a list showing the brand and type of paints proposed for this item of work. Manufacturer's catalogue or specification sheets, in triplicate, for materials selected shall be submitted to the Engineer with the list of brands and types. No material shall be used without the approval of the Engineer.

Colours and samples

Colour scheme shall conform the Finish Schedule and as directed by the Engineer. All tinting and matching shall be to the satisfaction of the Engineer.

For all painted finishes, samples shall be prepared as per direction of the Engineer on pieces of the same kind of material surface at least on an area of 150mm by 300mm. The finished sample shall be approved by the Engineer.

Protection

Drop cloths or other approved protection materials shall be furnished and laid on all areas where painting and finishing is being done so as to adequately protect floor and other places from all damages caused during the execution of the painting work.

Surface preparation

For metallic surface

All metallic surfaces shall be prepared before application of paint.

For ferrous metal, the surfaces shall be cleaned by brushing with wire brush or sand paper to remove all rust, weld spatter and other foreign particles. Any grease and oil film shall be removed with a solvent, using a fine steel wood pad or a coarse cloth. All damages to shop coat caused by erection, repairing and cleaning shall be spot primed with the same materials used for the shop coat.

In case of galvanized metal, the surfaces shall be cleaned and dried. Any grease and oil film shall also be removed with a solvent, using a fine steel wood pad or a coarse cloth. It is considered that paint will adhere to galvanized iron if the surface is washed with vinegar or slaked lime and washing soda before painting.

In all cases manufacturer's instructions are to be strictly followed in preparing the surfaces to be painted.

For wooden surface

Wood, the surfaces, which are to be painted, shall be well seasoned and the surface to be painted shall be perfectly dry.

The surfaces of woodwork to be painted or polished should be rubbed down perfectly smooth with medium and fine grade sandpaper. All rubbing to be done with the grain. Worked timber should be primed as soon as possible particularly on the cut end grain. New woodwork shall be knotted, primed and stopped before given coats of paint.

Application of paint

Wooden and ferrous metallic surfaces

The workmanship for painting shall be of high quality and experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not suitable for the production of good results. All spaces shall be broom cleaned before painting or finishing is started.

All paint shall be applied with brushes under adequate illumination, evenly spread, smoothly flowed on without runs or sags. Paint shall be worked into all corners and crevices.

Materials shall be applied in strict accordance with the manufacturer's directions. In particular, no prepared paint shall be thinned by any methods except as directed by the manufacturer. All paint shall be thoroughly mixed before being applied.

Each coat applied must be inspected and approved by the Engineer before the application of the succeeding coat. Otherwise no credit for the coat applied will be given and the Contractor may require to repeat the work at his own expenses. The Contractor shall notify the Engineer when each coat is ready for inspection.

No exterior painting shall be done in rainy and damp weather until the surface is thoroughly dry. No interior painting shall be done on damp surfaces.

Drying time for every coat shall not be less than 72 hours and 48 hours for exterior paints and interior paints respectively. Each coat shall be thoroughly dry before application of subsequent coat.

All natural finished woodwork, painted woodwork and painted metal shall be slightly sanded between coats using No.'00' sandpaper. The finished surface must be smooth, evenly leveled and free from brush marks.

Natural finished woodwork only shall be rubbed with fine sandpaper after the last coat has received the desired finish as per approved sample.

All woodwork for natural finish shall be sealed on the back and all surfaces, which will be concealed after erection with two coats of an approved transparent sealer prior to installation.

After being fitted by the Carpenter, all edges of the doors and windows shall be finished in the same way as the faces.

All exposed piping (except PVC), if specified shall be painted to match the adjoining wall surfaces where such wall surfaces are either glazed tile or painted.

Painting around finish hardware of other removable items already in place shall not be allowed.

Wherever scaffolding is necessary, it shall be free standing so as not to damage or scratch the painted surface.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during painting.

Galvanized Iron surfaces

Galvanized iron should not be painted until it has been exposed to the weather for a year as paint adheres badly to new galvanized iron. If necessary to paint sooner, a coat composed of about 200 grams of copper acetate added to 5 litres of water, or 60 grams of muriatic acid added to a mixture of 60 grams each of copper chloride, copper nitrate and sal-ammoniac, dissolved in 5 litres of soft water, to which a small quantity of hydrochloric acid has been added, should be given. This will be sufficient for about a surface area of 250 square meter.

Completion

At completion of painting work, the Contractor shall remove any paint spot and stain caused during the whole process of works as stated under this Sub-section from floors, walls, glass, hardware, equipment and other surfaces leaving these surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section and the Contractor shall repaint or retouch, as directed by the Engineer, any surface which do not comply with the requirements of these specifications or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from defects and blemishes.

All rubbish and accumulated painting materials shall be removed from the premises.

3.4.1.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually painted with required quality in accordance with the provisions of the BOQ and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.1.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and paint and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.1	Synthetic enamel painting	Square meter

3.4.2 Plastic painting

3.4.2.1 Description

Works covered under this item shall consist of painting plastered wall or ceiling surfaces or the places as directed by the Engineer. Synthetic resin emulsion paint of any approved brand and colour shall be used in minimum 3 coats in accordance with these specifications, as per the provisions in the BOQ and/or as directed by the Engineer or as specified by the manufacturers. Painting shall be done in a manner to obtain an even, smooth finish of confirm shade and without any mark of brush and joint.

3.4.2.2 Materials

Paint shall consist of ready-mixed synthetic emulsion resin base water-thinned approved products supplied in original sealed containers bearing the manufacturer's trade mark.

All painting materials shall be of the best quality and be delivered at the Site in sealed original containers bearing manufacturer's labels and seals.

Materials to be used in the work shall conform to the reputed manufacturer's specifications and to the satisfaction of the Engineer.

Storage of materials

Materials and tools shall be stored in a single place at the Site as designated by the Engineer.

Storage area shall be maintained in a neat and clean condition with surroundings protected from damage.

Inflammable materials shall be stored in sealed containers. Waste shall be removed from the premises at the end of each day's work. Every precaution shall be taken to prevent fire.

Storage area shall be all time accessible to the Engineer.

3.4.2.3 Construction methods

General

Before purchasing materials, the Contractor shall submit to the Engineer a list showing the brand and type of paints proposed for this item of work. Manufacturer's catalogue or specification sheets, in triplicate, for materials selected shall be submitted to the Engineer with the list of brands and types. No material shall be used without the approval of the Engineer.

Colours and samples

Colour scheme shall conform the Finish Schedule and as directed by the Engineer. All tinting and matching shall be to the satisfaction of the Engineer.

For all finished painting on plastered masonry and concrete surfaces, samples shall be prepared as per direction of the Engineer on the surfaces to be painted. The finished samples shall be approved by the Engineer.

Protection

Drop cloths or other approved protection materials shall be furnished and laid on all areas where painting and finishing is being done so as to adequately protect floor and other places from all damages caused during the execution of the painting work.

Surface preparation

All surfaces to be painted shall be thoroughly cleaned of all grit, grease, dirt, loose materials, mortar drippings and the like. It is better that some soap is added in the wash.

The surface shall be given a thorough rub down to remove all loose materials and all cracks and surface irregularities shall be prepared with patching plaster and filler to obtain a smooth and even surface to the satisfaction of the Engineer. The filler shall always be spread from the same face of the filling knife, the other face shall be kept clean and free. Brush shall always be cleaned after use. Filler shall be applied before priming and the surface shall be rubbed before the application to ensure clean work and again after application on allowing 12 hours to dry.

The plastered surfaces shall be made smooth by sand papering and made free from marks before applying the first coat.

Voids and holes shall be filled after first the coat becomes dry by using filler compatible with the finishing specified and tinted, if required to camouflage repairs.

In the case of new cement plaster walls, a solution of 2 kg of zinc sulphate in 4 litres of water should be applied to the surface and when dry should be given a coat of pure raw linseed oil; or the surface can be treated with dilute sulphuric or hydrochloric acid (1 part acid to 50 parts water) and then washed down with water. Cares shall be taken to ensure that acids are added to the water and not water to the acids.

Application of paint

The workmanship for painting shall be of high quality and experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not suitable for the production of good results. All spaces shall be broom cleaned before painting or finishing is started.

All paints shall be applied with brushes under adequate illumination, evenly spread, smoothly flowed on without runs or sags. Paint shall be worked into all corners and crevices.

Materials shall be applied in strict accordance with the manufacturer's directions. In particular, no prepared paint shall be thinned by any method except as directed by the manufacturer. All paint shall be thoroughly mixed before being applied.

Each coat shall be thoroughly dry before application of subsequent coat.

Drying time for every coat shall not be less than 72 hours and 48 hours for exterior and interior painting respectively.

Each coat applied must be inspected and approved by the Engineer before the application of the succeeding coat. Otherwise, no credit for the coat applied will be given and the Contractor may require to repeat the work at his own expenses. The Contractor shall notify the Engineer when each coat is ready for inspection.

No exterior painting shall be done in rainy and damp weather until the surface is thoroughly dry. No interior painting shall be done on damp surfaces.

Wherever scaffolding is necessary, it shall be free standing so as not to damage or scratch the painted surface.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during painting.

Completion

At completion of painting work, the Contractor shall remove any paint spot and stain caused during the whole process of works as stated under this Sub-section from floors, walls, glass, hardware, equipment and other surfaces leaving these surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section and the Contractor shall repaint or retouch, as directed by the Engineer, any surface which do not comply with the requirements of these specifications or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from defects and blemishes.

All rubbish and accumulated painting materials shall be removed from the premises.

3.4.2.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually painted with required quality in accordance with the provisions of the BOQ and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.2.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and paint and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.2	Plastic painting on plastered surface	Square meter

3.4.3 Distemping

3.4.3.1 Description

Works covered under this item shall consist of distemping plastered wall or ceiling surfaces or the places as directed by the Engineer. Distemper of any approved brand and colour shall be used in minimum 3 coats in accordance with these specifications, as per the provisions in the BOQ and/or as directed by the Engineer or as specified by the manufacturers. Distemping shall be done in a manner to obtain an even, smooth finish of confirm shade and without any mark of brush and joint.

3.4.3.2 Materials

Paint shall consist of approved ready-mixed distemper supplied in original sealed containers bearing the manufacturer's trademark.

All distemping materials shall be of the best quality and be delivered at the Site in sealed original containers bearing manufacturer's labels and seals.

Materials to be used in the work shall conform to the reputed manufacturer's specifications and to the satisfaction of the Engineer.

Storage of materials

Materials and tools shall be stored in a single place at the Site as designated by the Engineer.

Storage area shall be maintained in a neat and clean condition with surroundings protected from damage.

Inflammable materials shall be stored in sealed containers. Waste shall be removed from the premises at the end of each day's work. Every precaution shall be taken to prevent fire.

Storage area shall be all time accessible to the Engineer.

3.4.3.3 Construction methods

General

Before purchasing materials, the Contractor shall submit to the Engineer a list showing the brand and type of distemper proposed for this item of work. Manufacturer's catalogue or specification sheets, in triplicate, for materials selected shall be submitted to the Engineer with the list of brands and types. No material shall be used without the approval of the Engineer.

Colours and samples

Colour scheme shall conform the Finish Schedule and as directed by the Engineer. All tinting and matching shall be to the satisfaction of the Engineer.

For all finished distemping on plastered masonry and concrete surfaces, samples shall be prepared as per direction of the Engineer on the surfaces to be painted. The finished samples shall be approved by the Engineer.

Protection

Drop cloths or other approved protection materials shall be furnished and laid on all areas where distempering and finishing is being done so as to adequately protect floor and other places from all damages caused during the execution of the distempering work.

Surface preparation

All surfaces to be distempered shall be thoroughly cleaned of all grit, grease, dirt, loose materials, mortar drippings and the like.

The surface shall be given a thorough rub down to remove all loose materials and all cracks and surface irregularities shall be prepared with patching plaster and filler to obtain a smooth and even surface to the satisfaction of the Engineer. The filler shall always be spread from the same face of the filling knife, the other face shall be kept clean and free. Brush shall always be cleaned after use. Filler shall be applied before priming and the surface shall be rubbed before the application to ensure clean work and again after application on allowing 12 hours to dry.

The plastered surfaces shall be made smooth by sand papering and made free from marks before applying the first coat.

Voids and holes shall be filled after first the coat becomes dry by using filler compatible with the finishing specified and tinted, if required to camouflage repairs.

In the case of new cement plaster walls, a solution of 2 kg of zinc sulphate in 4 litres of water should be applied to the plastered surface and when dry should be given a coat of pure raw linseed oil; or the surface may be treated with dilute sulphuric or hydrochloric acid (1 part acid to 50 parts water) and then washed down with water. Cares shall be taken to ensure that acids are added to the water and not water to the acids.

Application of distemper

The workmanship for painting shall be of high quality and experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not suitable for the production of good results. All spaces shall be broom cleaned before distempering or finishing is started.

All distemper shall be applied with brushes under adequate illumination, evenly spread, smoothly flowed on without runs or sags. Distemper shall be worked into all corners and crevices.

Materials shall be applied in strict accordance with the manufacturer's directions. In particular, no prepared distemper shall be thinned by any method except as directed by the manufacturer. All distemper shall be thoroughly mixed before being applied.

Each coat shall be thoroughly dry before application of subsequent coat.

Drying time for every coat shall not be less than 72 hours and 48 hours for exterior and interior painting respectively.

Each coat applied, must be inspected and approved by the Engineer before the application of the succeeding coat. Otherwise, no credit for the coat applied will be given and the Contractor may require to repeat the work at his own expenses. The Contractor shall notify the Engineer when each coat is ready for inspection.

No exterior distempering shall be done in rainy and damp weather until the surface is thoroughly dry. No interior painting shall be done on damp surfaces.

Wherever scaffolding is necessary, it shall be free standing so as not to damage or scratch the painted surface.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during distempering.

Completion

At completion of distempering work, the Contractor shall remove any distemper spot and stain caused during the whole process of works as stated under this Sub-section from floors, walls, glass, hardware, equipment and other surfaces leaving these surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section and the Contractor shall repaint with distemper or retouch, as directed by the Engineer, any surface which do not comply with the requirements of these specifications or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from defects and blemishes.

All rubbish and accumulated painting materials shall be removed from the premises.

3.4.3.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually distempered with required quality in accordance with the provisions of the BOQ and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.3.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and distemper and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.3	Distempering plastered surface	Square meter

3.4.4 White washing

3.4.4.1 Description

Works covered under this item shall consist of white washing on the plastered wall or ceiling surfaces or at locations as directed by the Engineer in minimum 3 coats in accordance with these specifications, as per the provisions in the BOQ and/or as directed by the Engineer. White washing shall be done in a manner to obtain an even, smooth finish without any mark of brush and joint.

3.4.4.2 Materials

Limestone

Limestone is high calcium lime with about 6% material insoluble in acid, obtained by burning pure limestone or chalk in a kiln. Limestone shall be slaked as early as possible after it is burnt in a kiln. Stone lime should be stored in an enclosed space in large heaps and air excluded as far as possible. Un-slaked lime weighs 640 kilogram per cubic meter when fresh, increasing to about 800 kilogram per cubic meter after 10 days.

Shell lime

Shell lime is also high calcium lime with about 6% material insoluble in acid, obtained by burning seashells in a kiln.

Gum arabic

This is a kind of glue used as a binding agent between the white wash and the plaster surfaces.

Robin blue

Robin blue is a kind of manufactured ready-made blue available in packets from reputed manufacturer. This is required for maintaining the whiteness of the wash.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious to concrete or reinforcement and shall not contain any visibly solid material. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. All other requirements shall be similar to what have been stated under the relevant Sub-sections of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

3.4.4.3 Construction methods

Samples

White washing scheme shall conform the Finish Schedule and as directed by the Engineer. All matching shall be to the satisfaction of the Engineer.

For all finished white washing on plastered masonry and concrete surfaces, samples shall be prepared as per direction of the Engineer on the surfaces to be washed. The finished samples shall be approved by the Engineer.

Protection

Drop cloths or other approved protection materials shall be furnished and laid on all areas where white washing is being done so as to adequately protect floor and other places from all damage caused during the execution of the distempering work.

Surface preparation

All surfaces to be white washed shall essentially be thoroughly cleaned by removing all grit, grease, dirt, loose materials, mortar drippings and the like. It is better that some soap is added in the wash.

The surface shall be given a thorough rub down with a brush or by rubbing with an old gunny bag to remove all loose materials. All holes, cracks, surface irregularities and minor repairs shall be made good with patching plaster and lime putty to obtain a smooth and even surface to the satisfaction of the Engineer. Lime putty is obtained by slaking lime with water and sifting it. The filler shall be let dry for 24 hours before white washing. The filler shall always be spread from the same face of the filling knife, the other face shall be kept clean and free. Filler shall be applied before priming and the surface shall be rubbed before the application to ensure clean work and again after application on allowing 12 hours to dry.

The plastered surfaces shall be made smooth by sand papering and made free from marks before applying the prime coat.

In the case of new cement plaster walls, a solution of 2 kg of zinc sulphate in 4 litres of water should be applied to the plastered surface and when dry given a coat of pure raw linseed oil; or the surface may be treated with dilute sulphuric or hydrochloric acid (1 part acid to 50 parts water) and then washed down with water. Cares shall be taken to ensure that acids are added to the water and not water to the acids.

Preparation of white wash

The lime shall be brought to the Site in an un-slaked condition and thoroughly slaked on the spot, mixed and stirred with sufficient water and requisite amount of blue and gum to make a thin cream and allowed to stand for 24 hours. If 4 grams of gum (or shellac) and 50 grams of common salt dissolved in hot water are added to 1 kilogram of limestone for the last coat, the white wash will not easily rub off. Indigo (blue) upto 3 grams per kilogram of lime dissolved in water is added and the wash stirred well.

The lime is placed 30cm deep in a drum or a tub with about 90cm of water and allowed to stand for about 24 hours or such longer period as may be necessary to slake the lime completely. It is better to add lime to the water and not water to the lime. The mixture should be well stirred.

Lime is considered to be completely slaked when the temperature of the lime and the water ceases to rise and any further addition of water also produces no further chemical action or heat. As a precaution, water should be allowed to stand on for 12 hours or more. A vigorous slaking with heat and noise indicates a high calcium content. After slaking, the lime should be screened through a 3.35mm sieve or kept in excess of water to meet the requirements. Limes must be thoroughly slaked which is also ground very fine. Any un-slaked particles left will produce "blisters".

Application of white wash

The workmanship for white washing shall be of high quality. Experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not suitable for the production of good results. All spaces shall be broom cleaned before washing or finishing is started.

The lime wash should be strained through a course cloth or sieved through a fine wire gauge before applying.

All white washing shall be applied with brushes under adequate illumination, evenly spread, smoothly flowed on without runs or sags. White washing shall be worked in to all corners and crevices.

The coats shall be applied alternatively vertically and horizontally. One stroke is given from the top down-wards and the other from the bottom up-wards over the first stroke and similarly, one stroke from the right and another from the left over the first brush before it dries. Each coat shall be let to dry before applying the next coat.

White wash shall be applied on surfaces in two coats over a priming coat. The final coat shall be applied vertically and finished surface shall be free of dust, dirt and must be free from brush marks. The finished dry surface shall not readily come off on the hand when rubbed.

Brush shall always be cleaned after use.

Wherever scaffolding is necessary, it shall be free standing so as not to damage or scratch the painted surface.

Adequate precautionary measures shall be taken so as not to damage or stain floors, walls or any other works while applying white wash. Any damage, stains or spots caused by white washing shall be rectified and removed at the expenses of the Contractor.

Each coat applied must be inspected and approved by the Engineer before the application of the succeeding coat. Otherwise, no credit for the coat applied will be given and the Contractor may require to repeat the work at his own expenses. The Contractor shall notify the Engineer when each coat is ready for inspection.

No exterior washing shall be done in rainy and damp weather until the surfaces are thoroughly dry. No interior washing shall be done on damp surfaces.

Each coat shall be thoroughly dry before application of the subsequent coat.

Drying time for every coat shall not be less than 72 hours and 48 hours for exterior and interior washing respectively.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during white washing.

Completion

At completion of white washing, the Contractor shall remove any wash spot and stain caused during the whole process of works as stated under this Sub-section from floors, walls, glass, hardware, equipment and other surfaces leaving these surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section and the Contractor shall rewash or retouch any surface, which do not comply with the requirements of these specifications or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from defects and blemishes.

All rubbish and accumulated painting materials shall be removed from the premises.

3.4.4.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually white washed with required quality in accordance with the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.4.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and all white washing materials and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.4	White washing	Square meter

3.4.5 Colour washing

3.4.5.1 Description

Works covered under this item shall consist of colour washing on the plastered wall or ceiling surfaces or at locations as directed by the Engineer in minimum 3 coats in accordance with these specifications, as per the provisions in the BOQ and/or as directed by the Engineer. Colour washing shall be done in a manner to obtain an even, smooth finish without any mark of brush and joint.

3.4.5.2 Materials

Lime stone

Limestone is high calcium lime with about 6% material insoluble in acid, obtained by burning pure limestone or chalk in a kiln. Limestone shall be slaked as early as possible after it is burnt in a kiln. Stone lime should be stored in an enclosed space in large heaps and air excluded as far as possible. Un-slaked lime weighs 640 kilogram per cubic meter when fresh, increasing to about 800 kilogram per cubic meter after 10 days.

Shell lime

Shell lime is also high calcium lime with about 6% material insoluble in acid, obtained by burning seashells in a kiln.

Gum arabic

This is a kind of glue used as a binding agent between the white wash and the plaster surfaces.

Colour

Mineral colours, not affected by lime, shall be added to white wash instead of indigo (blue).

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious to concrete or reinforcement and shall not contain any visibly solid material. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. All other requirements shall be similar to what have been stated under the relevant Sub-sections of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

3.4.5.3 Construction methods

Samples

Colour washing scheme shall conform the Finish Schedule and as directed by the Engineer. All tinting and matching shall be to the satisfaction of the Engineer.

For all finished colour washing on plastered masonry and concrete surfaces, samples shall be prepared as per direction of the Engineer on the surfaces to be washed. The finished samples shall be approved by the Engineer.

Protection

Drop cloths or other approved protection materials shall be furnished and laid on all areas where colour washing is being done so as to adequately protect floor and other places from all damage caused during the execution of the distempering work.

Surface preparation

All surfaces to be colour washed shall essentially be thoroughly cleaned through removing all grit, grease, dirt, loose materials, mortar drippings and the like. It is better that some soap is added in the wash.

The surfaces shall be given a thorough rub down with a brush or by rubbing with an old gunny bag to remove all loose materials. All holes, cracks, surface irregularities and minor repairs shall be made good with patching plaster and lime putty to obtain a smooth and even surface to the satisfaction of the Engineer. Lime putty is obtained by slaking lime with water and sifting it. The filler shall be let dry for 24 hours before colour washing. The filler shall always be spread from the same face of the filling knife, the other face shall be kept clean and free. Filler shall be applied before priming and the surface shall be rubbed before the application to ensure clean work and again after application on allowing 12 hours to dry.

The plastered surfaces shall be made smooth by sand papering and made free from marks before applying the prime coat.

In the case of new cement plaster walls, a solution of 2 kg of zinc sulphate in 4 litres of water should be applied to the plastered surface and when dry given a coat of pure raw linseed oil; or the surface may be treated with dilute sulphuric or hydrochloric acid (1 part acid to 50 parts water) and then washed down with water. Cares shall be taken to ensure that acids are added to the water and not water to the acids.

Preparation of colour wash

The lime shall be brought to the Site in an un-slaked condition and thoroughly slaked on the spot, mixed and stirred with sufficient water and requisite amount of colour and gum to make a thin cream and allowed to stand for 24 hours. If 4 grams of gum (or shellac) and 50 grams of common salt dissolved in hot water are added to 1 kilogram of limestone for the last coat, the colour wash will not easily rub off. Mineral colour in requisite quantity per kilogram of lime dissolved in water is added and the wash stirred well.

The lime is placed 30cm deep in a drum or a tub with about 90cm of water and allowed to stand for about 24 hours or such longer period as may be necessary to slake the lime completely. It is better to add lime to the water and not water to the lime. The mixture should be well stirred.

Lime is considered to be completely slaked when the temperature of the lime and the water ceases to rise and any further addition of water also produces no further chemical action or heat. As a precaution, water should be allowed to stand on for 12 hours or more. A vigorous slaking with heat and noise indicates high calcium content. After slaking, the lime should be screened through a 3.35mm sieve or kept in excess of water to meet the requirements. Limes must be thoroughly slaked which is also ground very fine. Any un-slaked particles left will produce "blisters".

Application of colour wash

The workmanship for colour washing shall be of high quality. Experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not suitable for the production of good results. All spaces shall be broom cleaned before washing or finishing is started.

The colour wash should be strained through a course cloth or sieved through a fine wire gauge before applying.

All colour washing shall be applied with brushes under adequate illumination, evenly spread, smoothly flowed on without runs or sags. Colour washing shall be worked in to all corners and crevices.

The coats shall be applied alternatively vertically and horizontally. One stroke is given from the top down-wards and the other from the bottom up-wards over the first stroke and similarly, one stroke from the right and another from the left over the first brush before it dries. Each coat shall be let to dry before applying the next coat.

Colour wash shall be applied on the surfaces in two coats over a prime coat. The prime coat for the colour wash shall be of white wash with lime or with whiting. The final coat shall be applied vertically and finished surface shall be free of dust, dirt and must be free from brush marks. The finished dry surface shall not readily come off on the hand when rubbed.

In replacing one colour with another, a coat of white wash shall be given or the old paint scraped off, before the new colour is given. Gum or rice water shall be added as for white washing.

Brush shall always be cleaned after use.

Wherever scaffolding is necessary, it shall be free standing so as not to damage or scratch the painted surface.

Adequate precautionary measures shall be taken so as not to damage or stain floors, walls or any other work while applying white wash. Any damage, stains or spots caused by colour washing shall be rectified and removed at the expenses of the Contractor.

Each coat applied must be inspected and approved by the Engineer before the application of the succeeding coat. Otherwise, no credit for the coat applied will be given and the Contractor may require to repeat the work at his own expenses. The Contractor shall notify the Engineer when each coat is ready for inspection.

No exterior washing shall be done in rainy and damp weather until the surfaces are thoroughly dry.

No interior washing shall be done on damp surfaces.

Each coat shall be thoroughly dry before application of subsequent coat.

Drying time for every coat shall not be less than 72 hours and 48 hours for exterior and interior washing respectively.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during application of colour wash.

Completion

At completion of colour washing, the Contractor shall remove any wash spot and stain caused during the whole process of works as stated under this Sub-section from floors, walls, glass, hardware, equipment and other surfaces leaving these surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section and the Contractor shall rewash or retouch any surface, which do not comply with the requirements of these specifications or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from defects and blemishes.

All rubbish and accumulated painting materials shall be removed from the premises.

3.4.5.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually colour washed with required quality in accordance with the provisions of the BOQ and/or shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.5.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and all colour washing materials and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.5	Colour washing	Square meter

3.4.6 Coloured cement painting

3.4.6.1 Description

Works covered under this item shall consist of applying coloured cement paint on the wall or ceiling plaster or at any other locations as directed by the Engineer. Cement paint of any approved brand and colour shall be used in minimum 2 coats over a coat of priming in accordance with these specifications as per the provisions in the BOQ and/or as directed by the Engineer or as specified by the manufacturers. Painting shall be done in a manner to obtain an even, smooth finish of confirm shade and without any mark of brush and joint.

3.4.6.2 Materials

Cement powder

Cement powder shall be manufactured of the best quality and of approved colour supplied in original sealed containers bearing the manufacturers labels and seals and be delivered at the Site.

Materials to be used in the work shall conform to the reputed manufacturer's specifications and to the satisfaction of the Engineer.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious to concrete or reinforcement and shall not contain any visibly solid material. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. All other requirements shall be similar to what have been stated under the relevant Sub-sections of the Sections on 'Concrete Work' and 'Construction Materials' of this Specification.

3.4.6.3 Construction methods

General

Before purchasing materials, the Contractor shall submit to the Engineer a list showing the brand and type of cement powder proposed for this item of work. Manufacturer's catalogue or specification sheets, in triplicate, for materials selected shall be submitted to the Engineer with the list of brands and types. No material shall be used without the approval of the Engineer.

Samples

Coloured cement painting scheme shall conform the Finish Schedule and as directed by the Engineer. All tinting and matching shall be to the satisfaction of the Engineer.

For all finished coloured cement painting on plastered masonry and concrete surfaces, samples shall be prepared as per direction of the Engineer on the surfaces to be painted. The finished samples shall be approved by the Engineer.

Protection

Drop cloths or other approved protection materials shall be furnished and laid on all areas where painting is being done so as to adequately protect floor and other places from all damages caused during the execution of the coloured cement painting.

Surface preparation

All surfaces to be painted shall essentially be thoroughly cleaned through removing all grit, grease, dirt, loose materials, mortar drippings and the like. It is better that some soap is added in the wash.

The surfaces shall be given a thorough rub down with a brush or by rubbing with an old gunny bag to remove all loose materials. All holes, cracks, surface irregularities and minor repairs shall be made good with patching plaster and lime putty to obtain a smooth and even surface to the satisfaction of the Engineer. Lime putty is obtained by slaking lime with water and sifting it. The filler shall be let dry for 24 hours before colour painting. The filler shall always be spread from the same face of the filling knife, the other face shall be kept clean and free. Filler shall be applied before priming and the surface shall be rubbed before the application to ensure clean work and again after application on allowing 12 hours to dry.

The plastered surfaces shall be made smooth by sand papering and made free from marks before applying the prime coat.

In case of any inconsistency with the manufacturer's instructions, the manufacturer's instructions shall prevail.

Preparation of paint

The paint shall be prepared by mixing and stirring coloured cement powder, sand/lime as per manufacturer's specifications and water in such quantities as will produce a mixture of the consistency of thin cream. When sufficiently mixed, the mixture shall be strained through a clean coarse cloth.

Application of paint

The workmanship for coloured cement painting shall be of high quality and experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not suitable for the production of good results. All spaces shall be broom cleaned before washing or finishing is started.

All painting shall be applied with brushes under adequate illumination, evenly spread, smoothly flowed on without runs or sags. Painting shall be worked into all corners and crevices.

Painting shall be applied on the surfaces in two coats over a prime coat. The prime coat shall be of white wash with lime or with whiting. The coats shall be applied alternately vertically and horizontally. The final coat shall be applied vertically and finished surface shall be free from dust, dirt and must be free of brush marks. The finished dry surface shall not readily come off on the hand when rubbed.

In replacing one colour with another, a coat of white wash shall be given or the old paint scraped off, before the new colour is given. Gum or rice water shall be added as for white washing.

Brush shall always be cleaned after use.

Wherever scaffolding is necessary, it shall be free standing so as not to damage or scratch the painted surface.

Adequate precautionary measures shall be taken so as not to damage or stain floors, walls or any other work while applying paint. Any damage, stains or spots caused by coloured cement painting shall be rectified and removed at the expenses of the Contractor.

Each coat applied must be inspected and approved by the Engineer before the application of the succeeding coat. Otherwise, no credit for the coat applied will be given and the Contractor may require to repeat the work at his own expenses. The Contractor shall notify the Engineer when each coat is ready for inspection.

No exterior painting shall be done in rainy and damp weather until the surface is thoroughly dry. No interior painting shall be done on damp surfaces.

Each coat shall be thoroughly dry before application of subsequent coat.

The washing shall be done with good hairbrush and not with brush made of jute.

Proper curing shall be done at least for 7 days on application of the final coat and/or as per instructions of the manufacturer.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during application of paint.

In case of any inconsistency with the manufacturer's instructions, the manufacturer's instructions shall prevail.

Completion

At completion of coloured cement painting, the Contractor shall remove any paint spot and stain caused during the whole process of works as stated under this Sub-section from floors, walls, glass, hardware, equipment and other surfaces leaving these surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section and the Contractor shall repaint or retouch, as directed by the Engineer, any surface which do not comply with the requirements of these specifications or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from defects and blemishes.

All rubbish and accumulated painting materials shall be removed from the premises.

3.4.6.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually painted with required quality in accordance with the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.6.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and all painting materials and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities and/or as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.6	Coloured cement painting	Square meter

3.4.7 Water repellent painting

3.4.7.1 Description

Works covered under this item shall consist of applying two coats of clean silicon water repellent on exposed brick or concrete surfaces and cement rendered on wall, ceiling and at any other locations in accordance with these specifications, as per the provisions in the BOQ and/or as directed by the Engineer or as specified by the manufacturers.

3.4.7.2 Materials

Silicon water repellent shall consist of sodium silicate or other alkaline silicates based clear approved product supplied in original sealed containers bearing the manufacturer's trade mark.

All silicon water repellent painting materials shall be of the best quality and be delivered at the Site in sealed original containers bearing manufacturer's labels and seals.

Materials to be used in the work shall conform to the reputed manufacturer's specifications and to the satisfaction of the Engineer.

3.4.7.3 Construction methods

General

Before purchasing materials, the Contractor shall submit to the Engineer a list showing the brand and type of silicon water repellent proposed for this item of work. Manufacturer's catalogue or specification sheets, in triplicate, for materials selected shall be submitted to the Engineer with the list of brands and types. No material shall be used without the approval of the Engineer.

Samples

For all finished silicon water repellent painting on masonry and concrete surfaces, samples shall be prepared as per direction of the Engineer on the surfaces to be painted. The finished samples shall be approved by the Engineer.

Protection

Drop cloths or other approved protection materials shall be furnished and laid on all areas where colour washing is being done so as to adequately protect floor and other places from all damages during the execution of the painting.

Surface preparation

All surfaces to be silicon water repellent painted shall essentially be thoroughly cleaned by removing all grit, grease, dirt, loose materials, mortar drippings and the like.

The surfaces shall be given a thorough rub down with a brush or by rubbing with an old gunny bag to remove all loose materials. All holes, cracks, surface irregularities and minor repairs shall be prepared in such a manner so as to provide a smooth and even surface to the satisfaction of the Engineer.

Application of silicon water repellent paint

The workmanship for silicon water repellent paint shall be of high quality and experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not suitable for the production of good results. All spaces shall be neatly cleaned before painting or finishing starts.

All silicon water repellent paints shall be applied with brushes under adequate illumination, evenly spread and smoothly flowed on. Silicon water repellent paint shall be worked into all corners and crevices.

The application of water repellent coat shall strictly comply with the manufacturer's instruction. The application shall preferably be carried out after a period of dry weather and before application, the surface shall be thoroughly cleaned and dried. A heavy coat shall be applied evenly direct from the container by flooding the surface with a wide brush so that at least 6mm penetration is achieved. A second coat shall be applied in the similar manner, which shall follow after 24 hours.

Brush shall always be cleaned after use.

Wherever scaffolding is necessary, it shall be free standing so as not to damage or scratch the painted surface.

Adequate precautionary measures shall be taken so as not to damage or stain floors, walls or any other work while applying the paint. Any damage, stains or spots caused by painting shall be rectified and removed at the expenses of the Contractor.

Each coat applied must be inspected and approved by the Engineer before the application of the succeeding coat. Otherwise, no credit for the coat applied will be given and the Contractor may require to repeat the work at his own expenses. The Contractor shall notify the Engineer when each coat is ready for inspection.

No exterior painting shall be done in rainy and damp weather until the surface is thoroughly dry. No interior painting shall be done on damp surfaces.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during painting.

Completion

At completion of silicon water repellent paint the Contractor shall remove any wash spot and stain caused during the whole process of works as stated under this Sub-section from floors, walls, glass, hardware, equipment and other surfaces leaving these surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section, and/or as per provision of the BOQ and the Contractor shall re-paint or retouch, as directed by the Engineer, any surface which do not comply with the requirements of these specifications and/or the provisions of the BOQ or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from all defects and blemishes.

All rubbish and accumulated painting materials shall be removed from the premises.

3.4.7.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually painted with silicon water repellent of required quality in accordance with the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.7.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport all silicon water repellent materials and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.7	Water repellent paint	Square meter

3.4.8 Varnishing

3.4.8.1 Description

Works covered under this item shall consist of varnishing to the surfaces of wood works in three coats in accordance with these specifications, as per the provisions of the BOQ and/or as directed by the Engineer.

3.4.8.2 Materials

Oil varnish

This is a kind of varnish belonging to the class 'Oil Varnish'. The essential constituent is 'resin' or rosin which is dissolved in oils, turpentine, or alcohol. Shellac, Gum Arabic, Rosin and Amber. Resins are most commonly used for preparation of varnishes. Various types of varnishes are obtainable in the market, each suited to a specific work. Preparation of varnishes is a difficult matter and it is best to purchase ready-made.

Storage of materials

Materials and tools shall be stored in a single place at the Site as designated by the Engineer.

Storage area shall be maintained in a neat and clean condition with surroundings protected from damage.

Inflammable materials shall be stored in sealed containers. Waste shall be removed from the premises at the end of each day's work. Every precaution shall be taken to prevent fire.

Storage area shall be all time accessible to the Engineer.

3.4.8.3 Construction methods

3.4.8.3.1 Samples

Before starting full scale finishing work, sample finishing shall be done on similar wooden surfaces on an area of 300mm x 300mm and shall receive the approval of the Engineer.

Modifications, if required, in the above specimen shall be done depending on the outcome of sample work.

No payment will be made unless samples are made beforehand and approval of the Engineer is received for the same.

3.4.8.3.2 Surface preparation

Wood, surfaces that would be varnished, shall be well seasoned. The surfaces to be varnished shall be perfectly dry.

The process of preparing the surfaces shall include removal of all machine and plain marks and defects that will make an imperfect surface. Unless the surface is perfectly smooth and free from defects, varnish shall not be applied.

The following rules shall be maintained in preparing the wood surfaces.

- ☐ Before assembling the work, all marks shall be removed from the visible parts with a plane or cabinet scraper.
- ☐ All traces of glue from around the joints shall be removed.
- ☐ Defects, such as cracks and holes that can not be removed, shall be filled with stick shellac or its equivalent.
- ☐ After the shellac or its equivalent hardens, it shall be placed down until it is nearly leveled with the adjoining surfaces.

The surfaces then shall be scraped and sanded thoroughly. Emery paper shall be used as abrasive. Four grades of abrasive paper shall be used successively in the order of No. 2, No. 1, No. 0 and No.

00. Sand papering shall be done with the grain. When thoroughly sand papered, the dust shall be brushed off with a stiff brush and inspected to see if the surfaces are free from all blemishes. It shall then be rubbed with a clean woolen rag.

Before application of varnish or painting, all articles shall receive inspection and approval of the Engineer.

3.4.8.3.3 Application

Type of finish

Unless otherwise specified wooden surfaces shall receive clear shellac varnish.

Finishing materials

Fillers shall be White Zinc or natural paste fillers.

Sealers shall be of shellac wash coat. This is a mixture of seven parts alcohol to one part shellac, using Two-Pound-Cut shellac. Two-Pound-Cut shellac means that there are 1.8 kg of shellac mixed to 4.5 liters of alcohol.

Finish shall be done with a mixture of equal amount of alcohol and Four-Pound-Cut shellac.

Benzene shall be used as a cleaning fluid.

Application method

Fillers made in the form of heavy paste by adding desired amount of turpentine shall be applied with a stiff brush, brushing first with the grain and then across it, covering only a small area at a time. It shall be allowed to dry for a few minutes until it loses its glossy appearance.

Excess fillers shall be wiped off across the grain with rough cloth. The surface shall then be rubbed down with the grain lightly with soft cloth to remove the excess. It should be pressed in such hardness so that the filler is not wiped off the pores.

Finishing shall be applied only after the filler has dried up.

Clean shellac varnish shall be applied with a good quality brush, 40mm to 75mm wide. Varnishing shall start near the center and top of a vertical surface or the middle of a horizontal surface, quickly brushing out in long sweeping strokes without going over the same area several times as shellac dries out vary rapidly.

Brushing should be done towards the edges and care should be taken not to allow the shellac to run over the edges and pile up. It shall then be allowed to dry for 3 to 4 hours. The surface shall be lightly rubbed down with No.00 dry abrasive paper along the grain.

Grit and dust shall be removed with soft cloth before applying the second coat with slightly reduced alcohol mixture. It shall then be allowed to dry and rubbed down lightly with No.00 dry abrasive paper along the grain.

Grit and dust shall be removed again before applying the third coat with 25 percent alcohol mixture.

After the last coat dries up, the surface shall be wiped out lightly with Benzene.

The workmanship for varnishing shall be of high quality for this purpose, experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not congenial for the production of good results. All spaces shall be broom cleaned before varnishing or finishing starts.

All varnish shall be applied under adequate illumination. Varnish shall be worked into all corners and crevices.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during varnishing.

Completion

At completion of varnishing work, the Contractor shall remove any varnished spot and stain caused during the whole process of works as stated under this Sub-section leaving the surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section and as per provisions of the BOQ. The Contractor shall re-varnish or retouch, as directed by the Engineer, any surface which does not comply with the requirements of these specifications, as per provisions of the BOQ or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from defects and blemishes.

All rubbish and accumulated varnishing materials shall be removed from the premises.

3.4.8.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually varnished with required quality in accordance with the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.8.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and varnish and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.8	Varnishing	Square meter

3.4.9 French polishing

3.4.9.1 Description

Works covered under this item shall consist of French polishing to the surfaces of wood works in three coats over a coat of priming in accordance with these specifications, as per the provisions of the BOQ and/or and/or as directed by the Engineer.

3.4.9.2 Materials

Spirit varnish

It belongs to the class of Spirit Varnish. It is prepared by dissolving ¼ kilo-gram of shellac in ½ litre of methylated spirit or naphtha and straining the solution through a double thickness of coarse muslin. A number of other recipes are also in use.

Storage of materials

Materials and tools shall be stored in a single place at the site as designated by the Engineer.

Storage area shall be maintained in a neat and clean condition with surroundings protected from damage.

Inflammable materials shall be stored in sealed containers. Waste shall be removed from the premises at the end of each day's work. Every precaution shall be taken to prevent fire.

Storage area shall be all time accessible to the Engineer.

3.4.9.3 Construction methods

Samples

Before starting full scale finishing work, sample finishing shall be done on similar wooden surfaces that shall receive the approval of the Engineer.

Modifications, if required, in the above specimen shall be done depending on the outcome of sample work.

No payment will be made unless samples are made beforehand and approval of the Engineer is received for the same.

Surface preparation

Wood, surfaces that are to be polished, shall be well seasoned. The surfaces to be polished shall be perfectly dry.

The surfaces of woodwork to be polished should be rubbed down perfectly smooth with medium and fine grade sandpaper. All rubbing shall be done with the grain.

Application

The workmanship for polishing shall be of high quality and experienced and skilled painters shall be engaged for the work.

No work shall be done under conditions, which are not congenial for the production of good results. All spaces shall be broom cleaned before polishing or finishing is started.

All polish shall be applied under adequate illumination. Polishing shall be worked into all corners and crevices.

When wood becomes dry, all cracks and holes are to be filled up with putty and the whole surfaces are rubbed down with sandpaper and allowed to be hard. The surfaces shall be painted first with a filler composed of 3 kilo-gram of whiting mixed in 3 litres of methylated spirit and then sand papered when dried. The polish then be applied to the wood surfaces with a polishing pad of soft cloth containing absorbent cotton filling. Application shall be made by light strokes along the grain. Several coats may be necessary before the desired shine and finish is achieved. The pad shall be dabbed with a drop of olive or mustard oil after each coat in order to allow a smooth working and finish.

Fillers can also be made in other ways as mentioned below:

- ☐ Whiting mixed with water
- ☐ Three parts linseed oil and one part bees wax boiled
- ☐ Plaster of Paris either in water or raw linseed oil

Frequent applications of raw linseed oil rubbed in well rags will give a very fine polish to the wood surfaces.

A good furniture polish can be made of equal parts of vinegar and linseed oil or better vinegar and olive oil in the same proportions as this mixture is less sticky than the former.

The Contractor shall rectify at his own expenses any damage that may be caused to the adjacent works during polishing.

Completion

At completion of polishing work, the Contractor shall remove any polished spot and stain caused during the whole process of works as stated under this Sub-section leaving the surfaces in perfect condition.

The Engineer shall conduct a final inspection of all works completed in accordance with this Sub-section and as per provisions of the BOQ. The Contractor shall re-polish or retouch, as directed by the Engineer, any surface which does not comply with the requirements of these specifications, as per provisions of the BOQ or which have been damaged during performing works. All surfaces finished under this Sub-section shall be left in perfect condition, free from defects and blemishes.

All rubbish and accumulated polishing materials shall be removed from the premises.

3.4.9.4 Measurement

Measurement shall be taken for payment in square meter of the surface area actually French polished with required quality in accordance with the provisions of the BOQ and/or as shown on the Drawings and/or as directed by the Engineer. Only the completed works as accepted by the Engineer will be eligible for payment.

3.4.9.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and French polish and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.4.9	French polishing	Square meter

3.5 DOORS, WINDOWS AND CEILINGS

3.5.1 Wood work for door/window frames and shutters

3.5.1.1 Description

Works covered under this item shall consist of furnishing, finishing and installing of wooden door/window frames and shutters of the size and shape shown on the Drawings and/or as specified in the Bill of Quantities and/or as directed by the Engineer including supplying and fixing of all finished hardware and glazing.

3.5.1.2 General requirements

Design drawings

Design Drawings shall be thoroughly studied by the Contractor before the Work is commenced. Detail of joints as shown on the Drawings must be specifically checked. If any detail description or specification is found missing or in the opinion of the Contractor inadequate, inconsistent or otherwise, the Contractor shall draw the same to the attention of the Engineer who may make necessary arrangements as deemed fit. On no account, the Contractor shall use his own judgment when any discrepancy is noticed in the Drawings, details and descriptions.

Shop drawings

Detailed Shop Drawings of doors and windows and other wooden works including glazing and installation details, when required, shall be submitted to the Engineer for approval.

Shop Drawings shall include the submission of manufacturer's literature, brochures and delivery date for all finish hardware and manufacturer's literature or specification for glass.

Fabrication of wooden doors/windows shall not start until the Engineer approves the Shop Drawings.

Samples

Within 35 days (or as may be specified otherwise) following the Contract is awarded, the Contractor shall furnish the Engineer, for his approval, a complete list in 4 copies of all hardware proposed for use under the Contract, scheduling all hardware for every door/window.

The Contractor shall submit to the Engineer two pieces of wood specimens, each of size 150mm x 250mm x 25mm, for his approval.

The Contractor shall submit to the Engineer one sample of each type of finished hardware for doors and windows for his approval. However, the hardware shall be of the quality equal to or better than the samples, if available in the Engineer's office.

The Contractor shall submit to the Engineer two pieces of glass sample, each of size 150mm x 200mm and of required thickness proposed for glazing for his approval. The samples shall bear the name of the manufacturer, thickness and the type of glass.

All approved samples may be kept at Site for comparing the materials supplied by the Contractor.

The works of this Sub-section shall not commence until the samples get approval of the Engineer.

3.5.1.3 Other requirements

Dimensions shown on the Drawings are finished dimensions. In sizing rough components, necessary allowance, therefore, must be kept for the working loss arising from planing, smoothening and finishing.

Requisite precautionary measures against fire, denting, breakage or loss must be ensured while the articles are in transit and till the supply is completed.

Polishing or painting, as the case may be, shall be done at Site on receiving approval of the woodwork, carpentry etc. by the Engineer. The working area shall be cleaned properly before the finishing works start and subsequently before each day's work to ensure reasonably dust-free surroundings.

Particulars of the workshop, working area and storage space must be furnished to the Engineer, which shall be checked by him. If required, modifications shall be made as instructed by the Engineer to ensure proper atmosphere and amenities.

The Contractor shall provide adequate locked-up storage space. The Contractor shall replenish all lost or damaged hardware at his own expenses.

In case of inflicting injury to any part of the building/other works while installing, the Contractor shall rectify the same employing proper workers of the trade and furnishing all requisite materials at his own expenses.

The Contractor shall keep the Employer indemnified against all charges, which may arise out of this Contract in case of procurement of timbers from local sources.

3.5.1.4 Materials

3.5.1.4.1 Timber

General

Timber, only as specified on the Drawings and Bill of Quantities, shall be used. Timber used for woodwork shall be well seasoned, kiln dry containing not more than 8% to 12% moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects, such as large or loose knots, saps, shakes, upsets, wane edge and twisted fibre. It shall also be free from all diseases such as decay, wet rot, dry rot, woodworms and white ant. Timber shall be finished to the exact dimensions shown on the Drawings or as directed by the Engineer. The pieces of wood shall be properly finished by planer and other tools before joining and the completed wood works shall be accepted by the Engineer before fixing those in position.

Wood for frame

High quality, well-seasoned Garjan, Jarul, Local Sal, Shilkarai/Chikrashi, Telsu and Teak Chambol or any other equivalent type of wood as approved by the Engineer, shall be used for frame work or any other related works required.

Wood veneered flash door shutter

Jack wood, Gamari and Chapalish wood, Teak Chambol wood and Chittagong Teak wood veneered flash door shall be used for door shutter or sash or any other related works required. Any other equivalent type of wood may be used when it is required by the Engineer.

Wood for solid door shutter

High quality Jack wood, Chittagong Teak wood, Gammari and Chapalish wood and Teak Chambol wood or any other equivalent type of wood, as approved by the Engineer, shall be used for solid door shutter or any other related works required.

Wood for panel door shutter

High quality Jack wood, Chittagong Teak wood Gammari and Chapalish wood and Teak Chambol wood or any other equivalent type of wood, as approved by the Engineer, shall be used for solid door shutter or any other related works required.

3.5.1.4.2 Finish hardware

Materials and finish

Two sets of complete list indicating the manufacturer's name, brand name, type, size and location of all hardware to be installed shall be submitted to the Engineer for his approval. No hardware shall be ordered until the Engineer has approved this list.

Unless otherwise specified on the Drawings and in the Bill of Quantities or directed by the Engineer, specifications of the finish hardware shall be as follows:

Door hinges

Hinges shall be locally available, best quality iron or brass hinge of 100mm size and attached with No. 8 steel screw 32mm long, as approved by the Engineer or as directed by him.

Door stopper

Door stopper shall be made of timber as specified previously in the relevant portion of this Sub-section and shall be 100mm long to act as a stopper to keep the door in open position. Cleat with 65mm steel hinge, "Lion" brand or approved equal shall be fixed with No. 6 steel screws 20mm long, "Diamond" or "Star" brand or equal standard approved by the Engineer or as directed by him. One cleat to be furnished for each leaf as approved by the Engineer.

PVC buffer block

PVC buffer block shall be locally available best quality PVC block 38mm diameter and attached to wall with No.8 steel screw 50mm long, "Diamond" or "Star" brand or approved equal or as directed by the Engineer. One block to be furnished for each leaf as approved by the Engineer.

Door handle

Door handle shall be locally available best quality chromium or nickel plated 150mm long, attached with No.7 steel screw 25mm long or as directed by the Engineer. Two handles to be furnished for each door, one inside and one outside as approved by the Engineer.

Door tower bolts

Door tower bolts shall be locally available best quality 250mm and 200mm brass or iron bolts fitted on the interior side of the door leaf. 250mm long bolts shall be fitted at the top of the leaf vertically and the 200mm long bolts shall be fitted at the bottom of the door leaf horizontally. The 250mm and 200mm tower bolts shall be fitted with No. 6 brass screw 20mm long and as approved by the Engineer.

Hatch bolt

Hatch bolt shall be locally available best quality brass or iron bolt 300mm long fixed with approved bolts and nuts fitted on the outside of the door for locking arrangement as per direction of the Engineer.

Window hinge

Window hinge shall be locally available best quality 100mm iron hinge, "Lion" brand or approved equal, 75mm x 50mm in size and fixed with No. 7 steel screw 25mm long "Diamond" or "Star" brand or approved equal or as directed by the Engineer. Three hinges shall be furnished per window.

Window handles

Window handles shall be locally available best quality Chromium plated 100mm long, "Lion" brand or approved equal or as directed by the Engineer. One handle shall be furnished for each leaf at the centre on the inside.

Windows catch hook

Window catch hook shall be locally available best quality, "Diamond" brand or approved equal, galvanized iron 225mm long or as directed by the Engineer. One catch hook shall be furnished for each leaf.

Window tower bolt

Window tower bolt shall be locally available best quality iron, "Diamond" brand or approved equal. Tower bolts 150mm long be fitted on the interior side of the window leaf. Tower bolts shall be fixed with No. 5 steel screw 20mm long, "Diamond" or "Star" brand or approved equal or as directed by the Engineer and fixed vertically one each at the top and bottom on the interior side of the leaf to close the window from inside.

Glass

All glass shall be the approved best quality locally available sheet glass unless otherwise specified and shall be of the various sizes and thickness as shown on the Drawings and Bill of Quantities. All glass shall be free from bubbles, distortion and flaws of every kind with even surface and free from all other imperfections. Each piece of glass shall bear a label indicating the name of the manufacturer, the thickness and the type of glass. Label shall remain on the glass till they are cleaned finally on completion of work.

Lock sets

All Lock sets shall be of the best quality 'Yale' brand door lock or approved equal in perfect operating conditions or as directed by the Engineer, if not shown on the Drawings or mentioned elsewhere. Strikes shall be used where required to protect trim from being marred by hatch bolt. Three keys shall be furnished with proper identification for each lock set.

3.5.1.5 Joinery

Joints shall be made according to the sizes and profiles as shown on the Drawings.

No extra nails or screws, other than those used in the approved samples, shall be used. Nails and screws to be used on finished surfaces shall be fitted slightly below the surface. Polyvinyl acetate adhesive of 'Aica Aibon' brand or other equivalent brand shall be used where use of adhesive is required or instructed. Wooden pins, where required or instructed, shall be of the same specimen, perfectly round and pressure fitted in the holes which shall be circular.

All joints shall be of such true-fit that they will not be discernible from a distance of one meter.

Layout of the joints shall be made by using accurate instruments. A knife can be used whenever a line is to be cut. A sharp pencil can be used for all layouts and specially when part of the area is to be cut away. All measurements shall be made from a common starting point, edge or surface. All identical joints shall be laid out at the same time. Two members of each joint shall always be identified with a pencil mark for quick identification during assembling.

Right instrument or machine shall be used for each cut. The cut shall always be made just inside or outside the layout line. The joints shall be trimmed out with a router plane or chisel when necessary.

Proper type of clamping devices shall be used for assembling the joint. A trial assembly shall be made to make sure that each joint shall fit properly. A correct method of fastening shall have to be determined. The same shall be completely square and aligned when properly assembled.

3.5.1.6 Gluing up

The stock shall be glued together where necessary. The glue shall be of 'Aica Aibon' brand Polyvinyl-acetate emulsion adhesive or its equivalent quality. The grain of all the pieces shall run in the same direction. The edge of gluing stock shall be of the same maturity and strength.

Good glue must develop the full strength of the wood under all condition stress. To obtain this result, it is necessary to control the gluing operation as well as the condition of the material. The moisture content before gluing shall not be too low or too high.

The average moisture content of wood is about twelve percent. High quality glue joints can not be made on wet wood. The moisture content of timber shall be checked through each step of manufacturing preferably with an electrical Moisture Meter.

The following points must be checked in order to ensure proper gluing:

- ☐ Parts of the assembly are at proper moisture content and temperature.
- ☐ Gluing surfaces have been made smooth, free from irregularities and even as much as possible.
- ☐ All joints have been placed under equal pressure.
- ☐ Excess glue has been removed before machining.

3.5.1.7 Fabrication and installation

All materials and finish shall get the approval of the Engineer before they are installed. All hardware and accessories shall be purchased in the manufacturer's original packages complete with all required trimmings. They shall conform to the requirements of the specifications and no substitution shall be made for the samples submitted without prior approval of the Engineer. Required templates shall be submitted for proper installation.

All wood works shall be fabricated and installed in a way to conform to the details and dimensions indicated on the Drawings in the Bill of Quantities and as directed by the Engineer.

All hardware and accessories shall be of best stainless and non-corroding variety of screws, bolts, nuts and other fastenings and approved by the Engineer before attaching them. These shall be of the same finish as the material, which they attach and shall be of the type and standard of the manufacturer.

All items of finish hardware and accessories shall be carefully fitted and adjusted to ensure smooth operation. All items of finish hardware and accessories shall be in perfect operating condition and undamaged while installing.

Door/window frames shall be properly cut, housed together and jointed with 'mortice' and 'tenon' joints. The frames shall be rabbeted on one side by a cut measuring 13mm in one direction and the full thickness of the shutter in the other. Frames shall be plumbed and leveled with corners at right angles. All exposed surfaces shall be smoothened with sandpaper. Back faces of wood, remaining in contact with or against concrete or masonry, shall be treated with a minimum of two coats of wood preservation paint, such as creosote or solignum. Wood preservatives, to be used, shall be approved by the Engineer.

The frame shall be fitted vertically in position true and plumb and fixed with clamps made with M.S. angle iron of size 375mm x 40mm x 6mm set in cement concrete within the masonry wall. There shall be six clamps for door frames and four clamps for window frames in general. However, the number and the size of the clamps shall conform to the requirements of the Drawings and as specified in the

Bill of Quantities. The clamps shall be fitted by filling the recess properly so as to fit the frame nicely with the wall.

Door sash shall be of panel design and made as shown on the Drawings. Panel-sash frame shall be housed and jointed with mortise and 'tenon' joints. Panels for doors shall be solid wood, placed properly in retaining grooves with 4mm gap between adjacent panels on all sides or as indicated/shown on the Drawings.

Door/window frames and door sash shall be approved by the Engineer on assembling and before installing in position.

All hardware shall be installed and all door/window assemblies shall be fitted properly with minimum clearances. Hinges shall be recessed flush with surrounding wood surfaces. All sash shall be tested for proper and smooth operation without hinge bind.

On completion of door/window installation, all wood surfaces shall be French polished or painted.

3.5.1.8 Glazing

General requirements

All glazing work shall be performed in accordance with the typical glazing details shown on the Drawings. Joints and spaces, to be sealed, shall be thoroughly dried and made free from dust and other foreign materials before glazing. All glass shall be set with proper clearance as recommended by the manufacturer at all edges. Glass with nipped or damaged edges shall not be installed. Adjacent materials, which are solid, shall be cleaned immediately before the sealant and compound harden or stain the adjoining surfaces.

Glazing process

Glass to be cut to provide a clearance of 1.7mm to 3mm on all sides. A thin layer of sealant made of chalk, double boiled linseed oil and resin is to be applied to the frame surfaces coming in contact with the glass. The glass panes shall be fitted in to the rabbet not less than 20mm wide taking care to centre with equal clearance of jambs between glass and frame. The glass is next to be pressed firmly in to the place against the sealant. A bead of sealant is then to be laid in to the spaces between the glass and the frame. Sufficient sealant shall be applied so that when the stop is put in place, the sealant will be forced in to the gap between the glass and the stop and completely fill the space between the frame, glass and stop. The removal stop is then to be installed. The remaining space between the face of glass and stop shall be completely filled with sealant.

Cleaning

No glazing shall be considered complete until and unless paints and other stains have been removed from the surface of the glass. Glass must be cleaned and polished with pads of damp cloth and then with clean dry soft cloths. It will have to be finally finished with appropriate glass cleaning fluid and made absolutely free of foreign particles.

Defects and breakage

The Contractor shall replace any glass not conforming these specifications or having defects not admissible under the manufacturer's grading rules. The Contractor shall replace all glass, broken, cracked or chipped by his workers or by faulty installation or from any other cause. All glasses shall remain in perfect condition at the time of handing over of the building to the Employer.

3.5.1.9 Measurement

All wood door/window frames and assemblies completed, including all hardware installed in place, shall be measured in cubic meter for the specified section of the installed frame and accepted by the Engineer.

All wood door/window leaf and assemblies completed, including glass panes and all hardware installed in place shall be measured in square meter of the installed area and accepted by the Engineer.

3.5.1.10 Payment

For all wood door/window frames, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per linear meter, which payment shall constitute the full compensation for furnishing all materials and assemblies, fitting and fixing the frames, filling the recess, painting, all tools and appliances and labour including storage, transport, providing scaffolding and other works as well as all incidentals necessary for completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

For all wood door/window shutters including window glass panes, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which payment shall constitute the full compensation for furnishing all materials, hardware and assemblies, fitting and fixing the shutters/panes, all tools and appliances and labour including storage, transport, and providing scaffolding and all other works as well as all incidentals necessary for satisfactory completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.5.1	Wood door/window frame	Cubic meter
3.5.1	Wood door/window shutters/panes	Square meter

3.5.2 Veneered partex fixed panel door/window**3.5.2.1 Description**

Works covered by this item shall consist of supplying and fitting fixing Gammari Veneered Partex Panel of the size and shape as shown on the Drawing or as directed by the Engineer including supplying and fixing of all necessary hardware and meeting all requirements as described under the Sub-section on the 'Wood Work for Door/Window Frames and Shutters'.

3.5.2.2 General requirements

Same as stated under the Sub-section on 'Wood Work for Door/Window Frames and Shutters'.

3.5.2.3 Other requirements

Same as stated under the Sub-section on 'Wood Work for Door/Window Frames and Shutters'.

3.5.2.4 Materials

Gammari Veneered Partex door/window panel.

3.5.2.5 Joinery

Same as stated under the Sub-section on 'Wood Work for Door/Window Frames and Shutters'.

3.5.2.6 Gluing up

Same as stated under the Sub-section on 'Wood Work for Door/Window Frames and Shutters'.

3.5.2.7 Finish hardware

Same as stated under the Sub-section on 'Wood Work for Door/Window Frames and Shutters'.

3.5.2.8 Fabrication and installation

Same as stated under the Sub-section on 'Wood Work for Door/Window Frames and Shutters'.

3.5.2.9 Measurement

All Veneered Partex panel door/window and assemblies completed and all hardware installed in place shall be measured in square meter of the installed area. Only the works completed in accordance with the provisions of the BOQ, and/or as shown on the Drawings and/or as directed by the Engineer and accepted by the Engineer will be eligible for payment.

3.5.2.10 Payment

For all Veneered Partex panel door/window and assemblies, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which payment shall constitute the full compensation for furnishing all materials, hardware and assemblies, fitting and fixing the panel, all tools and appliances and labour including storage, transport, and providing scaffolding and all other works as well as all incidentals necessary for satisfactory completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.5.2	Veneered Partex fixed panel door/window	Square meter

3.5.3 Aluminum doors, windows and curtain walls

3.5.3.1 Description

Works covered under this item shall consist of supplying and fixing aluminum products of various types and uses such as doors, windows, curtain wall, curtain rail, cladding/flushing of sills, window grills, etc. fitted with necessary hardware, glass (where required) and finished in accordance with applicable Drawings and specifications.

3.5.3.2 Materials and products

Doors, windows and curtain walls

Doors, windows, curtain walls etc. shall be of approved standard conforming to the U.S. Architectural Aluminum Manufacturing Association (AAMA) or approved equivalent specifications. The frames and such members shall be of extruded shape made of 6063-T5 high quality aluminum alloy having a minimum section thickness of 1.8mm unless otherwise shown on the Drawings or indicated in the Bill of Quantities and shall conform to the U.S. Architectural Aluminum Manufacturing Association or approved equivalent standard.

Fasteners, hardware and anchors

Fasteners, hardware and anchors shall be of aluminum or non-magnetic, non-corrosive material compatible with aluminum. All windows shall be provided with non-jamming latches of rocker type designed to be locked from inside. Window locks shall be 'flush type' as manufactured by the Adams Rite Manufacturing Company of Glendale, California or any approved equivalent. The doors shall be provided with cylinder lock and suitable built-in-non-jamming latches and bolts.

Security locks shall be pin type 'Mortice' lock, 6 or 7 pins and adaptable to Master, Grand Master and Great Grand Master keys. Sliding windows and doors shall be fitted with adjustable sealed bearing sheaves of durable hydrated nylons or approved equivalent. Closer, push/pull and kick plates shall have to match with the frames. Any other necessary hardware to be incorporated in the works shall also match with the frame. Assembly and installation screws shall be of stainless steel. Doors, windows, curtain walls etc., to be installed with 'Teflon' injected expanding bolts and sills, shall contain adequate provisions for drainage. Head, sills and jamb members shall be comprised as single unit.

Aluminum to aluminum contact between hardware parts or moving members shall not be permitted. Such contacts shall be properly insulated.

Glazing beads

Glazing beads shall be aluminum shape-in-interchangeable type.

Weather stripping

Weather stripping shall be of neoprene or silicon treated woven wood or any approved equivalent.

Joints

All joints shall be mechanically done square (telescopic) joints. No 'Mitral' joints and forced fitting shall be accepted. All units shall be fabricated at the factory with high dimensional accuracy. It shall be rigid and designed to permit complete weather stripping. In principle, the parts should be put together by self-tapping screws.

Surface finish

All exposed surfaces of aluminum members shall be factory finish and of substantially uniform appearance maintaining the "Architectural" standard.

All exposed surfaces shall be given a natural Anodic Oxide Hardcore coating of 15 micron in thickness and a density of 4 mg per square centimeter and a uniform colour tone conforming to the U.S. Architectural Aluminum Manufacturing Association or any other approved equivalent standard. The colour spectrum shall be an-lock. Finish of hardware shall match closely with the door/window/curtain wall finish.

Accessories

All accessories necessary for proper fixing and operation such as anchors, clips, fins, sub-frames, metal sills, mullion, covers, other trim, cleaning anchors, glazing beads, weathering and glazing strips, hardware and mechanical operators, etc. shall be supplied ready to set in place with the door, window, curtain wall units.

Steel or wood sub-frames shall be painted with Zinc Chromatic primer incase of steel and with wood preservative in case wood. Steel anchor shall be properly insulated from aluminum frame.

Sealant

Sealant shall be one part elastic compound of "Architectural" grade caulk and shall be in matching colour.

3.5.3.3 Shop drawings

The Contractor shall prepare detailed design of all works involved in line with the Employers design and prepare Shop Drawings for the total works and submit to the Engineer for approval before factory fabrication starts. All exterior doors, windows and curtain walls shall be designed to withstand a wind pressure of 180 kg/cm².

3.5.3.4 Installation

All units shall be assembled at Site under proper conditions, erected, fixed and glazed in place in strict conformity with the manufacturer's instruction. All cut-out operations for hardware preparation shall be made accurately and reinforced as required.

All doors, windows, curtain walls, etc. shall be set plumb, square, level and in exact alignment with surrounding works and shall be securely anchored ready for operation. All joints between the masonry opening and frames shall be caulked and sealed after installation of the frames. All installation works shall be done and finished in such a way as to ensure a free and smooth operation.

Abrasion or other injuries to the finished surfaces shall be carefully avoided. Cleaning should be accomplished with plain water or a petroleum type cleaning agent or with the manufacturer's recommended cleaning reagent. No corrosive reagent shall be used.

3.5.3.5 Measurement

All aluminium door and window frame shutter with glass assemblies complex including all hardware, installed in place shall be measured in square meter of the installed frame. Only the works completed in accordance with the provisions of the BOQ, and/or as shown on the Drawings and/or as directed by the Engineer and accepted by the Engineer will be eligible for payment.

3.5.3.6 Payment

For all aluminium door and window frame shutter with glass, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which payment shall constitute the full compensation for furnishing all materials and assemblies and hardware, fitting and fixing, all tools, accessories and appliances and labour including storage, transport, and providing scaffolding and all other works as well as all incidentals necessary for satisfactory completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.5.3	Aluminium door, windows and curtain walls	Square meter

3.5.4 Gypsum board false ceiling

3.5.4.1 Description

Works covered under this item shall consist of supplying, fitting and fixing thermal acoustical insulation of ceiling finished in accordance with the specifications of Drawings and Bill of Quantities.

3.5.4.2 Materials and products

Materials for false ceiling shall be made of noncombustible extruded mineral fibre or gypsum board tiles of thickness 12mm and size 600mm x 1200mm or as otherwise required and suspended from the roof by means of adjustable height suspension system and on an appropriate frame work of galvanized steel or aluminium cross rails, furring channels, furring channel joineries, locking keys fasteners, renal plugs etc. and aluminium ceiling tees or any other appropriate and approved material, section and quality.

The ceiling tiles shall be supplied with adjustable height, corrosion resistant metal suspension systems with necessary accessories, all in adequate quantities as recommended by the manufactures.

The Contractor shall submit three sets of samples of all types of materials and products to the Engineer for his approval before procuring the materials. One set will be kept at the office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

3.5.4.3 Shop drawings

The Contractor shall prepare detailed design of all works involved in line with the Employers design and prepare Shop Drawings for the total works and submit to the Engineer for approval before any work starts.

3.5.4.4 Installation

All units shall be assembled under proper conditions, erected and fixed in place in strict conformity with the manufacturer's instruction. All cut-out operations shall be made accurately and reinforced as required.

Abrasion or other injuries to the finished surfaces shall be carefully avoided. Cleaning should be accomplished with appropriate type cleaning agent as recommended by the manufacturer or as directed by the Engineer. No corrosive reagent shall be used.

3.5.4.5 Measurement

All false ceiling including all aluminium channel, mineral fibre or gypsum board and including all other hardware, installed in place will be measured in square meter of the installed frame and accepted by the Engineer.

3.5.4.6 Payment

For all false ceiling, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which payment shall constitute the full compensation for furnishing all materials and assemblies, fitting and fixing, all tools, accessories and appliances and all labour including storage, transport, and providing scaffolding and all other works as well as all incidentals necessary for satisfactory completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.5.4	Gypsum board false ceiling	Square meter

3.5.5 Aluminium false ceiling

3.5.5.1 Description

Works covered under this item shall consist of supplying, fitting and fixing non-combustible aluminium channel false ceiling finished in accordance with the specifications of Drawings and Bill of Quantities.

3.5.5.2 Materials and products

Materials for false ceiling shall be made of non-combustible extruded aluminium channel, aluminium board tiles of 2mm thickness and suitable size and suspended from ceiling by means of adjustable height suspension system and on a frame work of galvanized steel or aluminium cross rails, furring channels, furring channel joineries, locking keys fasteners, royal plugs etc. and aluminium ceiling tees or any other approved section of approved quality.

The ceiling tiles shall be supplied with adjustable height, corrosion resistant metal, suspension systems with necessary accessories, all in adequate quantities as recommended by the manufacturer.

The Contractor shall submit three sets of samples of all types of materials and products to the Engineer for his approval before procuring the materials. One set will be kept at the office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

3.5.5.3 Shop drawing

The Contractor shall prepare detail design of the works involved in line with the Employer's design and prepare Shop Drawing for the Work and submit to the Engineer for approval before starting the work. No work shall start before obtaining such approval.

3.5.5.4 Installation

All units shall be assembled under proper conditions, erected and fixed in place in strict conformity with the manufacturer's instruction. All cut-out operations shall be made accurately and reinforced as required.

Abrasion or other injuries to the finished surfaces shall be carefully avoided. Cleaning should be accomplished with appropriate type cleaning agent as recommended by the manufacturer or as directed by the Engineer. No corrosive reagent shall be used.

3.5.5.5 Measurement

All false ceiling completed with noncombustible aluminium channel and including all other hardware, installed in place will be measured in square meter of the installed ceiling area and accepted by the Engineer.

3.5.5.6 Payment

For all false ceiling, completed with noncombustible aluminium channel, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which payment shall constitute the full compensation for furnishing all materials and assemblies, fitting and fixing, all tools, accessories and appliances and labour including storage, transport, and providing scaffolding and all other works as well as all incidentals necessary for satisfactory completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.5.5	Aluminium false ceiling	Square meter

3.5.6 Polycarbonate sheet

3.5.6.1 Description

The work covered under this item shall consist of supplying and spreading polycarbonate sheet on roof, covering the opening or over "skywalk"/"sky-bridge" connecting the proposed building with the old one in accordance with the applicable plans, Bill of Quantities and these specifications.

3.5.6.2 Materials

Polycarbonate sheet

Polycarbonate sheet has excellent resistance when compared to other transparent glazing material. The sheet is available with thickness of 4mm, 6mm, 8mm, 10mm and 16mm. The colours are also various like clear, opal, gray, brown, green and blue. Other properties are as follows:

Polycarbonate sheet can be cold with a minimum radius of 150 times the thickness.

Thickness	4mm	6mm	8mm	10mm	16mm
Radius	10cm	90cm	120cm	150cm	cm

Other Properties

Properties	Standard	Unit	Values
Density	DIN 53479	g/cm ³	1.2
Modulus of Elasticity	DIN 53457	N/mm ²	2000-2200
Tensile Strength at Break	DIN 53455	N/mm ²	>60
Tensile Strength at Yield	DIN 53455	N/mm ²	>70
Coefficient of Thermal Expansion	VDE 0304/1	K ₋₁ 10 ₋₆	60-70
Thermal Conductivity	DIN 52612	W/k.m	0.2
Heat Resistant Temperature	DIN 53460	°C	145-150
Moisture Absorption	DIN 53495	%	0.36
Vapour Permiability	DIN 53122	g/m ² d	2.28 (1mm)

Thermal Transmission Coefficient (K).

Material	K [kcal/(h.m ² .°C)]	K [W/(m ² .°C)]
Glass 4mm	5	5.8
Double glass 4/12/16	2.6	3
Acrylic Sheet 4mm	04.6	5.3
Fiber glass 1.2mm	5.5	6.4
PC 4mm	3.4	3.9

PC 6mm	3.2	3.7
PC 8mm	3.1	3.6
PC 10mm	2.9	3.4
PC 16mm	2	2.3

3.5.6.3 Installation

The material for the polycarbonate sheet shall be selected by the Engineer as regards to its thickness, colour and other properties unless otherwise those have been specified on the Drawings or in the Bill of Quantities.

The Contractor shall submit three sets of samples of all types of materials and products to the Engineer for his approval before procuring the materials. One set will be kept at the office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

Manufacturer's literature or specifications shall be strictly followed for installation and laying of all polycarbonate sheet.

3.5.6.4 Measurement

All polycarbonate sheet as laid and installed in place will be measured in square meter of the installed roof area and accepted by the Engineer.

3.5.6.5 Payment

For all polycarbonate sheet roofing, completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which payment shall constitute the full compensation for furnishing and installation of all materials and assemblies, all tools, accessories and appliances and labour including storage, transport, and providing scaffolding and all other works as well as all incidentals necessary for satisfactory completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.5.6	Polycarbonate sheet	Square meter

3.6 STAIR RAILINGS

3.6.1 Wooden handrail for stairs

3.6.1.1 Description

Works covered under this item shall consist of furnishing, finishing and installing of wooden handrails fixed on balustrade of brass square bar for stair landing in accordance with the applicable Drawings, design and these specifications or as directed by the Engineer.

3.6.1.2 Design drawings

Design Drawings shall be thoroughly studied by the Contractor before any work is commenced. If any detail description or specification is found missing or in the opinion of the Contractor inadequate, inconsistent or otherwise, the Contractor shall draw the same to the attention of the Engineer who may make necessary arrangements as deemed fit. On no account, the Contractor shall use his own judgement when any discrepancy is noticed in the design, Drawing, details and description.

3.6.1.3 Samples

Within 35 days following the Contract is awarded, the Contractor shall furnish, for approval of the Engineer, two pieces of samples of wood specimens 150mm x 250mm in area of 25mm thick for the type of wood to be used in the work for approval of the Engineer.

All approved samples may be kept at Site for comparing the materials supplied by the Contractor.

No work for this item shall start until the samples get approval of the Engineer.

3.6.1.4 Other requirements

Dimensions shown on the Drawings are finished dimensions. In sizing rough components, necessary allowance, therefore, must be kept for the working loss arising from planing, smoothing and finishing.

Polishing or painting, as the case may be, shall be done at Site on receiving approval of the woodwork, carpentry etc. by the Engineer. The working area shall be cleaned properly before starting finishing work and subsequently before each day's work to ensure reasonably dust-free surroundings.

In case of inflicting injury to any part of the building/other works while installing, the Contractor shall rectify the same employing appropriate skilled workers of the trade and materials required at his own expense.

The Contractor shall keep the Employer indemnified against all charges, which may arise out of this Contract in case of procurement of timbers from local sources.

3.6.1.5 Materials

Timber

Type of timber, only as specified on the Drawings or and in the Bill of Quantities, shall be used. Timber used for woodwork shall be well seasoned, kiln dry containing not more than 8% to 12% moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects such as large or loose knots, saps, shakes, upsets, wane edge and twisted fibre. It shall also be free from all diseases such as decay, wet rot, dry rot, woodworms and white ant. Timber shall be finished to the exact dimensions shown on the Drawings or as directed by the Engineer. The pieces of wood shall be properly finished by planer and other tools and the completed wood works shall be accepted by the Engineer before fixing those in position.

Unless otherwise specified timber used for handrail shall be Chittagong Teak meeting the requirements stated under the relevant portion of the Sub-section on 'Wood Work for Door/ Window Frames and Shutters' of this Specification. The size should be in accordance with the Drawings and the Bill of Quantities or as directed by the Engineer.

3.6.1.6 Fabrication and installation

Railing shall be fabricated of materials indicated on the Drawings or in the Bill of Quantities and fixed to accurate form and position. The Contractor shall perform this job in true perfection.

All woodwork in handrail shall be carried out, finished and varnished and waxed in accordance with the provisions of the relevant Sub-sections of this Specification.

3.6.1.7 Measurement

All wooden handrail finished, varnished, completed and installed in place, shall be measured in cubic meter for the specified section of the installed handrail and accepted by the Engineer.

3.6.1.8 Payment

For all wooden handrail, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per cubic meter, which payment shall constitute the full compensation for furnishing all materials, fitting and fixing the handrail with varnishing, waxing and finishing it, including all tools and appliances and labour including storage, transport, providing scaffolding and other works as well as all incidentals necessary for completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.6.1	Wooden handrail	Cubic meter

3.6.2 Brass pipe for stairs

3.6.2.1 Description

Works covered under this item shall consist of furnishing, fitting, fixing brass pipe of required diameter for stair and any other location in accordance with the provisions of the BOQ, the applicable design Drawings and these specifications and/or as directed by the Engineer.

3.6.2.2 Design drawings

Design Drawings shall be thoroughly studied by the Contractor before the Work is commenced. If any detail description or specification is found missing or in the opinion of the Contractor the descriptions are inadequate, inconsistent or otherwise, the Contractor shall draw the same to the attention of the Engineer who may make necessary arrangements as deemed fit. On no account, the Contractor shall apply his own judgement when any discrepancy is noticed in the design Drawing, details and description.

3.6.2.3 Shop drawings

The Contractor shall prepare detail design of the works involved in line with the Employer's design and prepare Shop Drawing for the Work and submit to the Engineer for approval before starting the work. No work shall start before obtaining such approval.

3.6.2.4 Materials

The materials shall consist of brass pipe of required diameter and thickness as shown on the Drawings and/or specified in the BOQ and/or as directed by the Engineer.

3.6.2.5 Samples

The Contractor shall submit three sets of samples of all types of materials and products to the Engineer for his approval before procuring the materials. One set will be kept at the Office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

The works of this Sub-section shall not commence until the samples get approval of the Engineer.

3.6.2.6 Fabrication and installation

The brass pipe shall be accurately bent, cut and welded as required and fixed with the vertical post or wall by means of brass tray, anchor bolt or welding. The weld must be smoothen by using grinder.

The Contractor shall carryout this work in true perfection in accordance with the Shop Drawings approved by the Engineer earlier, the Design Drawings and the Bill of Quantities.

3.6.2.7 Other requirements

In case of inflicting damages to any part of the building/other works while fitting and fixing, the Contractor shall rectify the same employing workers of appropriate skill of the trade and materials required at his own expenses.

3.6.2.8 Measurement

All brass pipe completed and installed in place, shall be measured in linear meter for the specified section and actually installed in accordance with the provisions of the BOQ and/or the design Drawings and/or as directed by the Engineer. Only the works completed and accepted by the Engineer will be eligible for payment.

3.6.2.9 Payment

For all brass pipe, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per linear meter, which payment shall constitute the full compensation for furnishing all materials, fitting and fixing the pipe, all tools and appliances and labour including storage, transport, providing scaffolding and other works as well as all incidentals necessary for completion of all works as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.6.2	Brass pipe	Linear meter

3.6.3 Stainless steel pipe for stairs

3.6.3.1 Description

Works covered under this item shall consist of furnishing, fitting, fixing stainless steel pipe of required diameter for stair and any other location in accordance with the provisions of the BOQ, the applicable design Drawings and these specifications and/or as directed by the Engineer.

3.6.3.2 Design drawings

Design Drawings shall be thoroughly studied by the Contractor before the Work is commenced. If any detail description or specification is found missing or in the opinion of the Contractor the descriptions are inadequate, inconsistent or otherwise, the Contractor shall draw the same to the attention of the Engineer who may make necessary arrangements as deemed fit. On no account, the Contractor shall apply his own judgement when any discrepancy is noticed in the design Drawing, details and description.

3.6.3.3 Shop drawings

The Contractor shall prepare detail design of the works involved in line with the Employer's design and prepare Shop Drawing for the Work and submit to the Engineer for approval before starting the work. No work shall start before obtaining such approval.

3.6.3.4 Materials

The materials shall consist of brass pipe of required diameter and thickness as shown on the Drawings or specified in the BOQ or as directed by the Engineer.

3.6.3.5 Samples

The Contractor shall submit three sets of samples of all types of materials and products to the Engineer for his approval before procuring the materials. One set will be kept at the Office of the Engineer, one set at the Site office and the remaining set will be returned to the Contractor.

The works of this Sub-section shall not commence until the samples get approval of the Engineer.

3.6.3.6 Fabrication and installation

The stainless steel pipe shall be accurately bent, cut and welded as required and fixed with the vertical post or wall by means of stainless steel tray, anchor bolt or welding. The weld must be smoothen by using grinder.

The Contractor shall carryout this work in true perfection in accordance with the Shop Drawings approved by the Engineer earlier, the Design Drawings and the Bill of Quantities.

3.6.3.7 Other requirements

In case of inflicting damages to any part of the building/other works while fitting and fixing, the Contractor shall rectify the same employing workers of appropriate skill of the trade and materials required at his own expenses.

3.6.3.8 Measurement

All stainless steel pipe completed and installed in place, shall be measured in linear meter for the specified section and actually installed in accordance with the provisions of the BOQ and/or the design Drawings and/or as directed by the Engineer. Only the works completed and accepted by the Engineer will be eligible for payment.

3.6.3.9 Payment

For all stainless steel pipe, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per linear meter, which payment shall constitute the full compensation for furnishing all materials, fitting and fixing the pipe, all tools and appliances and labour including storage, transport, providing scaffolding and other works as well as all incidentals necessary for completion of all works as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.6.3	Stainless steel pipe	Linear meter

3.6.4 Brass nosing for stairs steps**3.6.4.1 Description**

Works covered under this item shall consist of furnishing, fitting, fixing 3mm thick 30mm x 30mm brass plate nosing in stair steps including 87mm long anchor bar of section 3mm x 25mm M.S. plate embedded in the concrete in accordance with the applicable Drawings, design and these specifications or as directed by the Engineer.

3.6.4.2 Construction method

The brass plate shall be accurately cut, formed, fitted and finished true to the form and dimension as indicated on the Drawings. The brass plate shall be fixed to the anchor bar by 3 Nos. of rivet or as shown on the Drawings.

3.6.4.3 Measurement

Measurement for payment shall be made in running meter of finished visible brass nosing fitted to the stair steps, installed and finished as shown on the Drawing and accepted by the Engineer.

3.6.4.4 Payment

For all brass nosing, the amount of complete and accepted work measured as provided above shall be paid at the Contract unit price per running meter which payment shall constitute full compensation for furnishing all materials including anchor bar, equipment and labour in assembling, fixing, fitting as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.6.4	Brass nosing	Running meter

3.7 MISCELLANEOUS METAL WORK

3.7.1 Metal works

3.7.1.1 Description

Works to be performed under this Section include, but is not limited to, the furnishing and installing of all structural steel and miscellaneous metal work, anchors, bolts and fastenings, and metal fabrications as shown and noted on the Drawings and as specified herein.

Metal work includes steel doors, steel window and glazing thereof, security grilles, stair railing, collapsible gate. M.S. pipe handrails, rolling shutter, boundary gates and other metal works shown on the Drawings or as directed by the Engineer.

The materials, fabrication, workmanship and installation of the entrance gates shall conform to the requirements of this Section.

3.7.1.2 Shop drawings

The Contractor shall submit full details, large scale Shop Drawings of all structural steel and metal work, showing sizes, details of fabrication and construction, methods of assembly and installation details to the Engineer for review and approval. The Contractor shall also provide manufacturer's literature for fabricated items, where necessary.

All shop and field weld shall be indicated by standard welding symbols of the American Welding Society. Drawings shall show the size, length and type of each weld.

3.7.1.3 Materials

General

All materials shall be of new stock and of the best commercial quality for the indicated purpose. Stock items shall be well manufactured by concerns having specialization in the particular item free from defects impairing strength, durability or appearance and subjected to the approval of the Engineer.

Manufactured steel clips and angles will require to be accepted where such is the obvious intent of the Drawings.

All anchor bolts and other parts required for securing each item of work to the construction shall be new.

The Contractor shall take and verify all measurements as may be necessary or required. He shall be responsible for all field dimensions, all fittings and the proper attachment of all works included herein.

Steel materials

- **Structural Shapes:** All structural and miscellaneous steel members and components shall be standard structural sections, shapes and plates, as indicated on the Drawings, conforming to ASTM A 6, ASTM A 36 (minimum yield point of 2530 kg/cm²) of standard specifications for 'Structural Steel for Building' or approved equal.
- **Structural Tubing :** Steel tubes, where indicated, shall be welded steel tubing, conforming to BS 1387:1967 (medium), of size and shape indicated on the Drawings.
- **Bars :** Steel bars shall be made from billet steel and shall conform to ASTM A 616 or approved equal.

Brass

Brass shall be Red Brass, conforming to ASTM Specifications Designation B 36 as amended to date.

Anchors, bolts and fastening

Bolts and studs, nuts and washers shall conform to ASTM A-307, A-449 and A-563 as applicable or approved equal.

Anchors, Bolts and Fastening: Bolts and nuts, other than those with self locking screw thread, shall be coarse-thread series. Bolts and nuts shall be the regular hexagon head types.

Washers: Round washers shall be of American National Standard B 27.2 Type, or approved equal. Cut washers shall be placed under all bolts and nuts, bearing on steel and at other locations indicated on the Drawings. Beveled washers shall be square, smooth and sloped so that contact surfaces of bolt head and nuts are parallel.

Galvanizing: All exposed bolts, studs, nuts and washers shall be hot-dip galvanized in accordance with ASTM A 153.

Pipe sleeves

Pipe sleeves through concrete or masonry walls and footings shall be standard weight, wrought iron, mild steel, or cast iron sleeves with not less than 6mm space all around between the sleeve and pipe or conduit.

Pipe

Pipe for handrails, railings, and pipe guards, as shown on the Drawings, shall be welded steel pipe conforming to ASTM A 53, Type E or S, grade A or approved equal. All pipes shall be galvanized.

Pipes for gate frames and other locations, indicated on the Drawings, shall be welded steel pipes, conforming to BS 1387 (medium). Pipe fitting, where indicated or if any required shall conform to ASTM A 420. Standard manufacturer's weldable steel pipe, conforming generally to the foregoing requirements, will be acceptable. All pipes and pipe fittings shall be galvanized.

Electrodes

All arc-welding electrodes shall conform to AWS standards for steel Arc-welding Electrodes. Electrodes shall be rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use.

Concrete and masonry anchors

Where anchors are not included in the concrete or masonry construction, anchors shall be Phillips "Read Head" Concrete or Masonry Anchors manufactured by Phillips Drill Co. "Wej-It" Expansion Products, Inc., or approved equal of the sizes and types indicated on Drawings or as required.

Grout

Master Builders, "Embccco" Pro-mix Grout, Conrad Sovin's "Metal-mix Grout", Sonneborn's "Ferrolith G Redi-mixed Grout" or approved equal, high strength, non-shrink grout shall be used.

3.7.1.4 Miscellaneous items

Structural steel and miscellaneous metal items and their related components are not necessarily to be described individually. The most important and those requiring details will be described. Structural and miscellaneous items, not mentioned or described, shall be furnished and installed in accordance with the intent of the Drawings and specifications and as required to complete the specific work.

3.7.1.5 Fabrication

Steel works and firms or shops, skilled and experienced in the fabrication of structural steel and miscellaneous metal work, shall perform metal fabrication.

All foreign materials shall be removed and deformations are rectified prior to sizing for fabrication.

Cutting shall be done in a neat and workmanlike manner without damaging the sections. All cuts shall be made square, precise and true to dimensions shown on the Drawings.

The ends of all members shall be carefully reamed out free from burrs before fabrication and shall be checked carefully against deformations and if required such defects shall be rectified.

Tubular sections shall be bent true to profile without any deformation using bending equipment.

Fabrication work shall be neat, true to plumb, square, true to dimension and profile, accurately fitted with tight joints and intersections.

All exposed welded joints shall be grounded smooth without impairing the strength of the joint. Necessary procedures must be adopted prior to making such joints.

Finished surfaces of exposed members shall be smooth and free from markings, burrs or other defects.

3.7.1.6 Welded connections

Welders shall be experienced in the type of welding work to be performed. If at any time the welder's performance quality is found not satisfactory, as determined by the Engineer, the welder shall be replaced.

Welded connections shall be made in accordance with AWS D 1.1.

Welds exposed in the finished work shall be ground and dressed smooth so that the shape and profile of the welded item is preserved. Embedded metal frames for floors and deck openings shall be with continuous welds at corners and ground smooth where exposed to view.

Railing shall be fabricated in straight run sections with top and intermediate rails, posts and flange connections, welded ready for installation in the field. Splices, where required, shall be reinforced with sleeve within the pipe and secured with set screws on the underside of the pipe.

3.7.1.7 Shop coating

All works shall conform to the details of the Drawings and except for galvanized metal brass or bronze, be furnished at the Site with one prime coat of red lead oxide unless otherwise required by the Engineer. The Engineer shall approve the anti-rust prime coat.

Before applying anti-rust prime coat, all rusts, loose milled scales, dirt, welding flux, spatter and other foreign materials shall be removed with wire brushes or steel scrapers. All grease and oil shall be removed by solvent recommended by paint manufacturer. Surfaces shall be dry when painted.

Dissimilar metals shall be insulated from each other with one heavy coat of asphalt paint on contact surfaces in addition to the prime coat specified above.

Prime coat shall be thoroughly and evenly applied and shall be well worked in to corners and joints taking care to avoid sags and runs. Bolts, which are to remain permanently in the work, shall be dipped in paint to cover the entire bolt.

Prime coat shall be omitted from surfaces to be embedded in concrete or masonry. Prime coat shall also be omitted from surfaces to be welded in the field, except where the primer used can be conclusively shown to have no adverse effect on the weld.

The Contractor shall submit the manufacturer's specification to the Engineer for his approval prior to applying primer.

3.7.1.8 Installation

General

Installation of miscellaneous metal works and metal fabrication shall be in accordance with the Drawings and approved Shop Drawings, true and horizontal and perpendicular, as the case may be, plumb, level and square, with angles and edges parallel with related lines of the work.

Shop fabricated items, subjected to damage, shall be braced and carefully handled to prevent distortions or other damage.

Before concrete is placed, items to be installed shall be properly braced to prevent distortion by pressure of concrete.

Field welding, where required, shall conform to the requirements specified for shop fabrication.

Anchors, bolts, studs and fasteners

All anchors, bolts and washers, inserts etc. as required for the installation and completion of the work and other miscellaneous steel or iron fastenings to be installed in forms before concrete placement, or built in to concrete, shall be provided as indicated on Drawings, details, and schedules at the time schedule for the concrete work. Bolts and anchors shall be present by the use of templates or such other methods as may be required to locate the anchors and anchor bolts accurately.

Expansion bolts, where approved, shall be carefully installed in snug-fitting, smoothly drilled holes, all in accordance with the manufacturer's instructions. Expansion bolts shall be installed so that the load acts on the bolt in shear and withdrawal. Expansion bolts shall be carefully located in order to eliminate the risk of damage to concrete reinforcement and other embedded items. Expansion bolts shall not be used except where indicated on Drawings or where first approved by the Engineer in writing.

Base and bearing plates

Bases and plates and pipe posts, where shown in the Drawings, shall be set accurately using a high strength, non-shrink grouting mortar as herein before specified to obtain uniform bearing. Grouting mortar shall be mixed and installed in accordance with the manufacturer's specifications and instructions. Surfaces to receive the grout shall be cleaned and moistened thoroughly immediately before the grout is placed. Exposed surfaces of grout shall be water-cured with wet burlap or rags for 7 days.

Doors, windows and gates

Doors, window units and entrance gates shall be properly and correctly installed by expert persons with all hardware and accessories furnished and installed as shown on the Drawings and as required for complete and finished installations. Doors, windows and gates shall operate freely, properly and smoothly at completion. Glazing of windows shall be performed in accordance with the requirements and procedures as stated previously in the relevant Sub-section.

3.7.1.9 Painting

After installation of steel works and metal fabrication, abraded areas, field areas, field bolts and welds to be touched up and spot shall be painted with the same type of corrosion inhibitor primers as were used for shop painting. Field welds shall be thoroughly wire brushed or sanded prior to painting touch up.

All metal surfaces shall then be painted with three coats of an approved synthetic exterior enamel paint for metal as manufactured by "Berger" or approved equal.

3.7.1.10 Measurement

The different items on structural and miscellaneous metalwork, as indicated on the Drawings and specified herein, will be measured by the various units listed in the Bill of Quantities.

3.7.1.11 Payment

Structural and miscellaneous metalwork will be paid for at the relevant Contract unit prices quoted in the Bill of Quantities for the installed work accepted by the Engineer measured in place.

Pay Items shall be:

Clause	Description	Unit of measurement
3.6.4	Brass nosing	Running meter

3.7.2 Barbed wire fencing with angle iron posts

3.7.2.1 Description

Works covered by this item shall consist of supplying and providing barbed wire fencing on the top of boundary wall and where required in accordance with the applicable plans and Drawings.

3.7.2.2 Materials

The barbed wire shall be GI 12 BWG 2-ply with 4 points barbs.

3.7.2.3 Construction methods

The barbed wire shall be fitted and fixed @ 150mm centre to centre in both horizontally and vertically supported by iron angle posts of section 38mm x 38mm x 6mm. The angle iron posts shall be embedded in the RCC or in the brick work upto 300mm. The angles shall be fabricated in a way as to provide in length of 600mm in vertical position and 450mm in inclined position or as shown in the Drawing or as required by the Engineer. The angle posts shall be fixed @ 2.4m centre to centre. At the joints the binding and tightening shall be done with 18 BWG wire. No sagging in the barbed wires, after fixing, shall be allowed.

3.7.2.4 Measurement

All barbed wire fencing completed and installed in place, shall be measured in square meter for the length fenced and accepted by the Engineer.

3.7.2.5 Payment

For all barbed wire fencing, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter, which payment shall constitute the full compensation for furnishing all materials like barbed wire, angle iron posts, binding wires, fitting and fixing the angle iron posts inside RCC or masonry, making holes in the angle posts, straightening, tightening, binding the joints, all tools and appliances and labour including storage, transport, providing scaffolding and other works as well as all incidentals necessary for completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.7.2	Barbed wire fencing with angle iron posts	Square meter

3.7.3 Barbed wire fencing with RCC posts

3.7.3.1 Description

Works covered by this item shall consist of supplying and providing barbed wire fencing supported with RCC posts of required sections in accordance with the applicable plans and Drawings.

3.7.3.2 Materials

Barbed wire

The barbed wire shall be GI 12 SWG 2-ply with 4 points barbs.

RCC posts

Each RCC posts shall have a section 150mm x 150mm having a total length of 2.13m with a spread footing for an area of 450 square millimeter or as shown on the Drawings or as directed by the Engineer.

The specifications for cement, sand, brick chips, water and reinforcement shall conform to the specifications described under the Section on 'Construction Materials' of this Specification.

3.7.3.3 Construction methods

The RCC posts shall be constructed with cement concrete with one part of cement, two parts of sand and 4 parts of brick chips. Reinforcement for the posts shall comprise 4 nos. 10mm diameter main rods and 6mm diameter stirrups @ 150mm centre to centre. Reinforcement for footing shall comprise 5 nos. 10mm diameter rod in both ways. The posts shall bear 8 loops made with 6mm diameter rods embedded in to the posts. The posts shall be plastered with 6mm thick cement plaster with 1 part cement and 4 parts sand up to a length of 500mm.

Each RCC post shall be embedded within the ground up to a depth of 0.76m or as shown on the Drawing or as directed by the Engineer

The barbed wire shall be fitted and fixed in 8 lines drawn through the loops of the RCC posts horizontally @ at least 112mm centre to centre and two lines diagonally from posts to posts. The barbed wire shall be straighten, tighten and shall be bound with 18 BWG wire with the loops of the posts. No sagging in the barbed wires, after fixing, shall be allowed.

3.7.3.4 Measurement

All barbed wire fencing with RCC posts completed and installed in place, shall be measured in running meter for the length fenced and accepted by the Engineer.

3.7.3.5 Payment

For all barbed wire fencing with RCC posts, the amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per running meter, which payment shall constitute the full compensation for furnishing all materials like barbed wire, RCC posts, binding wires, fixing of the RCC posts making loops in the RCC posts, straightening, tightening, binding the joints, all tools and appliances and labour including storage, transport, providing scaffolding and other works as well as all incidentals necessary for completion of all works as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of measurement
3.7.2	Barbed wire fencing with angle iron posts	Square meter

3.8 STEEL WORKS IN ROOF TRUSS

3.8.1 Description

This work shall consist of supplying, fabrication and erection of structural steel components covering roof truss, steel beam, column etc. using different member sections including angels, T-sections, I-sections, channels, plates etc. The structural steel components shall be fabricated and connected using gusset plate, bolt, rivet, welding etc. The work shall be undertaken in accordance with this specification and as per drawing, design, length, size, thickness, strength and level as indicated in the drawing or as per direction of the E-I-C.

3.8.2 Materials

Structural steel works to be furnished according to the following specification unless otherwise specified in the drawings:

- Specification for weld-able Structural Steel BDS 878 : 1978
- Dimension and Properties of Hot Rolled Steel Beams, Column, Channel and Angle sections BDS 1355 : 1992.
- Specification of Structural Steel : ASTM A 36 M-91.
- Specification of High-strength Bolts for Structural Steel joints: ASTM A325 M-91.
- Specification for Steel Structural Rivet : ASTM A502-91

3.8.3 Construction Methods

MS sections shall be accurately fabricated, assembled, fitted and finished true to the form, shape, camber and dimensions as indicated in the drawings. MS sections shall be assembled with Gusset Plates using bolts/nuts or riveted or welded etc. as shown in the drawings complete with all other necessary materials. After completion of the same shall be provided with two coats of anticorrosive paint over a prime coat of red oxide paint etc. Prior to painting, the surface shall be cleaned of mill scale, rust, oil grease and dirt. Surface not painted to the Engineer's satisfaction shall be repainted at

Contractor's own cost. The completed truss then be hoisted/erected in position using satisfactory system.

3.8.4 Measurement

Measurement for payment of MS sections will be made in weight in kg as worked out from various lengths and sizes of material used. Weight of Gusset Plates in kg will be determined from sizes and thickness of materials used. No separate measurement shall be taken for any fastening and painting works.

3.8.5 Payment

For all MS sections and Gusset Plates, the amount of complete and accepted works as measured above shall be paid at the Contract unit price per kg, which payment shall constitute for all furnishing materials, equipment and labour in assembling, fixing, fitting as well as all incidentals including nuts, bolts, welding, painting etc. as necessary to complete the works as per specifications and requirements described under this sub-section, the Bill of Quantities, as shown on the drawings and as directed by the E-I-C.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.8	Steel works in roof truss	kg

3.9 CORRUGATED IRON SHEET ROOFING

3.9.1 Description

This work will be executed for making roof for different Sheds in the Market and Passenger Waiting Shed in Ghat. Roofing material should be galvanized/colour corrugated steel of 0.45m thickness manufactured by reputed Suppliers.

3.9.2 Materials

Corrugated Iron Sheet to be supplied according to the following specifications:

- (a) Code of Practice for galvanized corrugated sheet roof and wall covering BDS 868 : 1978.
- (b) Specification for Galvanized Steel Sheet and Coil BDS 1122 : 1985.

3.9.3 Construction Methods

Roofing will be fitted and fixed on MS sections with 'J' Hook with screws, limpet washers and putty etc. Adequate lapping between two sheets should be provided to avoid any water leakage and spacing of 'J' Hook should be such that it would provide sufficient rigidity of CI sheet with the MS sections. The entire work should be done as per the complete satisfaction and direction of E-I-C.

3.9.4 Measurement

The quantity of roofing should be measured from the exposed area of one surface only.

3.9.5 Payment

For all CI Sheet work payment shall be made at the Contract unit price per square meter, which payment shall constitute for all furnishing materials, equipment and labour in assembling, fixing, fitting as well as all incidentals including 'J' hooks, putty etc. as necessary to complete the works as per specifications and requirements described under this sub-section, the Bill of Quantities.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.9	Corrugated iron sheet roofing	Square meter

3.10 PLAIN SHEET RIDGING

3.10.1 Description

This item of work consists 0.45 mm thick galvanized/colour iron plain sheet ridging with 300 mm lapping on either side of CI sheet roofing.

3.10.2 Construction Methods

Ridging shall have to be fixed with galvanized/colour bolts, nuts, 'J' hook etc. on the top edge of CI sheet roofing.

3.10.3 Measurement

Measurement will be in running meter.

3.10.4 Payment

For all Plain Sheet Ridging payment shall be made at the Contract unit price per linear meter, which payment shall constitute for all furnishing materials, equipment and labour in assembling, fixing, fitting as well as all incidentals including 'J' hooks, putty etc. as necessary to complete the works as per specifications and requirements described under this sub-section, the Bill of Quantities.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.10	Plain sheet ridging	Linear meter

3.11 M. S.GRILL

3.11.1 Description

The M.S. grill shall be made of steel frame of mild steel with grill as per drawing and design. This is to be fitted at any places as per drawing and direction of the Engineer.

3.11.2 Construction Requirement

The mild steel shall conform with the requirements of ASTM A-53. The structural steel shall conform with the requirement of ASTM A-36. These flat and angle M.S. sections are to be cut to sizes, fabricated, welded (continuous) and to the shape and sizes of the frame as per drawing. This frame shall have two coats of synthetic enamel paint over a coat of approved anticorrosive primer. The enamel paint should be of approved colour. Each frame must have min. 10 nos. of clamps on 4 sides of the frame.

One sample frame should be prepared and deposited with the Engineer for his approval. Only after approval the manufacturing should start.

3.11.3 Grill by Flat Bar for Window/Verandah Etc.

3.11.3.1 Description and Construction Requirements

The work covered under this item shall consist of supplying, fitting, fixing, window or Verandah grill of any design made with (25 x 6) mm F.I bar including fabricating by M.S angle/flat bar frame, welding, painting with two coats of Synthetic enamel paint of approved quality and color over a coat of primer etc. complete for all floor as per drawing and direction of the Engineer.

3.11.4 Window Grill by MS Rod (16mm Dia)

3.11.4.1 Materials and Construction Requirements

M.S rod grill work using 16mm die M.S rod placing @ 100mm c/ c vertically with 3 Nos. FI bars of 38mmx6mm size horizontally including making holes, welding with the supply of all necessary materials fitting & fixing, painting 2 coats using synthetic enamel paint of approved color etc. over a coat of primer complete according to drawing as per instruction of the Engineer.

3.11.5 Verandah Grill, Grill Gate etc. by MS Rod (10mm Dia)

3.11.5.1 Materials and Construction Requirements

Providing verandah railing with 40mm/50mm dia G.I. pipe hand rail welded with 12mm dia G.I. pipe post fixed vertically @ a25mm c/c. 75mm of the bottom of the pipes to be embedded in floor with 50mm x 50mm x 6mm M.S. base plate welded at bottom, all complete in/c making necessary grooves in floor, packing the post with cement concrete (1:2:4), mending good all damages, finishing etc. all complete as per plan and direction of E-I-C.

3.11.6 Basis of Measurement

Measurement for payment shall be made in Square meter.

3.11.7 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances, cutting, shaping, welding, grinding, including two coats of anti-corrosive paints over one coat of primer. This payment will also include labour, storage, transport and all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section, the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.11	M.S. Grill	Square meter
	Grill by flat bar for window/verandah etc.	Square meter
	Window grill by MS rod	Square meter
	Veranda grill, grill gate etc. by MS rod	Square meter

3.12 ROLUNG SHUTTER**3.12.1 Materials and Construction Requirements**

The work covered under this item shall consist of supplying, fitting and fixing of rolling shutter made of 24 SWG G.P sheet unit minimum 69mm width having 10mm & 12mm dia circular folding at ends, rolled in machine, locked together properly to form rolling shutter top of the shutter to be fitted with circular spring box made of 22 BWG sheet, containing best quality spring made in China, nutted with 38mm G.I pipe at one end and the other end nutted to shutter in/c fitting the G. I. pipe again with 375mmx300mmx6mm pankha at ends with side guide channel (side channel consist of 50mmx100mmx6mm M.S. plate with 2mmx19mmx3mm F.I. bar middle channel consist of 2x150mmx6mm M.S. plate with 2mmx19mmx6mm) fixed to wall or column with clamps (minimum 3mmx25mmx6mm), mending the damages, bottom end of shutter fitted to folder G. P. sheet (minimum 125mm width, two layer) which is again fitted to 25mmx25mmx3mm angle, providing handle both sides, (with F.I bar 25mmx6mm riveted) and locking arrangement both sides, painting two coats with approved colour and brand of synthetic enamel paint over a coat of priming etc. complete in all respect as per drawing, design and direction of the Engineer (Rolling shutter must be riveted at sides with G.P sheet and patty).

3.12.2 Basis of Measurement

Measurement for payment shall be in square meter of the area along outline of the frame.

3.12.3 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per square meter which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including storage, transport, preparing, mixing and applying putty, primer and all white washing materials and providing scaffolding as well as all incidentals necessary to complete the work as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.12	Rolling shutter	Square meter

3.13 SEPTIC TANK

3.13.1 Scope

This item of work shall consist of construction of different sizes of Septic Tank in accordance with the details as shown on the Drawing, as per the BOQ and these specifications or as directed by the Engineer.

3.13.2 General

A Septic Tank is a rectangular chamber of brickwork or of RCC with all inside wall cement plastered, usually built underground. Septic Tanks are constructed of different sizes depending upon the number of users.

The tanks are made airtight and watertight. Entering of light is also prevented to help decomposition of sewage. The layers of scum and sludge are not disturbed by the flow of water and the inflow and outflow of the tank are also arranged as to give least disturbance. Both the inlet and outlet pipes are bent downwards and their open ends should rest at a position midway in the water. The centre of the outlet pipe is generally kept about 150mm below the centre of the inlet. Inlets and outlets should be of standard 'T' fittings of glazed earthenware pipes. When the tank width is more than 1.5m, there should be two inlets. Another precaution taken against possible disturbance of the scum is by making a vertical partition in the tank, called a hanging 'baffle wall', extending from above top-water level to 45cm from the floor, and from 25 to 45 cm away from the inlet pipe. The baffle walls need to be made in small tanks. In long tanks, a second baffle wall is sometimes provided which is built from the floor to a little below the water level in the tank and at a distance of about 60cm from the outlet end. Instead of the second baffle, a 'scum board' may be provided to prevent movement of the scum by wave action or any other disturbance. A scum board is made of a thin slate, flagstone, RCC, or even wood often suspended from the top in to the grooves in the sides of the tank to remain submerged about 25cm to 35cm in to the liquid. The outlet pipe may be straight instead of bent down, where a scum board has been provided.

The size of the Septic Tank is based on the number of users and the amount of dilution water in the sewage. Average retention period of sewage in the septic tank is 12-24 hours. It may be even more where the sewage is fresh as in residential installations, and which are generally designed to hold 24 hours supply, and 8-12 hours retention where the sewage has traveled a long distance and has been subject to a process of some disintegration.

According to IS 2470, Septic Tank shall have minimum width of 75cm, minimum depth of 1m below water level and a minimum liquid capacity of one cubic meter. Length of the tank shall be two to four times the width.

The Tank should be built as far away from the house as possible on the leeward side. If the Tank is located at a greater distance, the vent pipe may be taken to a height of about 3.5-4.5m. The floor of the Tank should be sloped at 1 in 30 towards one side or the centre to facilitate cleaning of deposits and the manhole should be above this. IS 2470 has recommended a slope of 5-10 percent towards the inlet. The Tank is usually covered with RCC slabs, removable or fixed, with manhole covers.

A Septic Tank should be initially filled with water. Disinfectants should not be used beyond very small quantities which may be absolutely necessary as they kill bacterial life making the Septic Tank non-functioning. Soap and grease from the bath-rooms are also harmful.

3.13.3 Construction Method

Items of work

All works shall be carried out in accordance with the specifications shown on the Drawing, described in the BOQ and or as directed by the Engineer. Work components involved are categorized in to the following:

1. Earth excavation for the Tank including leveling the bed.
2. Cement Concrete floor over a layer of Brick Flat Soling and covered with Patent Stone Floor with neat cement finishing.
3. Main and partition walls with Brick Masonry work. Insides of the walls are plastered with Cement Mortar with neat cement finishing.
4. R.C.C. Tees.
5. R.C.C. top slab.
6. Water sealed heavy type C.I. manhole cover with locking arrangements.

Earth excavation and back-filling

The ground shall be excavated for the Tank with the dimension as shown on the Drawing making proper accommodations for the required size and back filling the sides on construction of the structure. Necessary shoring and bailing out water shall be undertaken where necessary for protection of the sides facilitating excavation. The bed of the excavation shall be well leveled making it suitable for placing Brick Flat Soling. The work shall proceed in accordance with the methods and procedures as described under the Section 'Excavation and Back Filling for Structures' of the 'Standard Specifications for Building and Allied Works' used by the LGED.

Brick flat soling

On leveling the bed, Brick Flat Soling is to be laid in a single layer. The brick joints are to be tightly filled with sand of specified F.M (minimum FM 0.8) in order to prevent any movement of the bricks. The work shall proceed in accordance with the methods and procedures as described under the Sub-section 'Brick Flat Soling' of the 'Standard Specifications for Building and Allied Works' used by the LGED.

Cement concrete

The floor shall consist of cement concrete with patent stone floor on the top smoothened with neat cement finishing. Unless otherwise specified, the cement concrete and the patent stone floor should be 150mm and 25mm thick respectively. The cement concrete shall be constructed with a concrete mixture prepared with 1 part cement, 2 parts sand of specified F.M (minimum FM 1.0) and 4 parts brick chips (12mm down graded). The bed of the excavation shall be well leveled making it suitable for placing brick flat soling. The work shall proceed in accordance with the material specifications and methods and procedures as described under the relevant Sections/Sub-sections of the 'Standard Specifications for Building and Allied Works' used by the LGED.

Brick masonry work

All main and partition walls are to be constructed with brick work of thickness as shown on the Drawings or as described in the BOQ or as directed by the Engineer. Cement mortar shall be prepared with 1 part cement and 4 parts sand of specified F.M (minimum FM 1.2). All inside walls shall be covered with 20mm thick cement plaster with cement mortar prepared with 1 part cement and 4 parts sand of specified F.M. Material specifications, construction methods and procedures etc. shall conform to the requirements stated under the relevant Sections /Sub-sections of the 'Standard Specifications for Building and Allied Works' used by the LGED.

R.C.C. work

Two Tees and the top slab shall be of R.C.C. with minimum one percent reinforcement. Unless otherwise specified, the thickness of the slab should be 100mm constructed with Cement Concrete of proportion 1 part cement, 2 parts sand of specified F.M (minimum FM 1.8). and 4 parts brick chips (12mm down graded). Material specifications, construction methods and procedures etc. shall conform to the requirements stated under the relevant Sections/Sub-sections of the 'Standard Specifications for Building and Allied Works' used by the LGED.

Manhole cover

Requisite numbers of water sealed manhole cover each having diameter of 450mm, made of heavy type cast iron with proper locking arrangements are to be fitted and fixed.

3.13.4 Measurement

Measurement of payment for the Septic Tank shall be made for the actual number constructed, finished as per the specifications shown on the Drawings, BOQ, these Specifications and accepted by the Engineer.

3.13.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per number which payment shall constitute the full compensation for furnishing and preparing all materials of the different items of work involved including storage, handling, transport of materials, all equipment and labours, all excavation with necessary shoring and bailing out water and disposal of soil, backfilling the sides, all concreting, brick work, plastering, cast iron cover and frame with locking arrangements including centering, shuttering, fabricating reinforcement, casting and curing as well as all incidentals to complete the Work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.13	Construction of Septic Tank of requisite size	Each

3.14 SANITARY SEPTIC TANK OF SPECIAL TYPE DEVELOPED BY LGED

3.14.1 Scope

This item of work shall consist of construction of different sizes of Sanitary Septic Tank of special type developed by LGED. Work shall be carried out in accordance with the details as shown on the Drawing, as per the BOQ and these specifications or as directed by the Engineer.

3.14.2 General

Ordinary septic tank is commonly used all over the country. In this septic tank, effluent is discharged to a deep soak pit or soak well, which pollutes underground water with water borne pathogenic bacteria and causes harm for human life when this polluted water is pumped out by shallow tube well to use in drinking purposes. Local Government Engineering Department has developed a sanitary septic tank system in the name of LGED Sanitary Septic Tank by removing all non-sanitary aspects of ordinary septic tank and at the same time reducing construction cost as well. In this Sanitary Septic Tank System, sewage is treated in an anaerobic condition in the Digester Tank for a retention period of minimum 24 days, thus the effluent of this system becomes pathogenic bacteria free and can be discharged to drain or shallow depth leaching pit or irrigation field.

LGED has developed several models of sanitary septic tank depending on number of users and nature of uses. Each model has three chambers, which are— Inlet chamber, Digester Tank and Outlet chamber.

Inlet Chamber

The sewage first enters into this chamber. The floor is comprised of 150mm thick C.C (1:3:6) over a layer of brick flat soling. The side wall consists of 175mm thick brick masonry wall placed with cement-sand mortar (1:6). Inside of the chamber is plastered (12mm thick) with neat cement finishing. Inlet chamber and Digester Tank is connected by RCC inlet pipe having 150mm diameter in general with requisite gradient. The invert level of end of Inlet Pipe at the inlet chamber is placed at bed level of inlet chamber.

Digester Tank

From the Inlet Chamber sewage enters into this Digester Tank. The soffit level of end of inlet pipe within Digester Tank is placed at 200mm (minimum) down from the invert level of the end of the inlet pipe in the Inlet Chamber.

Normally the floor of the Digester Tank is constructed of cement concrete (1:3:6) over a layer of brick flat soling. The outer wall is of thick brick masonry of 250mm thick using cement mortar of proportion 1 part cement and 6 part sand when the height is limited up to 1.83m. The Digester Tank is separated in to two chambers by an end-supported separator. Inside of the Digester Tank is plastered (12mm thick) with neat cement finishing. The top slab is having a minimum thickness of 100mm made of RCC (1:2:4) with two manholes. Manhole cover is made of 100mm thick RCC. Bituminous putty is pasted around the manhole edge before placing RCC cover in order to make the Digester Tank airtight. This Digester Tank is connected to the Outlet Chamber by RCC outlet pipe having 150mm diameter in general with requisite gradient. Within the Digester Tank the soffit level of the end of the outlet pipe is placed above 100mm from the soffit level of the end of inlet pipe.

Outlet Chamber

From the Digester Tank the effluent enter into this chamber. The floor is comprised of 150mm thick C.C (1:3:6) over a layer of brick flat soling. The side wall consists of 175mm thick brick masonry wall placed with cement-sand mortar (1:6). Inside of the chamber is plastered (12mm thick) with neat cement finishing. From this chamber the effluent is discharged into the surface drain or agricultural land or soak well. Outlet chamber and inlet chamber is connected atop with a PVC vent pipe of 38mm diameter embedded in the ground for venting excess methane gas generated through anaerobic decomposition of bio-mass. The invert level of the end of the outlet Pipe in the outlet chamber is placed at the bed level of the outlet chamber. The soffit level of the end of the outlet Pipe within the Digester Tank is placed at 100mm down from the invert level of the end of the outlet pipe in the outlet chamber.

The Technology

A 100mm hydraulic pressure head is created within the Digester Tank. Excess gas generated from decomposition of the biomass in the liquid volume is escaped out through the Outlet Chamber.

The gas evolved is composed of mainly methane, which is generated processing dissolved oxygen in incoming liquid flow. Due to absence of oxygen, all pathogenic bacteria in the liquid are designed to be killed. Thus the effluent can be discharged safely to shallow drains, leaching pit or agricultural land.

3.14.3 Construction Method

Construction methods are similar to those as stated under Sub-section 3.13.3 of the item 'Septic Tank'

3.14.4 Measurement

Measurement of payment for the Special type Sanitary Septic Tank shall be made for the actual number constructed, finished as per the specifications shown on the Drawings, BOQ, these Specifications and accepted by the Engineer.

3.14.5 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per number which payment shall constitute the full compensation for furnishing and preparing all materials of the different items of work involved including storage, handling, transport of materials, all equipment and labours, all excavation with necessary shoring and bailing out water and disposal of soil, backfilling the sides, all concreting, brick work, plastering, RCC manhole cover with specified material and workmanship including centering, shuttering, fabricating reinforcement, casting and curing as well as all incidentals to complete the Work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.14	Construction of Special type Sanitary Septic Tank of requisite	Each

3.15 SOAK WELL

3.15.1 Scope

This item of work shall consist of construction of different sizes of Soak well, depending upon the number of users, in accordance with the details as shown on the Drawing, as per the BOQ and these Specifications or as directed by the Engineer.

3.15.2 Construction Method

The Soak Well shall be constructed with 250mm thick solid brick and honeycomb Brick Masonry work over a R.C.C Well Curb. The well shall have a water-sealed manhole cover made of heavy-duty cast iron with necessary locking arrangement. The well is to be filled with a mixture of graded brick aggregates and sand of specified F.M (minimum FM 1.0). upto the required depth. The brick work shall be constructed with cement mortar having proportion 1 part cement and 2 parts sand of specified F.M (minimum FM 1.2). In case of R.C.C, it shall be made with concrete mixture prepared with 1 part cement, 2 parts sand of specified F.M (minimum FM 1.8). and 4 parts brick chips (12mm down graded). Quantity of reinforcement for the R.C.C should be one and half percent. All Brick works and R.C.C works should be properly cured for the requisite period. Excavation of earth including bailing out water, back-filling the sides etc. should be carried out following the procedures as described under the Section 'Excavation and Back Filling for Structures' of the 'Standard Specifications for Building and Allied Works' used by the LGED.

Material specifications, construction methods and procedures etc. for Brick Masonry work, Cement Concrete work and R.C.C shall conform to the requirements stated under the relevant Sections/Sub-sections of the 'Standard Specifications for Building and Allied Works' used by the LGED.

3.15.3 Measurement

Measurement of payment for the Soak well shall be made for the actual number constructed, finished as per the specifications shown on the Drawings, BOQ and these Specifications and accepted by the Engineer.

3.15.4 Payment

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per number which payment shall constitute the full compensation for furnishing and preparing all materials of the different items of work involved including storage, handling, transport of materials, all equipment and labours, all excavation with necessary shoring and bailing out water and disposal of soil, backfilling the sides, all concreting, brick work, plastering, cast iron cover and frame with locking arrangements including centering, shuttering, fabricating reinforcement, casting and curing as well as all incidentals to complete the Work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.15	Construction of Soak Well of requisite size	Each

3.16 INSPECTION PIT

3.16.1 Description

Inspection Pits are constructed to connect the soil pipe from toilets with the Septic Tank. This will provide the opportunity to clear any blockage in the pipeline system. The work involves construction of masonry inspection pit with 250mm thick brick work in cement mortar (1:4), 100mm thick RCC top slab (1:2:4) with 1% reinforcement, 450mm dia water sealed R.C.C cover including necessary earthwork.

3.16.2 Construction Methods

The work should be executed similar to relevant sub-section(s) of 'Brick Work', 'Concrete Work', 'R.C.C Work', 'Plaster Work', etc. and as per instruction of Engineer.

3.16.3 Payment

Payment will be made for Contract unit price for each Pit.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.16	Inspection pit	Each

3.17 POLYTHINE SHEET

3.17.1 Description

This item will be used as impermeable synthetic sheet of 0.18mm thickness to prevent water leakage from concrete and RCC work.

3.17.2 Construction Methods

Polythine sheet will be laid on flat Brick soling or on finished ground surface.

3.17.3 Measurement

Measurement will be taken in square meter.

3.17.4 Payment

Payment will be made on the basis of Contract unit price per square meter.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.17	Polythene sheet	Square meter

3.18 TUBE-WELL

3.18.1 Scope of work

The work covered by this item of work consists of supplying, installation, development and commissioning of deep set tube-well pump with 75mm casing, 50mm, 38mm PVC well & blind pipe. Roboscreen, solvent cement, acetone, Sylhet sand etc. C.I pump head (Maya/Hydari). This work shall also include the construction of platform, drains and trial borings (as required) and lab-test of water for potability.

Pump head	:	C.I. Pump heads H6 (MAYA/HYDARI or approved equivalent)
PVC pipe	:	BS 3505 or equivalent
Platform	:	Made of plain concrete as per drawing.
Strainer	:	Roboscreen - approved by the Engineer's Representative.

3.18.2 Description of work

3.18.2.1 Boring

The tube-well shall be installed at site by any approved method. Soil samples of every change of layer must be preserved at site in sealed transparent plastic packet with level indicating 'depth'. A boring log shall be maintained during boring and the boring shall continue until a satisfactory layer of aquifer at depth not below 30.5m is encountered or as directed by the Engineer. Test boring shall be made and continued upto sufficient depth till good water bearing strata is encounter, which will provide safe yield and potable water. In places where ground water table is at such depth that single stage Hand Pump cannot yield water, then the Contractor shall install submersible Multistage Pump with the installation of casing.

Water samples from the boring shall be tested in an approved laboratory (PHE or IPE) at Contractor's cost before installing the pump. The test-report to be accepted by the Engineer.

3.18.3 Installation

On obtaining the bore-log and a satisfactory water test report, a detailed drawing indicating the proposed position of casing pipe, housing pipe, well and blind pipe, strainer etc. shall be drawn by the contractor and shall have to be approved by the Engineer's Representative.

The tube-well shall then be installed as per approved drawing & developed until sand-free water is obtained and potability is achieved.

3.18.4 Method of measurement for payment

Boring will be measured in linear meter including collection of soil and water samples. Supply of Hand Pump in each number, PVC pipe and G.I. pipe in linear meter, socket adapter in each number and PVC cap in each number.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.18	Boring	Linear meter
	Hand pump	Each
	PVC pipe and G.I. pipe	Linear meter
	Socket adapter	Each
	PVC cap	Each

3.19 PLUMBING AND PIPING

3.19.1 Scope

This item covers all operations in connection with plumbing and piping as indicated on the Drawings. All works shall conform to the National Plumbing Code (ASA A 40.8 55) published by the American Society of Mechanical Engineers unless otherwise modified.

3.19.2 General Requirements

Drawings

The Drawings shall indicate the general arrangement of all plumbing and piping details. However, where actual field conditions necessitate a rearrangement, the Contractor shall prepare and submit detailed Shop Drawings of the proposed rearrangement for approval of the Engineer. The scale of the Drawings may not permit to indicate all offsets, fittings and accessories, which may be required. The Contractor shall, therefore, carefully examine the Drawings and investigate the structural and finished conditions affecting all of his/her/their works and shall arrange such works accordingly, furnishing such fittings and accessories as may be required to meet all conditions.

Specifications

Materials, fitting, fixtures, equipment required for the works, which are not covered by the detailed specification, shall be as recommended by the manufacturer or shall be in consistent with the good practice which shall require the approval of the Engineer.

Gradients

Drainpipes shall be laid to the following minimum gradients unless otherwise specified or shown on the Drawings.

Size of pipes (diameter)	Gradient	
	Soil pipe*	Rainwater/Wastewater pipe
100mm	1 in 40	1 in 60
150mm	1 in 60	1 in 90
225mm	1 in 100	1 in 150
300mm	1 in 180	1 in 250
450mm	1 in 350	1 in 500

- A Soil pipe is any pipe which conveys the discharge of water closets, slop sinks and urinals, or fixtures having similar functions, sullage-water, with or without the discharge from other fixtures, to the building drain or
- building sewer.

Cutting and repairing

The work shall be carefully laid out in advance and any cutting of concrete or brick walls shall be done only with the written permission of the Engineer. Cutting shall be carefully done and the Contractor shall mend any damage caused to the buildings, piping, wiring or equipment by his/her/their workers as a result of cutting at no additional expense to the Employer.

Protection

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water and chemical damage or mechanical injury. At the completion of the work, fixtures, materials and equipment shall be thoroughly cleaned and delivered in a condition satisfactory to the Engineer.

Location of pipes

On the ground floor, water and sewer pipes will generally follow under the concrete floor at the approximate location as indicated on the Drawings. Pipe sleeves as detailed under Sub-section 3.20.10 shall be provided for the crossing beams. Pipe locations shall not interfere with the reinforcing steel in the beams or floor slab or with the shear concrete in or near the beams or walls. Wastewater lines shall be laid over the sewer line at crossing points. Prior to placing the pipe, a detailed Shop Drawing including its location shall get approved in writing by the Engineer.

3.19.3 Materials, Fixtures and Equipment

The Contractor shall submit to the Engineer for approval a complete list (in triplicate) of materials, fixtures, fittings and equipment, which are to be furnished by him/her/them together with the names and addresses of the manufacturers, their catalogue numbers and trade names. The Contractor shall also furnish other detailed information, where so directed, under various items. No consideration will be given to partial lists submitted at any time.

3.19.4 Excavating, Trenching and Back-filling

When pipes are laid underground, the trenches shall be excavated and back-filled following the specifications and procedures as described under the relevant Section of the latest edition of 'Standard Specifications of Building and Allied Works'. In addition or as an alternative the specifications, which shall also apply are as follows.

Excavation of the trenches shall be made true to the gradient and in accordance with the Drawings. The width of a trench shall be the nominal diameter of the pipe plus 40cm, with 55cm minimum in all soils. The trench should be sufficiently wide to allow space for timbering where required. The sides of the trenches should be as vertical as possible. If rock is encountered with, it shall be removed to 15cm below the level of the pipe and the trench refilled with excavated materials and compacted. Sand of minimum FM 1.0 may be used to make a cushion under the pipe. The gradient shall be set out by means of boning rods and depths marked according to the design reduced levels and as taken from prior agreed temporary Bench Marks. The depth of the trench shall not be less than 0.75m measured from the top of the pipe to the surface of the ground as a safeguard against the effects of any superimposed load.

Where wide excavation is not permissible, shoring shall have to be resorted to in deep trenches. Trenches in soft soils require interlocking sheet piling and bracings to prevent collapse of the sides and leaching of fines from the surrounding of soils.

In some grounds where the finished surface of the formation becomes soft after leveling, firm bottom may be obtained by spreading and compacting a layer of gravel or broken stone of 8cm in thickness over the trench bottom, which should be further excavated to receive this. The bed of the trench, if in soft ground or made up earth, should be well watered and rammed before laying the pipe. Any

depression shall be filled with earth and compacted in 20cm layers. It is important to excavate the trench to the correct width and depth at all points.

Any over-excavation shall be avoided. The Contractor at his/her/their own expenses shall fill up any over-excavation made. This type of filling shall be carried out with cement concrete prepared with one part cement, three parts sand of requisite F.M. (F.M. 1.0) and six parts 10mm down graded brick chips to be obtained from first class picked jhama bricks.

With all diligence the Contractor shall take all cares for securing the utility lines. If existing utility lines are exposed during excavation, they shall be well secured according to the instructions of the Engineer

After the excavation of the trench is complete, recesses in the formation bed shall be cut at the required positions to receive the sockets of the pipes and which should be of sufficient depth to allow hands to pass for making joints. The socket recesses shall be refilled with sand of minimum F.M. 1.0 after jointing the pipe.

The excavated material shall be deposited on one side of the trench and pipes stacked on the other side. The excavated materials shall not be placed within 1m or half of the depth of the trench, whichever is greater, from the edge of the trench.

No more than 30m of trench shall be excavated in advance for pipe laying unless otherwise directed by the Engineer.

Pipe laying in fill sections may be done either by support foundations as shown on the Drawings or by removing unsuitable materials in trenches and refilling with sand of minimum FM 1.0, compacted in 150mm layers (up to the required density), with the formation of berm of at least one pipe diameter on each side of the pipe with a minimum of 300mm of sand fill of same type over the pipe and 150mm below.

3.19.5 Materials and Equipment

General

All pipes, fixtures, fittings, setting compounds and jointing materials, shall conform to the specifications in accordance with the Standards listed and as shown against their names in the Tables given below unless otherwise specified or instructed by the Engineer.

Water supply service pipe

Materials	Standard
Acrylonitrile butadiene styrene (ABS) plastic pipe	ASTM D 1527, ASTM D 2282
Asbestos cement pipe	ASTM C 296, BDS 428, BDS 429
Brass pipe	ASTM B 43
Cast iron water pipe	ASTM D 377
Copper or Copper alloy pipe	ASTM B 42, ASTM B 302
Copper or Copper alloy tubing	ASTM B 75, ASTM B 88, ASTM B 251, ASTM B 447
Chlorinated polyvinyl chloride (CPVC) pipe	ASTM D 2846, ASTM F 441, ASTM F 442
Galvanized steel pipe	ASTM A 53
Polybutylene (PB) plastic pipe and tubing	ASTM D 2662, ASTM D 2666, ASTM D 3309
Polyethylene (PE) plastic pipe and tubing	ASTM D 2239, ASTM D 2737
PVC plastic pipe	ASTM D 1785, ASTM D 2241, ASTM D 2672

Water distribution pipe

Materials	Standard
Brass pipe	ASTM B 43
Copper or Copper alloy pipe	ASTM B 42, ASTM B 302
Copper or Copper alloy tubing	ASTM B 75, ASTM B 88, ASTM B 251, ASTM B 477
CPVC plastic pipe and tubing	ASTM D 2846, ASTM F 441, ASTM

	F 442
Galvanized steel pipe	ASTM A 53
PB plastic pipe and tubing	ASTM D 3309

Pipe fittings

Materials	Standard
Asbestos cement	ISO 160, ISO 881, ISO 392
Cast iron	ASME B 164, ASME B 16.12
Copper or copper alloy	ASME B 16.15, ASME B 16.18, ASME B 16.22, ASME B 16.23, ASME B 16.26, ASME B 16.29, ASME B 16.32
Grey iron and ductile iron	AWWA C 110, ISO 2531
Malleable iron	ASME B 16.3
Plastic	ASTM D 2464, ASTM D 2466, ASTM D 2467, ASTM D 2609, ASTM F 409, ASTM F 437, ASTM F 438, ASTM F 439
Steel	ASME B 16.9, ASME B 16.11, ASME B 16.28

Hanger spacing

Piping Materials	Max. Horizontal Spacing (m)	Max. Vertical Spacing (m)
Galvanized steel pipe	3.5	4.5
Copper pipe or copper alloy tubing > 38mm diameter	3.5	3.0
Copper pipe or copper alloy tubing < 38mm diameter	2.0	3.0
PVC pipe and tubing	1.0	1.0
Aluminium tubing	3.0	4.5
Brass pipe	3.0	3.0

Fixtures

Materials	Standard
Plumbing Fixtures and Drains	Federal specification: WW-P-541b or WW-P-542, as applicable.
Nipples	Federal specification pipe system WW-N-351
Unions (on ferrous type) 50mm and below 60mm and above	Federal specification WW-U-531 type B Federal specification WW-F-406

Joints between different pipings and fittings

Materials	Standard
ABS plastic pipe and fittings	ASTM D 2235, ASTM D 2661, ASTM D 3139, ASTM F 628, ASME B 1.20.1
Asbestos, cement pipe and fittings	ASTM D 1869
Brass pipe and fittings	ASME B 1.20.1
Cast iron pipe and fittings	ASTM C 564
Copper and copper alloy pipe and fittings	ASTM B 32, ASME B 1.20.1
PVC plastic pipe and fittings	ASTM D 2846, ASTM D 3139, ASTM F 493, ASME B 1.20.1
Galvanized steel pipe and fittings	ASME B 1.20.1
PB plastic pipe, tubing and fittings	ASTM D 2657, ASTM D 3140, ASTM D 3309
PE plastic pipe, tubing and fittings	ASTM D 2657
PVC plastic pipe and fittings	ASTM D 2564, ASTM D 2855, ASTM D 3139, ASTM D 3212, ASTM F 402, ASTM F 656, ASME B 1.20.1

Building drainage and vent pipe

Materials	Standard
Acrylonitrile butadiene styrene (ABS plastic pipe)	ASTM D 2661, ASTM F 628
Aluminum tubing	ASTM B 429, ASTM B 745 M
Brass pipe	ASTM B 43
Cast iron pipe	ASTM A 74
Copper or Copper alloy tubing	ASTM B 75 M, ASTM B 88 M, ASTM B 251 M, ASTM B 306
Galvanized steel pipe	ASTM A 53
Lead pipe	IS 404
Polyvinyl chloride plastic pipe	ASTM D 2665, ASTM D 2949, ASTM F 891

Building sewer or building storm sewer pipe

Materials	Standard
Acrylonitrile butadiene styrene (ABS plastic pipe)	ASTM D 2261, ASTM D 2751, ASTM D 2321, ASTM F 628
Asbestos	BDS 428, BDS 429
Bituminized fibre pipe	ASTM D 1861, ASTM D 1862
Cast iron pipe	ASTM A 74,
Concrete pipe	ASTM C 14 M, ASTM C 76 M
Copper or Copper alloy tubing	ASTM B 75, ASTM B 88 M, ASTM B 251 M
Polyvinyl chloride (PVC) plastic pipe	ASTM D 2665, ASTM D 2949, ASTM D 3034, ASTM D 2321, ASTM F 891
Vitrified clay pipe	ASTM C 4, ASTM C 700

Subsoil drainage pipe

Materials	Standard
Asbestos cement pipe	ASTM C 508
Bituminous fibre pipe	ASTM D 2311
Cast iron pipe	ASTM A 74
Concrete pipe	ASTM C 654 M
Polyethylene (PE) plastic pipe	ASTM F 405
Polyvinyl chloride (PVC) plastic pipe	ASTM D 2729, ASTM F 891
Vitrified clay pipe	ASTM C 4, ASTM C 700

Joints between different pipes and fittings

Materials	Standard
ABS plastic pipe and fittings	ASTM D 2235, ASTM D 2661, ASTM D 3212, ASTM F 628, ASME B 1.20.1
Aluminium tubing	ASTM C 564
Asbestos cement pipe and fittings	ASTM D 1869
Brass pipe and fittings	ASME B 1.20.1
Cast iron pipe and fittings	ASTM C 564
Concrete pipe and fittings	ASTM C 443
Copper or Copper alloy pipe & fittings	ASTM B 32, ASME B 1.20.1
Copper alloy tubing and fittings	ASTM B 32
CPVC plastic pipe and fittings	ASTM F 493, ASME B 1.20.1
Galvanized steel pipe and fittings	ASME B 1.20.1
PE plastic pipe and fittings	ASTM D 2657
PVC plastic pipe and fittings	ASTM D 2657, ASTM D 2855, ASTM D 3139, ASTM D 3212, ASTM F 402, ASTM F 656, ASME B 1.20.1
Vitrified clay pipe and fitting	ASTM C 425

Recommended depth of water seal trap for different fixtures

Fixture	Water Seal (mm)
Water Closets	50
Floor Traps	50
For Waste Branch of 75mm diameter or More	40
For Waste Branch of Less Than 75mm diameter	75

3.19.6 Plumbing (General Requirement)

Threads at the end of the G.I. pipes and inside the socket shall be examined and cleaned. Damaged threads shall be cut with sharp dies. Before installation, thread shall be coated with approved jointing compound and the pipes shall be fitted in to the socket tightly with the help of chain tongs or pipe wrenches.

If a pipe is embedded in a wall with insufficient cover (less than 40mm) or if it is carried exposed, it shall be supported by clamps and nails/nuts and bolts according to the approved designs/methods. The distance between supports shall not exceed 760mm and U-bolt shall not be less than 10mm.

Pipes placed vertically or horizontally within a shaft or exposed, shall be clamped to the wall or hang from the roof using approved type of bolt, pipe support, hanger etc. Pipe shall be supported or hang at a spacing of maximum 3.5m horizontally and 4.5m vertically.

Hanger bolt or support shall have sufficient strength to bear the weight of the pipe with the water in it. All M.S. materials shall be painted with two coats of red oxide paint before installation.

12mm and 20mm piping works shall be concealed and embedded in a wall by a vertical groove cutting from toilet false slab down to the fixture point. The work shall be carefully laid out in advance and any cutting of concrete or brick walls shall be done only with the written permission of the Engineer. Cutting shall be done carefully. The Contractor shall repair any damage done to the building, piping, wiring or equipment as a result of cutting at no additional expense to the Employer.

In brick walls, the pipes shall be encased by concrete of at least 40mm thick all around. The concrete shall be prepared with one part cement, three parts sand and six parts brick aggregates. The coarse aggregate of the concrete shall be 10mm down graded chips prepared from jhama bricks/gravel and fine aggregate being medium sand. All concrete materials shall conform to the specifications as described under the Section on 'Building Materials' of the 'Standard Specifications of Building and Allied Works'.

The openings through walls or floors for the installation of pipes shall be closed by using proper collars to prevent the entrance of rats.

When water supply pipes are laid underground, the trenches shall be excavated and back-filled following the specifications and procedures as described under the relevant Section of the 'Standard Specifications of Building and Allied Works'. In addition, the specification which shall also apply is to make the width of the excavation trench at least 0.4m more than the outside diameter of the pipe. The depth of ground cover shall be at least 0.9m under roadway or 0.75m under garden from the top surface of the pipe to the ground surface. The bottom of the trench shall be carefully prepared so that the pipe will be bedded well for its entire length on firm surface. In sloping ground, the pipe laying shall proceed in upward direction. The pipe shall be provided with anchor blocks of appropriate size as would be designed to withstand hydraulic pressure.

The excavated materials shall be deposited at a minimum distance of 450mm from the banks of the trench with ground adjacent being graded to prevent water running in. No more than 30m of trench shall be excavated in advance for pipe laying unless otherwise directed by the Engineer.

In laying pipe in fill sections, it may be done either by support foundations as shown on the Drawings or by removing unsuitable materials in trenches and refilling with sand of FM 1.0, compacted in 150mm layers (up to the required density), with the formation of berm of at least one pipe diameter on each side of the pipe with a minimum of 300mm of sand fill over the pipe and 150mm below.

All joints and connections shall be water tight for the pressure required by the test. The joints between different pipes and fittings shall conform to the standards ASME B 1.20.1. The requirements for the joints, not specified, shall be subject to the approval of the authority.

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury. At the completion of the work, fixtures, materials and equipment shall be thoroughly cleaned and delivered in a condition satisfactory to the Engineer.

3.19.7 Completion of Pipe Surround

After completion of the pipe laying and bedding, in accordance with the relevant provisions of the Specification, fill material shall, where required, be placed and compacted over the full width of the trench in layers not exceeding 150mm before compaction, to a finished thickness of 250mm above the crown of the pipe.

Subsequent back-filling shall then be carried out in accordance with the relevant provisions of the Specification.

3.19.8 Water Pipe, Fittings and Connections

Piping and fittings

Water distribution pipe in a building shall be maintained at a pressure so that none of the fittings are subject to a water head greater than 35m, unless otherwise stated.

The distribution system shall be maintained at a pressure not less than those specified in the table given below during pick demand period. The minimum size of supply of pipe for different fixtures shall also be in accordance with the table.

Water supply system design requirements

Fixture	Supply Control	Minimum size of supply pipe (mm)	Required flow pressure (kPa)
Bathroom group	Flush tank	-	55
Bathroom group	Flushometer valve	-	55
Bathtub	Faucet	13	55
Clothes washer		13	55
Combination fixture	Faucet	13	55
Dishwashing machine		13	55
Drinking fountain	Faucet	19	55
Kitchen sink	Faucet	13	55
Laundry tray	Faucet	13	55
Wash basin	Faucet	19	55
Pedestal urinal	Flush tank	13	55
Pedestal urinal	Flushometer valve	19	100
Restaurant sink	Faucet	19	55
Service sink	Faucet	13	55
Shower head	Mixing valve	13	55
Water closet	Flush tank	19	55
Water closet	Flushometer tank	19	55
Water closet	Flushometer valve	25	100
For fixture not listed here but maximum supply size requirement		13	55
		19	55
		25	100

The water flow velocity in the distribution system shall be controlled to minimize the possibility of water hammer.

The connection of potable water for health care plumbing fixtures shall be protected against back flow in accordance with the table given below.

Water supply protection for hospital fixtures

Fixtures	Protections required
Aspirators	Vacuum breaker
Bedpan washer	Vacuum breaker
Boiling type sterilizer	Air gap
Exhaust condenser	Vacuum breaker
Flush floor drain	Vacuum breaker
House connection	Vacuum breaker
Pressure sterilizer	Vacuum breaker
Vacuum system (cleaning and fluid section)	Air gap or vacuum breaker

The minimum air gaps for different water supply openings or outlet shall be at least 3 times the effective opening when they are placed close to a wall. The minimum air gaps shall be at least 2 times the effective opening when they are located away from a wall.

All piping and fittings of potable water supply shall be installed and maintained properly to avoid risk of contamination.

Water supply service and distribution pipes shall conform to the standards listed in the table under the head 'Water Supply Service Pipe' and 'Water Distribution Pipe' as shown before. The water supply pipes and tubing used outside the building or underground shall have a minimum working pressure of 1.1 MPa at 23o C. In case of water supply exceeding this pressure, the piping material shall have at least a rated working pressure equal to the highest available pressure. The hot water distribution piping shall have a minimum pressure of 550 kPa at 80oC. PVC plastic pipes shall not be used exposed and unprotected as riser or water distribution pipe. PVC plastic pipes shall not also be installed or laid under direct sunlight. Polythene or unplasticized PVC shall not be installed near the heaters or hot water piping. Lead pipes may be used only for flushing and overflow purposes in a water supply system.

The pipe fittings shall be in accordance with the standards listed in the Table under the head 'Pipe Fittings' as shown before.

A gate valve and drain valve on the service line shall be installed inside the building. The piping shall be extended to all fixtures, outlet and equipment from the gate valve. The cold water system shall be installed with a fall toward the shut off valve. Supply line taken from pressure or gravity tanks, shall be valved with approved type at or near its sources and an interior stop and waste valve or cock shall be provided for each outlet or group of outlets. Stops and waste cocks shall be accessible and of such size and so installed as to permit complete flow of the entire water supply system they serve.

A capped tee shall be installed below the shut off valve on each water service riser in each building.

Piping shall be installed as indicated on the Drawings. Pipes shall be cut accurately to measurements established at the building by the Contractor and shall be worked in to place without springing or forcing. Care shall be taken not to weaken the structural portions of the building. Piping above the ground shall run parallel with the lines of the building unless otherwise shown or noted on the Drawings. Branch pipe from service lines may be taken at top of main, bottom of main or side of main using such crossover fittings as may be required by structural or installation conditions, as approved by the Engineer.

Service pipes, valves and fittings shall be kept at sufficient distance from other works and other services to permit not less than 12mm between finished covering of the different services. No water piping shall be buried in floors unless specifically indicated on the Drawings. Changes on pipe sizes shall be made with reducing fittings. Use of bush shall not be permitted.

All water pipes shall be so graded or pitched that the entire system or parts thereof can be drained and the formation of traps or sags shall be avoided where possible. Where traps or sags will form, they shall have provision for complete drainage.

Allowance shall be made throughout for expansion and contraction of piping. Horizontal runs of piping over 15m in length shall be anchored to the wall or to the supporting construction about midway on the run to force expansion, evenly divided towards the end.

Air Chambers for water hammer control shall be provided on cold supplies at each faucet and control valve and flush valve and where not shown specifically on the Drawings shall consist of 250mm length of pipe of the same diameter as the branch supply, fitted with a cap.

No plumbing system or part thereof shall be covered until it has been inspected and approved. In brick walls, the pipes shall be encased by concrete of at least 40mm thick all around. The concrete shall be prepared with one part cement, three parts sand and six parts brick aggregates. The coarse aggregate of the concrete shall be 10mm down graded prepared from jhama brick chips/gravel and fine aggregate being medium sand. All concrete materials shall conform to the specifications as described under the Section on 'Building Materials' of the 'Standard Specifications of Building and Allied Works'. All GI pipes, less than 40mm diameter, when embedded in walls shall be located nearly in the middle of the wall thickness unless otherwise shown on the Drawings or specified.

If a pipe is embedded in wall with insufficient cover (less than 40mm) or if it is carried exposed, it shall be supported by clamps and nails/nuts and bolts according to the approved designs/methods that will make it adequately strong. The distance between supports shall not exceed 760mm and the diameter of U-bolt shall not be less than 10mm.

Hangers and supports

The piping shall be installed with proper hangers and supports to minimize undue strains and stresses. All fixtures and fittings shall be provided with hangers and supports to secure them properly.

Hangers, anchors and strapping materials shall be strong and ductile and shall not promote galvanic action. Vertical and horizontal piping shall be supported in accordance with the table under the head 'Hanger Spacing'.

Excavation of trenches

The width of excavated trench shall be at least 0.4m more than the outside diameter of the pipe. The depth of ground cover shall be at least 0.9m under roadway or 0.75m under garden from the top surface of the pipe to the ground surface. The bottom of the trench shall be carefully prepared so that the pipe will be bedded well for its entire length on firm surface.

Laying of pipes

In sloping ground, the pipe laying shall proceed in upward direction. The pipe shall be provided with anchor blocks to withstand hydraulic pressure.

Laying of pipe through ducts, chases, notches or holes

Provisions for laying pipes in ducts or chase shall be made during the time of construction. When these are cut into existing walls, they shall be large enough with smooth finishing for fixing the pipe and to accommodate thermal expansion. Piping subject to external pressure shall not be laid in notches or holes.

Lagged piping

Lagged piping shall be entirely covered with waterproof and fire insulating materials before their attachment to the walls outside the building and shall be anchored with the wall keeping a gap in between the wall and the piping.

Jointing of pipes

All joints and connections shall be gas tight and water tight for the pressure required by the test in accordance with the provisions under the sub-section on 'Testing' stated afterwards. The joints between different piping and fittings for water supply shall conform to the standards cited against them in the Table on 'Joints Between Different Pippings and Fittings'. The requirements for the joints not specified in the Table shall be subject to the approval of the Engineer.

In case of threaded pipes, pipe shall be reamed and shall have burrs removed after cutting and before threading. Screw joints shall be established with hemp yarn soaked in China lacquer or with an approved graphite compound applied to male threads only. Threads shall be fully cut and not more than three threads on the pipe shall remain exposed. Caulking of threaded joints shall not be allowed to stop or prevent leaks. Unions shall be provided where required for disconnection.

Special care for rat proofing

The location and installation of water meter box shall be such as not to permit the entrance of rats into the building. The openings through walls, floors or ceilings for the installation of pipes shall be closed by using proper collars to prevent the entrance of rats.

3.19.9 Sewage and Rain Water Piping, Fittings and Connections

Piping and fittings

Cast iron pipes and fittings wherever specified to be used shall be of heavy-duty and in conformity with the requirements of the standards as mentioned previously under this Sub-section with spigot and socket joints having projecting ears. All fittings shall be similar in every respect to the pipe. The pipe shall be coated with 2 coats of epoxy paint. Manufacturer may be MAANCO or approved equal.

PVC pipes and fittings, wherever specified to use, shall be of heavy-duty and in conformity with the requirements of the standards as mentioned previously under this Sub-section. Fittings shall also be of similar standard. Manufacturer may be LYRA, AZIZ or National Polymer or approved equal.

Installation

Pipe and accessories shall be handled in such a manner as to insure delivery to the point of installation in sound and undamaged condition. Special cares shall be taken not to damage the pipe coating. No other pipe or material of any kind shall be placed inside a pipe or fittings after the coating has been applied.

Cutting of pipe shall be done in a neat and workmanlike manner without any damage to the pipe. Unless otherwise authorized by the Engineer, cutting shall be done by means of an approved type of mechanical cutter. Wheel cutters shall be used when possible.

Before installation, the pipe shall be inspected for defects and tapped with a light hammer to detect cracks. Defective, damaged or unsound pipe shall be rejected. Deflections from straight line or grade, as required by vertical, horizontal curves or offsets, shall not exceed $6d$ per linear meter of pipe for pipe of not more than 350mm in diameter, where 'd' represents the nominal diameter of the pipe expressed in between the center lines extended of any two connecting pipes. If the alignment requires deflections in excess of these limitations, standard bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth as approved by the Engineer. Except where necessary in making connections to other lines or as authorized by the Engineer, pipe shall be laid with bells facing upgrades. Except at closures, not less than two lengths of pipe shall be in position ahead of each joint, with packing installed and earth fill tamped alongside the pipe, before the joint is poured. Adequate thrust blocking shall be provided for all pressure mains. Exposed ends of pipes in trenches shall be fully protected with a board or other approved stopper to prevent earth or other substances entering the pipes.

Bedding and encasing pipe drains

The trench bottom shall be rammed and compacted and carefully shaped as specified previously, true to the line and grade to the satisfaction of the Engineer. Drainpipes shall be laid and supported on false supports. Jointing shall then be done and after the said pipe section is tested to the satisfaction of the Engineer, the pipes shall be laid in position either on the arch so formed in the trench bed or on the concrete bed. When concrete bed is used, the width of the bed at the bottom shall be 350mm wider than the internal diameter of the pipe. The side slopes shall join the edges of the bottom of the concrete bed and the pipe tangentially as shown on the Drawings. The depth of concrete bed shall be minimum 100mm below the pipe and shall be increased at joints to maintain minimum 100mm from socket surface. The concrete bed shall be cured for ten days. In case of pipes, being laid on earth foundation, the pipes shall be surrounded to a height of at least 150mm above its top with sand of minimum FM 1.0.

Joints

Pipe jointing surfaces and components shall be kept clean and free from extraneous matter until the joints have been made or assembled. Care shall be taken to ensure that there is no ingress or other extraneous material into the joint annulus after the joint has been made.

Where pipes with flexible joints are required to be laid to curves, the deflection at any joint as laid shall not exceed three quarters the maximum deflection recommended by the manufacturer.

All joints (for smaller diameter pipes) shall conform to the following table, if not specified otherwise in the Schedule of Work.

Pipe	Hot poured Bituminous Compound	Pre-cast bituminous Compound	Cement Sand Mortar	Glued	Lead	Mechanized
RCC	A	A	A	NA	A	NA
Cast iron	A	A	A	NA	A	A
PVC	NA	NA	NA	A	NA	A

Note : 'A' stands for 'Applicable' and 'NA' stands for 'Not Applicable'.

Roofing pitch, tarred gasket, cement-sand mortar of approved quality shall be used for joining R.C.C. pipes and W.C. into sockets. Hemp yarn or twisted jute packing soaked in cement grout and cement sand mortar (1:2) shall be used for jointing C.I. and R.C.C. pipes. Hemp yarn soaked in china lacquer or an approved graphite compound shall be used in cleaned and dry threaded joints only.

Threaded joints

Threaded joints shall be American National Taper Screw Threads conforming to the requirements of Federal Specification GGG P 351a, with graphite and oil compound applied to the male thread only. Connections between threaded pipe and soil pipe shall be similar and the threaded pipe shall have a ring or half coupling screwed on to form a spigot end.

Mechanical joints or bolted joints (Flanged joints)

Pipes which are made with flanges are jointed together with bolts and nuts. Such joints are used in pipes for sluice valves, hydrants or meter connections which may have to be removed for repairs, vertical inlet and outlet pipes of reservoirs, for pipes where inlet pressure is high or resistance to longitudinal force is required as in the case of inverted siphons, in suction pipes of pumps where a close joint is wanted to prevent air being sucked in and where there are vibrations. Flanged joints, in general, widely used for inside work, overhead pipe lines, or for connections in confined or vertical positions, but are generally not employed for underground mains.

MS and GI pipes and fittings shall be flanged unless stated otherwise. Flanges and gaskets shall comply with BS 4504 and 4865 or equivalent respectively. The flanges shall be installed with the jointing materials such as gasket, nuts-bolts, washers, etc. for proper leak proof jointing.

Nuts and bolts shall be of GI with 2 washers per bolt. Gasket shall be made of 3mm thick rubber to BS 3063 or equivalent reinforced with fabric in accordance with BS 1787 or equivalent of such width so as to cover the machined face of the joint inside the bolt holes.

The flanged joint shall ensure permanent water-tightness against pressures up to the maximum test pressure. The use of jointing paste or grease will not be permitted. The bores of abutting pipes or fittings shall be concentric and no jointing material is to be left protruding into the bore.

Flanges shall be properly aligned before any bolts are tightened. All nuts shall first be tightened by hand and nuts on diametrically opposite sides of the joint circumference shall then be alternately and progressively tightened with a spanner so as to ensure even pressure all round the joint.

Jointing compounds shall not be used when making flanged joints, except that, to facilitate the making of vertical joints, gaskets may be secured temporarily to one flange face by a minimum quantity of clear rubber solution.

Bell and spigot joints

Before jointing bell and spigot pipe, all lumps, blisters, and excess coating material shall be removed from the bell and spigot ends of the pipes. All oil or grease shall be removed. The outside of the spigot and the inside of the bell shall be wire brushed and wiped clean and dry. Joint packing shall be carefully placed and tightly caulked to a uniform thickness. No loose or frayed ends of fiber shall protrude in to the space to be filled in with joint filler. Each joint shall be carefully inspected and checked for proper depth before the joint runner is attached. Pipe and bell end having approved inside contour may be packed with rubber ring gasket without caulking.

Lead filled joints

Bell and Spigot lead caulked joint is the most commonly used for underground water mains with cast iron pipes. This joint lends itself to expansion and contraction under moderate changes of temperature and has certain amount of flexibility, which enables the pipes to accommodate themselves to small settlements of the ground, which may occur under the pipes. These joints are not suitable for high-pressure hydraulic pipelines, and are liable to leakage when disturbed by ground movements or vibrations.

The depth of lead in the lead filled joints shall not be less than 60mm back of the face of the Bell.

The lead used for caulking shall be soft bluish grey pig lead free from admixtures of tin or other impurities. The spun yarn shall be clean hemp and soaked in hot tar or bitumen, cooled and dried before use.

To lead the joints the interior of the socket and the exterior of the spigot must be thoroughly cleaned and dried. This method requires special care in wet trenches. The spigot end should be inserted into the socket right up to the back of the socket and centered by tightly caulking in sufficient turns of tarred gasket or hemp yarn to leave on filled half the depth of socket for lead. Two or three laps of spun yarn, twisted into ropes of thickness of at least 10mm dia, will do. No piece of yarn shall be shorter than the circumference of the pipe. When more than a single strand is required for a joint, each strand shall be cut to sufficient length so that the ends will meet without causing overlap. When gasket or hemp yarn has been caulked tightly home, a jointing ring shall be placed round the barrel and against the faces of the socket.

Molten lead shall be poured in to fill the remainder of the socket. The lead shall then be solidly caulked right round the joint. The proper depth of each joint shall be tested before running the lead in by passing completely round it a wooden gauge notched out to the correct depth of lead. (Depth for the lead is about 25mm to 40mm according to the diameter of the pipe). Asbestos rope is also used in place of yarn. Any material used must be free of oil, tar or any greasy substance.

The objection to the use of spun yarn is that in time it rots, tends to become infected with bacteria and which may contaminate the water. It must be disinfected before use.

Lead caulked joints with lead wool yarn

This type of lead caulked is generally done when it is inconvenient or dangerous to use molten lead for joints for example, in cases such as inverted joints or in wet trenches. The spun yarn shall first be inserted and caulked into the socket as described under jointing with molten lead. Lead wool or lead yarn shall then be introduced in the joint in strings not less than 6mm thick and the caulking repeated with each turn of lead wool. The whole of the lead wool shall be compressed into a dense mass. The joint shall then be finally finished flush with face of the socket. The lead wool brought to site shall be properly protected and packed with wax paper or polythene sheet, to prevent oxidation.

Heating and pouring of lead

Lead shall be heated in a melting pot kept in easy reach of the joint to be poured so that the molten metal will not be chilled in being carried from the melting pot to the joint and shall be brought to a temperature which renders it thoroughly fluid so that when stirred it will show a rapid change in colour.

Before pouring, all scum shall be removed, and each joint filled at one pouring. Sometimes a little powdered resin is sprinkled on the molten lead and the latter shaken. The resin acts as a flux and keeps the lead in a liquid form. If the pipe is too large for the joint to be filled from one ladle, two or more ladles can be used.

The pouring of molten lead in the joints can be done by using proper leading rings of metal or asbestos, with clamps, or if these are not available, make a wrapper of spun yarn (or a ring of hemp rope) worked up with clay having the consistency of putty. This should be about 80mm wide and 20mm thick and 100mm longer than the circumstances of the joint. This be wrapped round the joint with the overlap on top leaving a V-shape large hole in it. Lead is poured in one operation only. The wrapper be stripped off when lead has hardened and use it for the next joint. For large pipes it is also necessary to leave one or more air vents around the lower half of the joints.

When scaling joints with molten lead, care should be taken to protect them against penetration of moisture.

When lowering the kettle with molten lead into the trench, any worker in the vicinity of the place where the kettle is lowered should move away to a safe distance from it. The kettle with molten lead can be approached only after it is at the bottom of the trench.

Cement sand mortar joints

Before jointing bell and spigot pipe all lumps, blisters and excess coating material shall be removed from the bell and spigot ends of the pipes. All oil or grease shall be removed. The outside of the spigot and the inside of the bell shall be wire brushed and wiped clean and dry.

Gasket of closely twisted hemp or oakum of one piece of suitable diameter (not less than 19mm) saturated with neat cement with 5% pudlo shall be wrapped with lap at the joint. The gasket shall be pushed tightly home in to the annular space within the socket or bell of the pipe with a suitable wooden caulking tool. A suitable runner shall be placed around the pipe to close the socket opening.

The joint shall be completely filled with cement mortar following the procedure as stated below:

- ☐ The joint is first yarned with hemp yarn dipped in cement slurry. The yarn is first inserted to slight depth and well pressed in the same manner as for lead jointing.
- ☐ Cement mortar prepared with 1 part cement and 1 part sand of minimum FM 1.0 with a water cement ratio not exceeding one part of water to 5 parts of cement (by weight) should be rammed thoroughly into the joint by caulking tools.
- ☐ The filling to complete and caulked again.
- ☐ Joints should be cured for 14 days after making.

Hot poured bituminous compound joint

Same gasket as in Cement Sand Mortar Joints shall be used. Bituminous compound as specified shall be heated to 350°F and poured into the joint to fill it completely.

Permissible deflection at joints

Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted, the deflection allowed at the joints shall not exceed 2.5 degree.

3.19.10 Waste Water, Drain and Vent Piping

Underground wastewater and drain piping

Underground wastewater and drain piping shall be of coal tar epoxy coated centrifugally spun reinforced concrete pipe and fittings unless otherwise mentioned. Surface wastewater and drainpipes shall be of heavy duty cast iron with spigot and socket joints and fittings. Vent pipes and fittings shall also be of heavy duty cast iron. All pipes, joints and fittings shall meet the requirements of the standards as shown previously in the different relevant Tables.

Drainage pipes and vent piping

Horizontal soil and waste pipes shall be given a grade as shown previously in the table on 'Gradients' unless otherwise noted on the Drawings. All main vertical sewer and waste stacks shall be extended full size to the end above the roofline as vents, except where otherwise specifically indicated. Where appropriate, two or more vent pipes shall be connected together and extended as one pipe through the roof. Vent pipes in roof spaces shall be run as close as possible to the underside of the roof with horizontal piping pitched down to stacks without forming traps in pipes, vertical centered fixture. Where circuit vent or wet vent serving other fixtures or line of fixture is connected to a vent pipe serving other fixtures, the connection shall be at least 1m above the floor on which the fixtures are located in order to prevent the use of any vent line as a waste. Horizontal waste lines receiving the discharge from two or more fixtures shall be provided with end vents, unless separate venting of fixtures is noted.

Fittings

Change in pipe size on soil, waste and drain lines shall be made with reducing fittings or recessed reducers. Changes in direction shall be made with the appropriate use of 45° elbows, half elbows, long sweep 6mm bends, 6mm, 3mm or 2mm bends, except that sanitary tees may be used on vertical stacks and where the changes in direction of flow is from the horizontal to the vertical and on the discharge from water closets. Approval of the Engineer shall be obtained prior to use of short radius fittings at places where it becomes necessary, arising from space conditions.

Union connection

Slip joints will be permitted only in trap seals or in the inlet side of the traps. Tucker or hub drainage fittings shall be used for making union connection wherever practicable in connection with dry vents. The use of long screws and bush is prohibited.

3.19.11 Clean-outs, Test Tees, Traps and Sleeves

Clean-outs

Clean-outs shall be of the same size that of the pipe, except the clean-out plugs, larger than 100mm, will not be required. Clean-outs outside of the building may be omitted if a clean out is indicated on building drain immediately inside the building.

Test tees

Test tees with cast iron cleaned plugs shall be installed at the foot of all soil, waste and drain stacks and on each building drain outside the buildings.

Traps

Each fixture and piece of equipment requiring connections to the drainage system shall be equipped with a trap. Traps installed on hub and spigot shall be extra heavy cast iron. Traps installed on threaded pipe shall be recess drainage pattern. Plugs shall be accessible inside of access panels if such panels are used.

Sleeves

All sleeves shall be furnished and set and the Contractor shall be responsible for their proper and permanent location. Pipe sleeves shall be 26 gauge prime and painted metal, properly secured in place with a space of approximately 6mm between the sleeve and the pipe passing through concrete or masonry walls and floors above the finished grade. Pipe sleeves in concrete beams or bearing walls shall be wrought or steel pipe. Where piping is insulated, the insulation shall be continuous through the pipe sleeves with a clearance of approximately 6mm between the outside of the passing pipe covering and the pipe sleeve. Where a pipe passes through floors it shall be made tight with plastic material. Sleeves through floors shall be extended not less than 12mm and not more than 25mm above finished floor. Where pipe passes through wet tank walls, a center flange sleeve shall be installed. The sleeves shall be provided with an integral flange. The space between the sleeves and the pipe shall be made watertight by inserting a packed oakum gasket, and filling the remaining space with pig lead and thoroughly caulking. Boxing out will be permitted where indicated on the Drawings.

3.19.12 Valves, Unions, Hose Bibs, Reducers, Sockets, Stop Cock, Open Tap

Valves

All valves shall conform to British Standard Specifications and shall be of adequate size and strength to withstand a test pressure of 1380 Kpa. They shall be fitted in suitable such position so as to ensure easy and smooth operation. Defective valves and installations shall be rejected and shall be replaced by the Contractor at his/her/their own cost.

Gate valves of appropriate size shall be used as specified in the schedule.

Globe valves shall be fitted as per Drawing and direction. The valve shall be of size as specified in the schedule.

Lift check valves shall be silent type. The valve shall be spring loaded and of sufficient strength to operate under a pressure condition where it is installed. In installation of check valves, care shall be taken to place it at the correct position and that a valve designed for a horizontal pipe is not placed on a vertical pipe or vice versa. The valves shall be of iron body with bronze trim stainless spring guided seat and disc.

Strainers shall be of Y pattern set in a horizontal run of the pipe it shall be so arranged as not to 'trip' pipes and must have the facility of disconnection and opening up for cleaning. The strainer shall have cast iron or bronze bodies and shall have removable cylindrical or conical nickel, copper or brass seat and disc.

Pressure reducing valve shall be installed on pipe in horizontal level at the entrance of the pipe over false ceiling to room connections. The fitting of the valve shall be proper. Pressure reducing valve shall be suitable to maintain a constant pressure at out-let as specified in the schedule. Valve shall be suitable to maintain pressure whether there is flow or no flow of water.

All valves shall be installed as per Drawing and direction. Approved type of sealing compound or 'Teflon' tape shall be used on thread to make threaded valve joint watertight.

Approved type of gasket shall be used between flanges of flange end valve. Nuts and bolts shall be properly tightened to make the joint water tight under test pressure. Cementer permanent joint shall not be used at any circumstance.

All valves shall be positioned in such a way so that it can operate easily and can be serviceable easily.

Valves shall be individually supported, clamped or hanged. Approved type of hanger support etc. shall be used.

Unions

For GI pipe up to 75mm in diameter malleable iron with zinc coated unions are to be used for joining, and for 100mm and larger diameter shall be flange pattern and shall be galvanized (Zinc coated) iron. Gaskets for flanged unions shall be of the best quality fiber, plastic, or leather. Unions shall not be concealed in walls, ceilings or partitions.

Hose bibs

Hose bibs shall be installed where shown on the Drawings and shall be single faucet shoulder type with 19mm hose connection.

Sockets

Sockets should be of good quality galvanized iron.

Stop cock

Supply, fitting, fixing of stopcock shall be carried out in accordance with the provisions of the Schedule. Stopcock shall be screwed end type suitable to be installed on threaded end G.I. pipe of diameter 13mm. Approved type of sealing compound or 'Teflon' tape shall be used on pipe thread to make the joint watertight. The contractor shall have to submit sample of stopcock to the Engineer for approval. If the stopcock does not withstand test pressure it will not be acceptable. Stopcock shall be well positioned so that operation and servicing become easy.

Open tap

Supply, fitting, fixing of CP open tap shall be as per schedule. Contractor shall have to submit sample of open tap, best quality available in the market, to the Engineer for approval. Each and every tap shall be pressure tested by the Contractor.

The tap, which will not sustain test pressure, will be rejected.

Approved type of sealing compound or 'Teflon' tape shall be used on pipe thread before fixing of threaded end open tap on G.I. pipe work.

3.19.13 Samples

Samples of pipes, fittings and other fixtures, to be used in the construction, shall be supplied by the Contractor for approval of the Engineer together with the names and addresses of the manufacturers and their catalogue numbers and trade names.

Approved samples shall be retained by the Engineer and shall be used as standard for comparison of the materials delivered to the Site and used under the Contract. The Contractor shall not procure any material unless the written approval is obtained from the Engineer.

3.19.14 Inspection

Piping and joints of the water supply systems shall not be enclosed, concealed or covered until they have been inspected and approved by the Engineer. All piping and fixtures shall be inspected for satisfactory supports and protection from damage and corrosion.

The new drainage and sanitation system or part of existing system shall not be covered or enclosed or put in to operation until it has been inspected, tested and approved by the Engineer. The Engineer may examine the appliances and fittings before their installation or during the progress of the work. An installation of plumbing work, whether new or existing, which is found to be defective or unsafe shall not be allowed to continue in use unless corrections have been made to comply with the Code requirements.

3.19.15 Testing

Water supply system

Testing of new pipe lines for leakage

After a section of the pipeline has been laid and jointed, it shall be tested for water-tightness before being covered in. Sections of about 300m length and between valves are taken for testing at a time, as the work proceeds. The trench may be partially back-filled except at the joints, which shall be left open. One open end of the pipeline is closed by fitting a watertight expanding plug of which several types are available or a valve or blank flange or cap. The pipes are slowly filled with water so that all air is expelled from the pipes through hydrants and blow-offs, by providing a 25mm inlet with a stopcock and allowed to stand full of water for at least 24 hours and then tested under pressure. If necessary the pipes should be tapped at high points to expel the air. The test pressure shall be 5 kg/sq. cm. or the maximum working pressure plus 50% whichever is greater. The pressure can be applied by means of a manually operated hand force pump or hydraulic pressure pump and the pressure is maintained for half an hour. If the trench has been back-filled, the duration of the pressure test shall be at least one hour.

If the section of the pipe line to be tested terminates with a sluice valve, the wedge of the valve shall not be used to retain the water instead the valve shall be temporarily fitted with a blank flange cap, or in the case of a socketed valve, with a plug and the wedge placed in the open position while testing.

When the joints are made with lead, all such joints showing visible leaks shall be re-caulked until tight. When the joints are made with cement and show seepage or slight leakage, such joints shall be cut out and replaced. Redone joints shall be re-tested.

While under-going test, pipes are struck with a small hammer to detect any leakage through cracks. All pipes, fittings valves, hydrant and joints are carefully examined for defects. The pipes shall remain

full of water until all tests have been made. When a pipe is laid on a steep gradient, the test should be carried out at the lower end of the pipe.

Leakage tests on cement joints shall be made after at least two weeks and on sulphur compound joints after four to five weeks.

No pipe installation shall be accepted unless the leakage (evaluated on a pressure basis of 10 kg/sq. cm) is less than 230 liters per 24 hours per kilometer per 25mm diameter of pipe of 3.66m length and proportionate for other lengths of pipes.

The distribution system to be tested shall be slowly and carefully charged with water to expel all air from the system and to avoid all shocks and water hammer. The piping and fittings shall be absolutely watertight when all draw off taps are closed. The system shall be able to maintain the pressures and flow required under working conditions.

The entire hot water system shall be tested for the maximum rated temperature and pressure of hot water storage system. The system shall be able to maintain the required test pressure. All safety devices shall be tested for their proper operation.

After installation of the entire water supply system or part thereof, it shall be tested and approved by the Engineer before its use. The Contractor shall arrange testing devices along with pressure gauge and pump.

Drainage and venting system

The piping of drainage and venting system shall be tested first with water. The final test of completed drainage and venting system may be done by smoke test. The water and smoke tests shall be performed as described below:

Water test

The Water Test shall be applied to the drainage and venting system either for the whole system or part (section) thereof. For the entire system, all openings in the piping except the highest opening shall be closed, and the system filled with water to the point of overflow. For the system to be tested in sections, each opening shall be tightly plugged except the highest opening of the section under test and each section shall be filled with water but no section shall be tested with less than a 3m head of water. In testing successive sections, at least the upper 3m of the next section shall be tested so that no joint or pipe in the building (except the top most 3m of the system) shall have been submitted to a test of less than a 3m head of water. The water shall be kept in the system or in the portion under test for at least 15 minutes before the inspection starts. The system or the part of the system under test shall be watertight at all points.

Smoke test

The final test for gas and water tightness of the completed drainage and venting system may be performed by Smoke Test. The test is performed by filling all traps with water and then introducing smoke in to the system produced by one or more smoke machines. The smoke is made by firing oily waste (brown paper or cotton waste soaked in creosote). Smoke is pumped in to the drains and pipes through a gully outside the house or an inlet ventilator, or through a clay plug in an inspection chamber. In making a Smoke Test, the tops of soil and ventilating pipes are left open until smoke is seen to issue when the openings are plugged securely with wet cloth or wet clay tied in a cloth and smoke pumped in for some considerable time.

If smoke-testing machine is not available, smoke rockets may be used which can be obtained from firework makers. The smoke produced is very dense and pungent, but the test cannot be prolonged as with a machine.

Direction of cracks and other defects in pipes

All pipes and fittings should be tapped with light hammer (about 2 kg weight) to sound for any cracks, blow-holes or sand-holes or any other defects. In case of doubt about cracks, confirmation may be obtained by pouring a little paraffin on the inside of the pipe at the suspected spot. If a crack is present, the paraffin seeps through and shows on the other surface. The thickness of the metal shall

also be examined and seen that the bell and spigot is well formed. The damaged portion of the cracked pipe may be cut at a point not less than 15cm beyond the visible extremity of the crack with a cutting machine or a diamond pointed chisel.

3.19.16 Completion Certificate

Water supply system

The licensed plumber shall issue completion certificate in a prescribed form to the Engineer on completion of the water supply system or part thereof for inspection and testing. After testing, the Engineer will allow the water connection from the water main (if any) and give the final approval to use the system.

Drainage and sanitation systems

After the installation of the drainage and sanitation system, the licensed plumber shall give a completion certificate to the Engineer in a prescribed form for inspection and testing. After testing, the Engineer will give the final approval to use the system.

3.19.17 Cleaning and Disinfecting

Sterilization of completed lines

Before being put into service for domestic use the entire water supply line should be chlorinated with a liquid chlorine solution-hypochlorite of lime (bleaching powder) may be used. The dose should not be less than 50 ppm of available chlorine and the time of contact not less than 8 to 12 hours – a residual of not less than 5 ppm shall be produced in all parts of the line. Alternatively the sterilization shall be considered to have been achieved if a chlorine residue of not less than 10 ppm remains in the water after 24 hours standing. During the chlorination process all valves and accessories shall be operated. The pipeline shall be thoroughly flushed with clean water after the test.

The new and repaired water supply system shall be disinfected before their use. The existing water supply system shall be cleaned and disinfected depending upon the quality of water. The following procedure may be adopted to disinfect the plumbing system.

- ☐ The water supply system shall be flushed with potable water until clean water appears at the outlets.
- ☐ The system or part thereof which requires disinfection shall be filled up with chlorinated water containing 50 mg/liter of chlorine for 24 hours or for 3 hours with a chlorinated water of chlorine concentration of 200 mg/liter.
- ☐ After the period of disinfection, the system shall be flushed with potable water until the chlorine is completely removed from the water in the system.
- ☐ The above procedure shall be repeated until the bacteriological examination shows presence of no water contamination within the system.

3.19.18 Measurement

Water supply system

All completed distribution piping and assemblies shall be measured in linear meter measured along the piping axis including fittings of any description and accepted by the Engineer.

H.C.I. sewerage pipe, rain water drain pipe and pipe fittings

For all H.C.I sewerage pipes, rainwater drain pipes and pipe fittings, measurement for payment shall be made for the actual number of linear meter measured along the piping axis, including fittings using suitable jointing solvent recommended by the pipe maker. Joints shall be of the spigot and socket type having the socket formed integral with the pipe or alternatively, separate sleeves may be used with the approval of the Engineer. The vertical discharge pipes shall be provided at the head with the copper or brass strainer of approved size and construction which will give a leak proof connection with the roof slab. The pipe shall discharge to gully by a back inlet. Bend at the foot of pipe shall be properly formed and of adequate radius.

RCC sewers pipe

Measurement shall be made for the actual number of linear meter of Pipe laid and completed and accepted by the Engineer.

Valves

Measurement for payment for all Valves shall be made for actual number of acceptable installed item taken as complete units and accepted by the Engineer.

C.I. gratings and H.C.I. traps

Measurement for payment shall be for the actual number of C.I. Gratings and H.C.I. Traps installed at floor trap or at drain inlet as per Drawing and direction and accepted by the Engineer.

Stopcock

Measurement for payment for Stopcock shall be on the basis of complete installed unit properly tested and approved and accepted by the Engineer.

Open tap

Measurement for payment for Open Tap shall be on the basis of complete installed unit properly tested and approved and accepted by the Engineer.

3.19.19 Payment

Water supply system

The amount of completed and accepted work measured as provided above shall be paid for at the corresponding Contract unit price per linear meter which payment shall constitute the full compensation for furnishing all materials including necessary fittings, specials such as bents, elbows, sockets, reducing sockets, Tees, unions, jum nuts, all equipment and layout including, storage, handling and transport of materials, installation and fixing of brackets, fixing bolts and screws, cuttings, tapping, installing and connecting of pipes, fittings and sleeve pipes, making holes or chase in wall or floor if necessary and restoration thereof to original condition, excavating pipe trenches, back-filling and compacting, connecting to the main, all cleaning and disinfection of pipe, all tests as well as all incidentals, necessary to complete the work according to the applicable plans and these specifications.

H.C.I. sewerage pipe, rain water drain pipe and pipe fittings

The amount of complete and accepted work measured as provided above shall be paid for at the unit Contract price per meter which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, installation, connecting of pipes with all fittings and jointing materials, excavation and for all incidentals necessary to complete the work.

RCC sewers pipes

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit price per metre of pipe which payment shall constitute full compensation for furnishing all materials, equipment and labour including setting out of trenches, laying and connecting pipes, testing for water tightness of joints and for providing all excavation, granular bedding, and back filling etc. and all incidentals necessary to complete the work according to applicable drawings.

Valves

The amount of completed and accepted work measured as provided above shall be paid for at the corresponding Contract unit price per complete unit which payment shall constitute the full compensation for furnishing all materials including necessary fittings, all equipment and layout including, storage, handling and transport of materials, connecting to the water pipe, all jointing materials as well as all incidentals, necessary to complete the work according to the applicable plans and these specifications.

C.I. gratings and H.C.I. traps

The amount of completed and accepted work measured as provided above shall be paid for at the corresponding Contract unit price per C.I. gratings and H.C.I. traps which payment shall constitute the full compensation for furnishing all materials including necessary fittings, all equipment and layout including, storage, handling and transport of materials, as well as all incidentals, necessary to complete the work according to the applicable plans and these specifications.

Stopcock

The amount of completed and accepted work measured as provided above shall be paid for at the corresponding Contract unit price per brass or CP stop cock which payment shall constitute the full compensation for furnishing all materials including necessary fittings, all equipment including, storage, handling and transport of materials, as well as all incidentals, necessary to complete the work according to the applicable plans and these specifications.

Open tap

The amount of completed and accepted work measured as provided above shall be paid for at the corresponding Contract unit price per open tap which payment shall constitute the full compensation for furnishing all materials including necessary fittings, all equipment including, storage, handling and transport of materials, as well as all incidentals, necessary to complete the work according to the applicable plans and these specifications.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.19	Supplying, fitting and fixing of G.I. Pipe	Linear meter
	Supplying, fitting and fixing of H.C.I. Sewerage Pipe	Linear meter
	Supplying, fitting and fixing of Rain Water Drain Pipe	Linear meter
	Supplying, fitting and fixing of RCC Sewers Pipes	Linear meter
	Supplying, fitting and fixing of Valves	Each
	Supplying, fitting and fixing of C.I. Gratings	Each
	Supplying, fitting and fixing of H.C.I. Traps	Each
	Supplying, fitting and fixing of Stopcock	Each
	Supplying, fitting and fixing of Open Tap	Each

3.20 OVERHEAD TANK**3.20.1 Description**

This item of work shall consist of supplying, fitting and fixing Overhead Tanks including painting the tank with anticorrosive paint of approved colour and quality along with cover on the top with locking arrangement, providing inlet and outlet pipe with flanges and plug, jum-nuts and 40mm diameter ball cock as shown on the Drawings and specifications as described in the BOQ or as directed by the Engineer or as specified by the Manufacturers.

3.20.2 Drawings

The Drawings shall indicate the type, shape and size of the tank in details. However, where actual conditions necessitate a rearrangement, the Contractor shall prepare and submit detailed Shop Drawings of the proposed rearrangement for approval of the Engineer. The Contractor shall carefully examine the Drawings and investigate the structural and finished conditions affecting all of his/her/their works and shall arrange such works accordingly, furnishing such fittings and accessories as may be required to meet such conditions.

3.20.3 Shop Drawings

The Contractor shall prepare detailed design of all works involved in line with the Employers design and prepare Shop Drawings for the total works and submit to the Engineer for approval before factory fabrication starts.

3.20.4 Materials

The Overhead Water Tanks may also be pre-fabricated and of the following type and capacity.

- a. Best quality G.I. Tank of 1800 liters capacity.
- b. Best quality Stainless Steel Cylindrical type Water Tank of 500, 1500 and 2000 liters capacity
- c. Best quality Fibre Glass Spherical type Tank of 1800 liters capacity made by 'Johannes' or other approved equivalent product of other companies.
- d. Best quality Plastic type Tank of 500, 1500 and 2000 liters capacity made by 'Gazi'/'Padma' or other approved equivalent product of other companies.

Manufacturer's Catalogue or Specification Sheets in triplicate for materials and type selected shall be submitted to the Engineer. No fabrication shall start without the approval of the Engineer.

All materials shall be of the best quality and be delivered at the Site.

Materials to be used shall conform to the Manufacturer's Specifications and to the satisfaction of the Engineer.

3.20.5 Installation

The pre-fabricated Overheat Water Tank, on supply and acceptance by the Engineer, shall be installed at the roof top with appropriate anchoring arrangements with bolts and nuts of sufficient strength so as not to be blown away by wind or storm or be dislodged under any other adverse conditions.

The Water Tank should be provided with a top cover with handle, cap with locking arrangements, inlet and outlet coupling, plastic ventilation system, stainless steel stand or any other stand of appropriate type and strength with anchoring arrangements with bolts and nuts and all other necessary fittings.

3.20.6 Inspection

Water Tanks shall not be anchored until they have been inspected and approved by the Engineer.

3.20.7 Cleaning and disinfecting

The Overhead Water Tanks shall be disinfected before their use. The Tank shall be cleaned and disinfected depending upon the quality of water. It shall be cleaned and disinfected at least once a year. The following procedures may be adopted for disinfecting.

- ☐ The Water Tank shall be thoroughly flushed with potable water until it becomes totally clean.
- ☐ For disinfecting, the Tank shall be filled up with chlorinated water containing 50 mg/liter of chlorine for 24 hours or for 3 hours with chlorinated water of chlorine concentration of 200 mg/liter.
- ☐ After the period of disinfecting, the Tank shall be flushed with potable water until the chlorine is completely removed from the water in the Tank.
- ☐ The above procedures shall be repeated until the bacteriological examination shows presence of no water contamination within the Tank.

3.20.8 Measurement

The Overhead Water Tank, anchored and installed, including all fittings stated in these Specifications and of any other descriptions as required and accepted by the Engineer shall be measured per unit.

3.20.9 Payment

The amount of completed and accepted work measured as provided above shall be paid for at the corresponding Contract unit price per number which payment shall constitute the full compensation for furnishing all materials including necessary fittings, specials such as top cover, handle, cap with locking arrangement, inlet and outlet coupling, plastic ventilation system, stand with anchoring arrangements with bolts and nuts and all other necessary fittings and where required making holes in the building structure and mending good the damages, as well as all incidentals necessary to complete the work according to the applicable plans and these specifications.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.20	Overhead Water Tank with all fittings and installation	Each

3.21 FERRULE CONNECTION

3.21.1 Scope of Work

Supplying, fitting and fixing of Ferrule Connection complete with Water Meter, piping, bends etc. shall be as per the direction and recommendation of the local Water Supply Authority. Under this item, the Contractor shall have to arrange all the formalities required for providing City/Municipal water connection to the underground reservoir. The Contractor shall have to arrange Water Meter from Water Supply Authority/Department (when applicable).

3.21.2 Measurement

Measurement for payment shall be made on complete installation of Ferrule Connection including road cutting, trench excavation for laying G.I. service pipe, installing Water Meter and stop valve and mending good the road in the original condition or back filling etc. The G.I. pipe work from ferrule up to the float-valve in water reservoir shall be measured in linear meter.

3.21.3 Payment

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit price which payment shall constitute all skilled and unskilled men, materials, all consumables including storage, handling and transport of materials, providing all incidentals whichever needed for the complete installation of ferrule connection including road cutting, trench excavation for laying G.I. service pipe, installing water meter and stop valve and mending good the road in the original condition or back filling etc. successful installation of the water incoming service line and filling the ground water reservoir in moderate flow rate.

The GI pipe work shall be paid at the Contract unit price in linear meter which shall be the full compensation for supplying, storage, handling and transport of materials including fitting, fixing as well as all incidentals, etc. all complete.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.21	Ferrule Connection	Complete Installation
	G.I. Pipe Work	Linear meter

3.22 TOILET FIXTURE AND FITTINGS

3.22.1 Scope

Fixtures will consist of lavatories, wash basins, sinks, urinals, squat urinals, long pans, commodes, etc. These shall be made of white/coloured vitreous China of the highest quality available as per "BISF standard" or approved equal and as specified in the BOQ. The basins and the sinks may also be made of metal. All toilet fixtures shall get the approval of the Engineer.

3.22.2 Standards

All sanitary appliances shall conform to the specifications in accordance with the Standards listed and as shown against their names in the Table given below unless otherwise specified or instructed by the Engineer.

Sanitary Appliances

Appliances	Standard
Ceramic wash basin and pedestals	BDS 1162-87
Ceramic wash down water closet pans	BS 1213
Foot rest vitreous china	BDS 1163-87 parts 1 & 4
Integrated squatting pans vitreous china	BDS 1163-87 parts 1 & 5
Metal hand rinse basin	BS 1329
Metal sink for domestic purpose	BS 1244
Urinals (bowl type) vitreous china	BDS 1163-87 parts 1 & 3
Wash-down water closet pans, vitreous china	BDS 1163-87 parts 1 & 2
Water closet seat plastic	BS 1254
Water closet flushing cisterns and pipes	BS 1125

3.22.3 Samples

Approved samples shall be retained by the Engineer and shall be used as standard for comparison of the materials delivered at the Site and used under the Contract.

The Contractor shall not procure any unit unless the written approvals of the samples are obtained from the Engineer.

3.22.4 Construction Requirements

Combi-closet (European)

The Combi-closet (European type) shall be wash down closet suit of 'P' or 'S' type commode with low down cistern with horizontal out go to closet bowl and cistern shall have the capacity to contain and flush down about 11 liters of water at each flush.

The closet bowl shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer and having a seat cover made of heavy type ebonite plastic. That it shall be provided with 4 holes for fixing into the floor with four round-headed wooden screws. The cistern shall be provided with a 12mm diameter CP stopcock, 12mm diameter plastic connection pipe with brass coupling, flush bend and float valve to control the water.

The cistern closet bowl and bend shall be white/coloured glazed high polished and of porcelain ware of proprietary products of BISF or approved equivalent.

The water closet shall be installed at a distance not less than 300mm from the back wall on a cement concrete base with wire net or rods, if necessary. It shall be anchored with the floor with four wooden screws. The closet shall be placed at least 450mm apart from the adjacent side-wall. The front seat shall be black or as specified, heavy duty, solid plastic complete with cover, chrome plated hinge/heavy duty plastic hinge and self-sustaining hinge. The flush equipment shall be of silent filling type.

Long pan

Long Pan of the size, as shown on the Drawings or required in the BOQ or as directed by the Engineer, with lose 'P' trap of mid level back inlet with low level flush cistern. The Long Pan shall be fitted with the floor slab level and the cistern to the wall with the help of wall bracket clamped by renal bolt as shown in details on the Drawings.

The Pan shall be white/coloured and glazed porcelain ware. The cistern shall be provided with the flush bend having capacity to contain and flush down about 11 liters of water.

The Pan shall be installed at a minimum distance of 200mm from the back-wall and 450mm from the side-wall.

Standing urinals

European type vitreous China clay Standing Urinals shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Urinals shall be complete with CP or Plastic bottle trap and other accessories like waste pipe with brass coupling, connection pipes, brass stopcock etc. as per BOQ. Waste pipe shall be properly clamped to wall by using 'U' bolt.

Urinals shall be installed at location shown on the Drawings and as per direction of Engineer. Urinals shall be directly clamped to wall by using royal plugs, etc. Urinal shall be complete with automatic cistern with flushing arrangement.

Squatting urinals

Super glazed vitreous China clay Squatting or Flat Urinals shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Urinals shall be complete with flushing inlet, fitted in cement concrete with cast iron painted body, 4.5 liters automatic flushing cistern in each group and all other accessories like 12mm diameter controlling valve, 30mm diameter PVC flush pipe with brass coupling, 12mm diameter plastic connection pipe etc. as per BOQ.

Auto flushing cistern shall be properly clamped to wall by using CI bracket.

Cutting of floor, fixing the Urinals with Cement Mortar prepared with one part cement and two parts sand of minimum FM 1.0 and finishing shall be done as per direction of the Engineer.

Wash hand basin

White super vitreous China clay Wash Hand Basin shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer. Wash Hand Basin shall be accompanied with CP or Plastic bottle trap.

Wash Hand Basin shall be installed at location shown on the Drawings and as per direction of the Engineer with heavy type CI brackets fixed on the wall by using approved type of renal bolt. Before fixing, bracket shall be painted with two coats of red oxide paint over a coat of primer.

Wash Hand Basin shall be fitted with 30mm diameter PVC waste water pipe with brass coupling (not exceeding 750mm in length), 12mm diameter plastic connection pipe with brass coupling, 12mm diameter brass stopcock, 12mm CP pillar cock and 30mm diameter CP basin waste with chain plug.

Pedestal type Wash Hand Basin shall be with combined central pillar cock of CP brass, rubber plug with CP chain.

Porcelain sink

Best production and finished white glazed porcelain made sink shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer. Porcelain sink shall be accompanied with CP bottle trap.

Sink shall be installed at location shown on the Drawings and as per direction of the Engineer with heavy type CI brackets fixed on the wall by using approved type of renal bolt. Before fixing, bracket shall be painted with two coats of red oxide paint over a coat of primer.

Sink shall be fitted with 40mm diameter PVC waste pipe with brass coupling (not exceeding 750mm in length), 12mm diameter CP bib cock, 40mm diameter CP waste, 40mm diameter CP chain plug, pillar cock and 30mm diameter CP basin waste with chain plug.

Glass shelf

Glass Shelf of 5mm thick glass plate with fancy CP brackets shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Glass Shelf shall be installed to the wall rigidly and properly with CP brackets, screws and frames at location shown on the Drawings and as per direction of the Engineer. Edges of the glass shall be properly rounded and polished.

Soap tray

White porcelain Soap Tray shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Soap Tray shall be fixed rigidly and properly on the wall with two numbers of plastic plug and countersunk screws. Location of the Soap Tray shall be as per Drawing and also as per direction of the Engineer.

The Contractor shall have to furnish best quality of available soap tray.

Toilet paper holder

White or coloured porcelain/Stainless steel/Plastic Toilet Paper Holder shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Toilet Paper Holder shall be rigidly fixed to the wall at location as shown on the Drawing and also as per direction of the Engineer.

The Contractor shall have to furnish best quality of available Toilet Paper Holder.

Towel rail

CP Towel Rail with CP holder shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Each leg of the holder bracket shall be rigidly fixed to the wall by using two numbers of plastic plug and screws.

The Contractor shall have to furnish super quality of available Towel Rail.

Towel ring

CP brass Towel Ring with CP bracket shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer.

The Towel Ring with CP bracket shall be rigidly fixed to the wall by using two numbers plastic plugs.

The Contractor shall have to furnish super quality of available Towel Ring.

Glass mirror

Beveled edge plate Glass Mirror, foreign made and shall be of 5mm thickness, silvered Electro-cooperid with red back complete shall be of the size as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Mirror shall be fitted on the wall at a height as directed by the Engineer or as shown on the Drawing with plastic plug. At back, plywood of 6mm thick shall be provided for damp protection. Corner of the glass shall be rounded and polished.

Glass plate shall be rigidly fixed through four numbers of 6mm holes with CP screws.

CP shower rose

CP Shower Rose shall be of size 125mm diameter or as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Shower head shall have at least 70 numbers 0.8mm diameter hole and shall be suitable to maintain a maximum pressure of 45 Kpa. Shower head shall be provided with air inlet to admit air above trapped water to avoid drip.

Shower Rose shall be rigidly fitted to the wall at a height as directed by the Engineer or as shown on the Drawing with CP screws.

Wall shower

Adjustable type Wall Shower shall be complete with stainless steel flexible pipe as shown on the Drawings or required in the BOQ or as directed by the Engineer.

Wall Shower shall be complete with CP handle, holder to fix it on wall clamp. Wall clamp shall also be made of CP brass. Stainless steel flexible pipe shall be 610mm length. One end shall be connected with shower head and the other end suitable to fix on 12.0mm dia G.I. pipe. Wall clamp shall be rigidly fixed to the wall by using two numbers of counter sunk screws and plastic plug of approved type.

3.22.5 Measurement

Combi-closet (European)

Measurement of payment shall be made for the actual number of Closets installed including cistern with all fittings taken as complete unit and accepted by the Engineer.

Long pan

Measurement of payment shall be made for the actual number of Long Pan installed including cistern with all fittings taken as complete unit and accepted by the Engineer.

Standing urinals

Measurement of payment shall be made for the actual number of Standing Urinals on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Squatting urinals

Measurement of payment shall be made for the actual number of Squatting Urinals on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Wash hand basin

Measurement of payment shall be made for the actual number of Wash Hand Basin on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Porcelain sink

Measurement of payment shall be made for the actual number of Porcelain Sink on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Stainless steel sink

Measurement of payment shall be made for the actual number of Stainless Steel Sink with sink tray made in Malaysia/Singapore/Thailand on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Glass shelf

Measurement of payment shall be made for the actual number of Glass Shelf on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Soap tray

Measurement of payment shall be made for the actual number of white porcelain Soap Tray on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Toilet paper holder

Measurement of payment shall be made for the actual number of Toilet Paper Holder on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Towel rail

Measurement of payment shall be made for the actual number of super quality Towel Rail on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Towel ring

Measurement of payment shall be made for the actual number of super quality Towel Ring on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Glass mirror

Measurement of payment shall be made for the actual number foreign made beveled edge plate Glass Mirror on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

CP shower rose

Measurement of payment shall be made for the actual number CP Shower Rose on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

Wall shower

Measurement of payment shall be made for the actual number Wall Shower on the basis of complete supply, fitting, fixing of units set and accepted by the Engineer.

3.22.6 Payment

Combi-closet (European)

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit price per Combi-closet including cistern which payment shall constitute full compensation for furnishing all materials, equipment and labour, including storage, handling and transport of materials, placing, fixing of commode and cistern including all internal fittings, connecting

with the water, waste and vent pipes, providing stop valves, connecting pipes, bend/trap and fittings, constructing concrete base where necessary, making holes in the floor and mending good the damages as well as all incidentals, necessary to complete the work.

Long pan

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit price per Long Pan including cistern which payment shall constitute full compensation for furnishing all materials, equipment and labour, including storage, handling and transport of materials, placing, fixing of commode and cistern including all internal fittings, connecting with the water, waste and vent pipes, providing stop valves, connecting pipes, bend/trap and fittings, concrete base where necessary, making holes in the floor and mending good the damages as well as all incidentals, necessary to complete the work.

Standing urinals

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Standing Urinal which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, placing, fixing of item, connecting to waste and water pipes, providing stop valves, connecting pipes, traps, bends and fittings, making holes in walls and floors and mending good the damages as well as all incidentals necessary to complete the work.

Squatting urinals

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Squatting Urinals which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, placing, fixing of item, connecting to waste and water pipes, providing stop valves, connecting pipes, traps, bends and fittings, making holes in walls and floors and mending good the damages as well as all incidentals necessary to complete the work.

Wash hand basin

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Wash Hand Basin which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, connecting to waste and water pipes, providing stopcock, pillar cock, connecting pipes, traps, bends and fittings, placing, fixing and painting of brackets, fixing of basin and fittings, making holes in walls and floors and mending good the damages as well as all incidentals, necessary to complete the work

Porcelain sink

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Porcelain Sink which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, connecting to waste and water pipes, traps, providing CP bib cock, CP chain plug, connecting pipes, bends and fittings, placing, fixing and painting of brackets, fixing of sink and fittings, making holes in walls and floors and mending good the damages as well as all incidentals, necessary to complete the work

Stainless steel sink

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Stainless steel Sink which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, connecting to waste and water pipes, providing CP bib cock, CP chain plug, connecting pipes, traps, bends and fittings, placing, fixing and painting of brackets, fixing of sink and fittings, making holes in walls and floors and mending good the damages as well as all incidentals, necessary to complete the work

Glass shelf

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Glass Shelf which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, providing CP brackets, placing and fixing of brackets, making holes in walls and mending good the damages as well as all incidentals, necessary to complete the work

Soap tray

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per porcelain white Soap Tray which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, fitting and fixing to the wall, making holes in walls and mending good the damages as well as all incidentals, necessary to complete the work .

Toilet paper holder

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Toilet Paper Holder which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, fitting and fixing to the wall, making holes in walls and mending good the damages as well as all incidentals, necessary to complete the work .

Towel rail

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Towel Rail which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, fitting and fixing to the wall, making holes in walls and mending good the damages as well as all incidentals, necessary to complete the work .

Towel ring

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Towel Ring which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, fitting and fixing to the wall, making holes in walls and mending good the damages as well as all incidentals, necessary to complete the work .

Glass mirror

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Glass Mirror which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, placing and fixing of glass mirror with plywood back, making holes in walls and mending good the damages as well as all incidentals, necessary to complete the work

CP shower rose

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per CP Shower Rose which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, placing and fixing of shower rose, making holes in the walls and mending good the damages as well as all incidentals, necessary to complete the work

Wall shower

The amount of completed and accepted work measured as provided above shall be paid at the Contract unit price per Wall Shower which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, placing and fixing of wall shower, making holes in the walls and mending good the damages as well as all incidentals, necessary to complete the work

Pay Items shall be:

Clause	Description	Unit of Measurement
3.22	Combi-closet	Per set
	Standing Urinals	Per set
	Squatting Urinals	Per set
	Wash Hand Basin	Per set
	Porcelain Sink	Per set
	Stainless steel Sink	Per set
	Glass Shelf	Per set
	Soap Tray	Per set
	Toilet Paper Holder	Per set
	Towel Rail	Per set
	Towel Ring	Per set
	Glass Mirror	Per set
	CP Shower Rose	Per set
	Wall Shower	Per set

3.23 SPECIFICATION OF ELECTRICAL INSTALLATION

3.23.1 Scope of work

The Section covers installation of electrical conductors and equipment within or on public and private buildings and premises connecting internal and external electrification works to the electrical mains as indicated on the Drawings. It also covers installations of conductors that connect to the supply of electricity. In addition, it includes general requirements relating to lightning protection in buildings.

All requirements as specified in the other Technical Specifications, followed by the LGED, shall also apply for the various sections of this Manual where applicable.

The principle items of work shall include, but not limited to:

- ☐ Arrangements for power supply.
- ☐ Distribution wiring system.
- ☐ Lighting and Power installation.
- ☐ Switch boards and distribution boards / panel boards.
- ☐ Earthing Systems.
- ☐ Lightning protection Systems.
- ☐ Inspection and testing.
- ☐ Electrical Pumps and Motors.

3.23.2 General requirements

Regulations

The installation in general shall be carried out in conformity with the Electricity Rules of the Govt. of the People's Republic of Bangladesh (Indian Electricity Rules and Act as adopted in Bangladesh) and the latest edition of the Regulation for Electrical Installations of the Institute of Electrical Engineer (London), (excluding the provisions that the light and fan points shall not be earthen), hereinafter referred as "I.E.E. Wiring Regulations" and the British Standard Code of practice for the relevant works. But where the under-noted specification differ from these rules and standards, the specification written hereunder shall be followed. Any special requirement of the Electrical Inspector, Government of the People's Republic of Bangladesh or the Power Development Board or the Telegraph and Telephone Department, Government of Bangladesh or the other legal authority shall also be complied with at no extra cost to the Employer.

Climatic and atmospheric conditions

The installations, equipment and materials shall be installed both externally and internally and shall, therefore, be designed and built to give efficient and reliable service continuously at the normal voltage and current rating in the prevalent climatic and atmospheric conditions at the relevant site.

Specifications

Except where otherwise specified, all electrical machines and accessories shall comply with the current National Standards provided that these Standards are not less stringent than the equivalent of the International Organization for Standardization (ISO) or the International Electro-technical Commission (IEC).

Further, standards of materials, workmanship and performance of machinery and equipment are to be as specified and of the best make. Machinery, accessories and other equipment shall be of sound workmanship, robust in design and of a grade and quantities suitable for the purpose.

Material required which are not covered by the detailed specifications shall be as recommended by the concerned manufacturer, or consistent with good practice and approved by the Engineer.

Manufacturer's qualifications

Electrical equipment to be furnished by the Contractor, shall be of makes and sizes proved to be successfully operating under the prevailing conditions, if not otherwise specified by the manufacturer and catalogues submitted prior to the ordering of equipment, accessories and the like.

Operation and Maintenance instructions

Before purchasing and installation of any machinery, accessories and equipment, the Contractor shall provide three complete sets of catalogues related to type and model number, drawings and instructions required for operation and maintenance of all items of equipment and instrumentation furnished.

These shall include instructions for lubrication, repair and servicing, parts lists and all other pertinent information available from the equipment manufacturers.

Brand names

Brand names are used herein merely to describe the nature of the described equipment and not used to endorse or indicate a preference for a particular product or manufacturer.

Goods, which have similar characteristics and provide performance in quality at least equal to those specified, shall be acceptable as approved by the Engineer.

Guarantee and warrantee

The Contractor shall guarantee all equipment in accordance with the conditions of the Contract. In addition to the guarantee requirements, equipment guarantee shall cover the following:

- i. faulty or inadequate design.
- ii. improper assembly or erection
- iii. defective workmanship or materials.
- iv. leakage, breakage or other failure.

For equipment, bearing a manufacturer's warranty certificate in excess of one year, a copy of the warranty is to be furnished to the Employer.

Factory Painting

On electrical equipment, drives, starters, control panels and similar self-contained or enclosed components, a factory primer and high quality oil-resistant backed industrial enamel finish are to be applied. Surfaces those are inaccessible after assembly, are to be painted otherwise protected by a method which provide protection for the life of the equipment.

Drawings

Design drawings and Shop Drawings

The Drawings shall show the general arrangement of all circuitry, wiring, feeders, cables and raceways, etc. The Contractor shall carefully examine the Drawings and shall be responsible for the proper installation of materials, fixtures and equipment in each unit as indicated without substantial alternation. However, where local conditions necessitate a re arrangement, the Contractor shall prepare and submit Drawings of the proposed rearrangement stating in details the proposed departures due to actual field condition or other causes to the Engineer for approval. Because of the small scale of the Drawings it may not be possible to indicate all offsets, fittings and accessories which may be required. The Contractor shall carefully investigate the structural and finish conditions affecting all of his/her/their works and shall arrange such works accordingly, furnishing such fittings, access traps, inspection boxes and accessories as may be required to meet such conditions. The Contractor shall prepare a Shop Drawing indicating the exact location of conduits and wiring for approval of the Engineer prior to installation.

As-built Drawings

After installation of the electrical machines and accessories, the Contractor shall prepare as-built Drawings together with specifications and data covering performance of materials of construction. Three copies of as-built Drawings shall be submitted to the Engineer.

Cutting and repairing

The work shall be carefully laid out in advance and any cutting of construction shall be done only with the written permission of the Engineer. Cutting shall be carefully done and any damage caused to the building, as a result of cutting for installations, piping, wiring for equipment, shall be repaired by skilled workers of the trade at no additional expense to the Employer.

Protection of fixtures

Conduit and pipe openings shall be closed with caps or plugs during installation. Fixture fittings and equipment shall be adequately protected against dirt, water and chemical or mechanical injury. At the completion of the work fixture, materials and equipment shall be thoroughly cleaned and delivered in a condition satisfactory to the Engineer.

Notice

The Contractor shall give all required notices to and maintain liaison with Electrical Inspector, Government of the People's Republic of Bangladesh and to the Electric Supply Department, the Power Development Board or any other legal Authority regulating the electrical works or installation.

Execution and superintendence

The works shall be carried out only by licensed workmen authorized by the Government or any other legal Authority set up for the purpose to undertake such works under the provision of the Indian Electricity Act 1939 and Rules as adopted in Bangladesh, and under the direct supervision of a whole time electrical supervisor having certificate of competency for the type of work under execution. Particulars along with a Photostat copy of the competency certificate of the electrical supervisor shall have to be submitted to the Engineer before commencing the work.

Approval and list of materials, fixture and equipment

As soon as practicable and within 30 days after the date of receipt of Contract and before any material, fixture or equipment is purchased, the Contractor shall submit to the Engineer for approval a complete list, in triplicate, of materials, fixtures and equipment to be incorporated in the work, together with the names and addresses of the manufactures and their catalogues/numbers and trade names. The Contractor shall also furnish other detailed information, where so directed, under the various items. No consideration will be given to partial lists submitted from time to time. Approval of materials will be based on manufacturer's published ratings. Any material, fixture and equipment listed, which is not in accordance with the specification requirements, shall be rejected. The product of any reputable manufacturer regularly engaged in the commercial production of equipment will not be excluded on

the basis of minor differences provided all essential requirements of this specification relating to materials, capacity and performance are met. Tear sheets of catalogue shall be furnished, if such catalogues are not readily available to the Engineer.

3.24 CIRCUIT WIRING IN A BUILDING

3.24.1 General

Every installation shall be divided into circuits as necessary to avoid danger in case of a fault and to facilitate safe operation, inspection, maintenance and testing.

3.24.2 Methods of circuit wiring

Separate branch circuits shall be provided for parts of the installation which need to be separately controlled. These branch circuits should not be affected by failure of other branch circuits.

The number of final circuits required and the points supplied by any final circuits shall comply with

- a) the requirement of over current protection
- b) the requirement for isolation and switching and
- c) the selection of cables and conductors.

All final circuits shall be wired using looping wiring system and no joint box shall used. All pool in positions shall be the switch boards.

Separate branch circuits shall be provided from miniature circuit breaker (MCB) or fuse distribution boards (FDB) for general lighting, automatic and fixed appliances with a load of 500 watt or more and plug receptacles. Each automatic or fixed appliance shall be served by an individual circuit.

Circuits with more than one outlet shall not be loaded in excess of 50% of their current carrying capacity.

Individual branch circuits must have spare capacity to permit at least 20% increase in load before reaching the level of maximum continuous load current permitted for that circuit. At least one spare circuit must be allowed in the distribution board for each five circuits in use.

Where an installation comprises more than one final circuit, each final circuit shall be connected to a separate way in a distribution board. The wiring of each final circuit shall be electrically separate from that of every other final circuit, so as to prevent unwanted energization of a final circuit.

Size of wire to be used in a branch circuit shall be at least one size larger than that computed from the loading if the distance from the over-current protective device to the first outlet is over 15m.

When the distance from the over current protective device to the first socket outlet on a receptacle circuit is over 30m the minimum size of wire used for a 15A branch circuit shall be 4mm² (7/0.036).

The length of lighting circuits shall be limited to a maximum of 30m, unless the load on the circuit is so small that voltage drop between the over-current protective device and any outlet is below 1%. The use of common neutral for more than one circuits shall not be permitted.

3.24.3 Layout and installation Drawings

An electrical layout Drawing shall be prepared after proper locations of all outlets for lamps, fans, fixed and transportable appliances, motors etc. have been selected.

All runs of wiring and the exact positions of all points of switch boxes and other outlets shall be first marked on the plan of the building and approved by the Engineer.

In designing the wiring layout, power and heating sub-circuits shall be kept separate and distinct from lighting and fan sub-circuits. All wiring shall be done on the distribution system with main and branch distribution boards placed at convenient positions considering both physical aspects and electrical load centers. All types of wiring whether concealed or surface, shall be as near the ceiling as possible. In all types of wiring, due consideration shall be given to neatness and good appearance.

Balancing of circuits in three-wire or polyphase installations shall be arranged beforehand. Conductors shall be so enclosed in earthed metal or incombustible insulating materials that it is not possible to have ready accesses to them unless the points between which a voltage exceeding 240 volts may be present are 2m or more apart. In case such points are kept apart, the means of access shall be marked to indicate the voltage present. Where terminals or other fixed live parts between which a voltage exceeding 240V exists are housed in separate enclosures or items of apparatus which although separated are within reach of each other, a notice shall be placed in such a position that any one gaining access to live parts is warned of the magnitude of the voltage that exists between them.

3.24.4 Conductors and accessories

Conductors

Conductors shall be of copper or aluminum. Conductors for power and lighting circuits shall be of adequate size to carry the designed circuit load without exceeding the permissible thermal limits for the insulation. The conductor for final sub-circuit for fan and light wiring shall have a nominal cross-sectional area of not less than 1.5mm² for copper conductors or 2.5 mm² for aluminum conductors. Phase and neutral wires shall be of the same size.

Flexible cables and flexible cords

The minimum cross-sectional area of conductors of flexible cords shall be 0.5mm² for copper conductors. Flexible cable or cords shall not be used as fixed wiring unless contained in an enclosure affording mechanical protection.

Flexible cords may be used for connections to portable equipment. For the purpose of this regulation, an electric cooker of rated input exceeding 3 kW is not considered to be portable. The flexible cord shall be of sufficient length so as to avoid undue risk of damage to the outlet, cord or equipment and of being a hazard to personnel.

Cable ends

All standard conductors having nominal cross-sectional area 6 mm² and above shall be provided with cable sockets. For stranded conductors of cross-sectional area below 6mm² and not provided with cable sockets, all strands at the exposed ends of the cable shall be soldered together or crimped using suitable sleeve or ferrules.

Cable joints

Cable joints are to be realized through porcelain/PVC connectors with PIB tape wound around before placing the cable in the box. Wherever feasible, heat shrink termination and joints shall be employed.

Special risk

Special forms of construction, such as flameproof enclosures, shall be adopted where there is risk of fire or explosion.

3.24.5 Sub-distribution Boards

Enclosures

Enclosures for sub-distribution boards located inside the building, shall be dust-proof and vermin-proof using sheet steel fabrication of a minimum thickness of 20 SWG. The boards shall be safe in operation and safe against spread of fire due to short circuit.

Enclosure sizes

Recommended sizes of enclosures for sub-distribution boards containing miniature circuit breakers or fuses, as recommended, have been shown in the Table below.

Recommended enclosure sizes for M.C.B. and Fuses

Dimensions (mm)			Number of M.C.B. or Fuse
Height	Width	Depth	
350	390	120	Up to 12
480	390	120	Up to 24
610	390	120	Up to 36
740	390	120	Up to 48

Location

Sub-distribution boards shall be located as close as possible to the electrical load centers.

3.24.6 Wiring of sub-distribution boards

- In wiring a sub-distribution board, total load of the consuming devices shall be distributed, as far as possible, evenly between the number of ways of the board leaving the spare way(s) for future extension.
- All connections between pieces of apparatus or between apparatus and terminals on a board shall be neatly arranged in a definite sequence, following the arrangements of the apparatus mounted thereon, avoiding unnecessary crossings.
- Cables shall be connected to terminals only by soldered or welded lugs, unless the terminals are of such form that it is possible to securely clamp them without cutting away the cable strands.

3.24.7 Electrical services shaft and bus ducts

Services shaft

The electrical shaft shall exclusively be used for the following purposes and shall have free access for operation and maintenance:

- electric supply feeder cables or rising mains
- telephone and intercom, fire alarm and signal cables etc.
- area fuse/mini-circuit breakers, sub-distribution boards for individual floors, if necessary

Bus duct

- Bus ducts are specially useful to minimize voltage drop on account of high amperage intermittent loads. The conductors supported by insulators inside the bus duct may be of copper or aluminium of solid, hollow or rectangular cross-section. The conductors may also be insulated. Bus ducts should be used for exposed work or where concealing is not of a permanent nature. The bus duct shall be laid with minimum number of bends for distribution system. Typical rating of feeder bus ducts for 3-phase, 3-wire or 4-wire system shall range from 200 Amperes to 3000 Amperes.
- Concrete horizontal ducts of suitable size shall be provided along the roads for a group of buildings to be fed by a single sub-station.

3.24.8 Types of house wiring

Surface/exposed wiring

Wiring run over the surface of walls and ceilings, whether contained in conduits or not, is termed surface or exposed wiring. Twin core flat wires may be run on wooden battens and round wires through PVC or GI pipes of approved quality.

The battens shall be made with good quality wood having a minimum thickness of 12mm. They shall be installed exposed and run straight on the ceiling or wall surfaces. Battens on walls shall be run either horizontally or vertically and never at an angle. Battens on ceilings shall be run parallel to the edges in either orthogonal direction and not at an angle. They shall be fixed to the wall or ceiling by wood pins or plastic rawl plugs using countersunk galvanized screws. The wires shall be fixed to the

battens by using galvanized steel clips or brass link clips of required size at a spacing not exceeding 100mm.

GI or PVC conduits, when used for surface wiring, shall be clamped with saddles at a spacing not exceeding 600mm, to the wall or ceiling using plastic rawl plugs with countersunk galvanized screws.

Concealed wiring

The wires in this type of wiring shall be encased in metallic (GI) or non-metallic (PVC) conduits that are buried in roof or floor concrete and in brick/concrete wall. The conduits in the walls shall be run horizontally or vertically and not at an angle. Conduits in concrete slabs shall be placed at the center of thickness and supported during casting by mortar blocks or 'chairs' made of steel bars or any other approved means. All conduits shall be continuous throughout their lengths.

Underground cables for electrical distribution in the premises/garden/compound of the building shall be encased in GI or PVC pipes and laid in earth trenches of sufficient depth. Armoured cables need not be encased in conduits except for crossings under road, footpath, walkway or floors.

Wiring for connections to machines shall be carried in steel pipes or cable tray hung from the ceiling or in concrete or steel cable tray running over the floor.

3.24.9 Conduits and conduit fittings

Non-metallic conduits and conduit fittings shall be of heavy wall water grade type. All bends shall be large radius bends formed by heat or by mechanical bending machine. The cross-section of the conduit shall remain circular at the bend and the internal diameter shall not be reduced. PVC pipe fittings shall be sealed with PVC solvent cement or by using glue or gum paste of approved quality. Conduits, installed in floors, shall have a slope of at least 1:1000 towards floor mounted pool box or cable duct.

3.24.10 Service entry

Overhead service connection to a building, shall be achieved with covered conductor or catenary wire (mainly for single phase consumers). The overhead service connection shall be led into buildings via roof poles or service masts made of GI pipe at least 38mm in diameter having a goose neck bend at the top and installed on the outer wall.

Underground service cables shall be laid in conformity with the requirements as stated above under the Sub-section on 'Concealed wiring'. Power and telecommunication or antenna cables shall be led in separately.

3.25 PIPE WORK

3.25.1 Materials

PVC conduit

PVC conduit must conform to NEMA TC-2 and WC 1094 designed for installation underground or in slabs, encased or exposed. These shall be heavy wall rigid type-40 rated for 90o cable. Recommended specifications of PVC conduit have been given in the following schedule.

Nominal Pipe Size		Outside Dia		Inside Dia		Wall Thickness		Wt. of Pipe	
in	Mm	In	mm	In	mm	In	mm	lb/10	kg/10
½	12	0.84	21.33	0.62	15.80	0.11	2.77	16	23.85
¾	19	1.05	26.67	0.82	20.83	0.115	2.92	22	32.80
1	25	1.315	33.27	1.04	26.44	0.135	3.43	32	47.71
1¼	32	1.66	42.66	1.38	35.05	0.14	3.55	43	64.11
1½	38	1.90	48.26	1.61	40.89	0.145	3.68	52	77.53
2	50	2.37	60.19	2.06	52.32	0.155	3.94	69	102.8

G.I pipe

G.I. pipe shall be as per the Schedule given below. They shall conform in all respect to the requirements of the BSS of 1940 as amended to-date. Inside surface of the pipe must be free from any burs. All G.I. bends shall be preformed and shall be of same material as the pipe.

Nominal Pipe Size		Outside Dia		Inside Dia		Wall Thickness		Wt. of Pipe	
in	Mm	In	mm	In	mm	In	mm	lb/10	kg/10
½	12	0.84	21.33	0.62	15.80	0.11	2.77	16	23.85
¾	19	1.05	26.67	0.82	20.83	0.115	2.92	22	32.80
1	25	1.315	33.27	1.04	26.44	0.135	3.43	32	47.71
1¼	32	1.66	42.66	1.38	35.05	0.14	3.55	43	64.11
1½	38	1.90	48.26	1.61	40.89	0.145	3.68	52	77.53
2	50	2.37	60.19	2.06	52.32	0.155	3.94	69	102.8

Junction boxes, pull boxes, circular boxes, etc.

Junction boxes and pull boxes shall conform to BS 4662 and shall be made of minimum 16 SWG sheet steel galvanized or any other materials as directed by the Engineer depending on where it is installed and to match with the existing construction in which these are installed. The circular boxes shall be of PVC. The cover of the metallic boxes should be fixed by using countersunk brass screw or galvanized machine screw. Box ears shall be at least 14 SWG. Each box (except circular boxes) must have an earth block of copper or brass of appropriate size (minimum) 9.5mm x 9.5mm x 9.5mm (3/8" x 3/8" x 3/8") block with 4.76mm (3/16") drilled hole being for one earthing lead and 3.2mm (1/8") machine screw (tapped for 24 t.p.i.) where earth continuity conductors shall be screwed in. The circular boxes shall have at least 12mm (½") long hub.

3.25.2 Installation

General requirements

The conduit shall be completely concealed in the walls, columns, R.C.C. slabs, and floors and shall be nicely finished. The conduits are to be continued between all floors and access shall be provided by access traps or inspection boxes made of cast iron or steel, as required at such places and as recommended by I.E.E. Regulation and approved by the Engineer.

Where conduit is shown on the Drawings or is otherwise specified as being concealed, such conduit may be embedded in structural slabs or in concrete fill laid on top of structural slabs, or concealed within hollow spaces. Where embedded in structural slab conduits shall not exceed 32mm trade sizes, unless there are specific identification to the contrary. In areas where the slab is less than 125mm thick, the overall diameter of the largest conduit shall not exceed one third of slab thickness.

All the conduits running through the boxes and columns shall be laid with the innermost reinforcement case with suitable effect in conduit so to make the outer surface of junction box cover for switch box edge flush with the finished surface level or beam of columns as approved.

All conduit running through slab beams, slab column and slab wall junction shall be connected through a bend and junction box provided with offset, if necessary, to make the outer surface of the junction box cover flush with the finished surface.

Care shall be taken when making concealed installation to see that adequate clearance is provided over the thickness elements, such as coupling etc. so that fill or architectural finishes may be applied which will be smooth, flat and not subject to sapling or cracking.

Raceways runs embedded in slab shall be spaced not less than three outside diameter center to center unless they are so co ordinated with the structures as not cause weakness.

PVC conduit/G.I. pipe

Pipe systems of each circuit must be completely erected before any of the cables are drawn-in. The pipe run should be continuous throughout its length and kept straight as far as possible. It should run either horizontally or vertically and never at an angle. The pipes are to be properly tied with the re-bar @ 0.914m (3'-0") spacing using 18 SWG G.I. wire and pacers. If the pipes are installed exposed in

wall/over false ceiling, they shall be placed over 3.175mm (1/8") space-bar and clamped with saddle of M.S. Flat bar of size 25.5mm x 3.18mm (1" x 1/8") @ 0.914m (3'-0") spacing using rope-plug/rawal bolt as per direction of the Engineer at no extra cost to the Owner.

During the laying of PVC Conduit/G.I. pipe, 2 Nos. G.I. wires of 12 SWG shall be installed inside the PVC Conduit/G.I. pipe although the length of PVC Conduit/G.I. pipe run. The ends of the pull wires must have sufficient length to facilitate pulling of cables and must terminate in the Switch Board, Junction Box, Pull Box, Circular Box or any other outlet of the conduits/pipes. The cost of pull wires and their installation shall be deemed to be included in the rates of the conduit/pipe work.

All pipe runs should be kept clear of gas, air and steam pipes and pipes of other services. To avoid other services pipes, the pipe should be either re-routed or set out so that at least 75mm (3") separation is maintained between other pipes and electrical pipes. Conditions other than these stated above, if encountered by the Contractor must be brought to the notice of the Engineer for instructions.

Pipes installed in wall shall be placed at the time of construction of the wall. No cutting of wall shall be allowed without prior approval of the Engineer.

PVC conduit/G.I. pipe bends

Whenever possible, instead of using bends, the conduit should be bent to the required angle using Pipe Bender. The minimum bending radius shall be such as to allow compliance with the Sub-section on 'Installation' of Cables of this specification for bends in cables and in addition the internal radius of bends shall not be less than two and half times the outside diameter of the conduit. PVC pipes shall be bent either by using a pipe bender or by using a hot-box bender or by using a flame. The bend must be well formed and be without reduction in internal diameter.

The recommended bending radii are given below:

Diameter of Conduit		Radius of Bends	
in	mm	in	mm
3/4	19	5	127
1	25	6	152
1 1/4	32	8	203
1 1/2	38	9	229
2	50	10 1/2	267
2 1/2	63	12	305
3	75	14 1/2	368

If the situation warrants use of separate bends, for the PVC conduit, such bends shall be made of PVC fibre or other insulating materials. No inspection bend shall be used but at place where inspection is required, steel boxes must be used.

Separate bend shall be used only after obtaining expressed approval of the Engineer.

In case of G.I. pipes, long radius preformed bend of same material and of required angle (22 1/2°, 45°, 60°, and 90°) shall be used. G.I. pipe may be bent to the required angle on obtaining expressed approval of the Engineer.

Conduit termination and fittings

At the end of a run, the PVC Conduit/G.I. pipe must terminate in a metal box, galvanized or black enameled. When a conduit is terminated in a metal box (except circular boxes), a smooth bore brass/PVC bush or ring bush must be used along with a brass lock-nut of the specifications in the tables given below.

Lock Nut

Conduit Size		Lock Nut				
in	mm	Thickness		Outer Dia		Threads
		(in)	(mm)	(in)	(mm)	No.
3/4	19	1-1/16	27	1-1/8	29	3
1	25	1-3/16	30	1-1/4	32	3

Bush

Conduit Size		Bush						
(in)	(mm)	C.D		Length		Threads	Length of Smoot Bore at End	
		(in)	(mm)	(in)	(mm)	No.	(in)	(mm)
3/4	19	7/8	22	11/32	9	4	5/64	2
1	25	1-1/8	29	27/64	11	5	7/64	3

PVC conduit/G.I pipe in floor

All PVC conduits/G.I pipes shall be installed having a slope of 1:1000 towards the floor mounted pull box or cable duct so that condensate or leakage water drains out easily to the pull box or cable duct. For runs of more than one conduit in the same floor, the direction of slope of different conduits should be decided in such a systematic manner as to ensure an uniform drain out of the leakage. All socket joints shall be made water tight. No U-bend in floor shall be installed.

3.25.3 Measurement

Measurement of payment shall be in linear meter of pipe/conduit in place for vertical and horizontal runs as measured from the "As built" drawing. Junction boxes, pull boxes and any other boxes including their covers shall be deemed to be included with the rate of pipes. No measurement shall be made for Junction boxes. Pull boxes, including their covers, unless such boxes appears as a separate item in the Schedule of Works.

3.25.4 Payment

The quantity of completed and accepted work measured as provided above shall be paid for at the Contract unit price per meter for pipe works, which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, providing all incidentals and consumables necessary to complete this item of work including the installation test.

Payment shall be:

Clause	Description	Unit of Measurement
3.25	Pipe work	Linear meter

3.26 CABLE WORK**3.26.1 General**

Cables shall be supplied by an approved manufacturer and where possible, the same manufacturer shall be used for all cables.

All cables shall be delivered with cable ends effectively seated.

When a cable is cut from a drum, both cable ends shall be immediately sealed to prevent ingress of moisture.

Rating

The Contractor shall ensure that each cable is adequately rated for its duty under normal and possible fault conditions

The rated voltage of the cable shall not be less than the operating voltage and when assessing the rating and cross section of each cable the following factors shall be taken into account-

- i. maximum voltage drop permissible
- ii. type and magnitude of load
- iii. fault level and duration related to circuit protection relays and fuse gear
- iv. over current setting of relays and circuit-breakers
- v. route length and disposition of cables
- vi. ambient temperature
- vii. method of taking

Conductors

Conductors for all types of cable shall be of high conductivity copper. All cores shall be at least 1.5 square millimeters in cross-section.

With the exception of mineral insulated cables all conductors in excess of 2.5 square millimeters shall be of copper.

Types

Cables complying with BS or IEEC approved equivalent standards will be accepted provided all cables, which are supplied for a specified operating voltage are to the same national Standard.

Standards specified in the following Sub-sections indicate the type of cables used in the design.

If the Contractor wishes to use cables to an alternative standard then details of current carrying capacity, de-rating factors, etc. shall be submitted to the Engineer for approval.

3.26.2 Materials

Single Core Cable and Conductors

Single core low voltage cables and conductors shall be as per BS 6004 (1975) or as per VDE 0271 specifications of copper conductor. PVC insulated conductors shall have 600/1000 volt grade of PVC insulation. All sizes over 2.5mm² shall be stranded.

All flexible cables shall be as per BS 6004 (1975), unless otherwise specified.

Multi-core cables

Multi-core low voltage cable shall be PVC insulated and PVC sheathed non-armored direct burial type, termite proof, made and tested according to VDE 0271/3.69 for this type of installation, rated voltage being 500/1000 volt.

Multi-core high voltage cables shall be PVC insulated, field-limiting conducting layers over each individual conductor and core, copper shield also over each individual core. PVC inner sheath over common covering of cores, flat steel wire armoring, helical steel taping and PVC outer sheath direct burial type, termite proof, made and tested according to VDE 0271/3.69 for this type of installation, rated voltage being 7000/12000 volts.

3.26.3 Installation

General

The advice of the cable manufacturer with regard to installation, jointing and sealing shall be followed.

The HT cables shall either be laid on cable racks or in built-up concrete trenches/tunnel/ basement or directly buried in the ground.

Methods of installation of cables and conductors shall be in accordance with the specifications shown on the Drawings.

Ducts cast-in-situ in concrete, laid before the concrete is poured, into which cables are to be drawn (whether or not the former are retained in position after the concrete has set), shall be so formed that the radial thickness of concrete surrounding the cross-section of the completed duct is not less than 15mm at any point.

Cable in conduits

Generally, single core cable (non-sheathed) are to be installed in PVC conduits. The conduit sizes shall be as shown on the Drawing(s). It must be ensured that cables are not scratched/damaged during pulling. For long lengths, pull boxes must be used even if not shown/indicated on the Drawings. Cables shall not be drawn round more than two 90o bends (or their equivalent) between Drawing-in-boxes and any single bend must not be less than 90o.

Cable bending radii

The internal radius of every bend in a cable shall be not less than the appropriate value stated below.

<i>Insulation</i>	Finish	Overall Diameter	Factor to be applied to overall diameter of cable to determine minimum internal radius of bend
Rubber of PVC (circular copper or circular stranded aluminum conductors)	Non-armored	i. Not exceeding 10mm	3
		ii. Exceeding 10mm but not exceeding 25mm	4
		iii. Exceeding 25mm	6
	Armored	Any	6
PVC (solid aluminum or shaped copper conductor)	Non-armored or Armored	Any	8

Cable termination and joints

The cable upto 2.5mm² size shall be solid conductor and therefore, jointing of these cables are to be done through porcelain/plastic connector and the connector shall be wound with PIB tape before placing in the box. Termination of cables upto 2.5mm², shall be done by making a hook at the end and for higher sizes, brass cable terminals must be used. Tee-off joint in the cable to lighting point, switches, etc. shall not be made. Looping in system of wiring is to be followed and the joints are to be made in the Switch Boards only. All 3-4 core PVC cables shall be terminated using brass glands of proper size.

Connection to switches

The phase wire should be connected to the switches and the neutral wire is to be solid in all switch connections.

Cable colour

All cables used must have colour as stated below.

- ☐ Two wire single phase A.C. system

Red, yellow or blue for phase line or switch wire, black for neutral line, green earth when flexible cords are use.

- ☐ Three wire two phase A.C. system

Red for one phase.

Black for common return.

Yellow for other phase.

- ☐ Three of four wire three phase A.C. system

Red for first phase.

Yellow for second phase.

Blue for third phase.

Black for neutral.

- ☐ Two wire D.C. system

Red for positive or switch wire.

Black for negative.

- ☐ For two wire final sub-circuits

Whether A.C. or D.C. supplying lighting fan or power circuit, the neutral or 'middle' wire shall always be black, and the phase or outlet wire (no matter with which phase it is connected to) shall always be red. The red wire shall always feed the switch and the same wire shall always be used from the switch to the light, fan or power outlet.

Polarity

The polarity of all apparatus used for the Works specified shall be arranged as follows:

- ☐ for two pole apparatus the phase of 'live' pole at the top (or at the left hand side) and the central or 'earthen' pole at the bottom (or hand side).
- ☐ for three or four pole apparatus, the phases in order are red, yellow, blue and neutral reading from top to bottom or left to right in the case of vertical and horizontal layouts, respectively, as viewed from the front.

Crossing road, pavement, culvert, etc.

In crossing road or pavement, a Hume pipe of suitable size shall be provided in the trench covered with pre-cast slabs or blocks strong enough to withstand the load over them.

Construction joint crossing

At construction joint crossing and expansion joint fitting as per Drawing is to be installed and the cables are to be run through such fittings.

Earth cable trench

Two size of the trench shall be of minimum 0.84m depth and 450mm width for each cable to be laid, where more than one cable is to be laid in the trench, the width of the trench is to be increased by 150mm for each extra cable for size below 70mm² (4 core) and 300mm for bigger size cable.

A cushion of sand (F.M 1.5) of 150mm thick, is to be placed over the bed of the trench over which the cables are to be laid.

After laying the cable, first class brick on edge or flat is to be placed as separators in between the cables. After installation of the brick separators, sand filling is to be done up to 150mm from the top of the bigger cable. After sand filling, two layers of first class brick flats are to be placed along the length and breadth of the trench as a protection against injury and indication that a power cable is laid. The rest of the trench shall be filled with earth, watered and rammed at 150mm layers. After cables are laid, the original ground conditions shall be restored. But if brick pavement, drain, concrete road or bituminous carpet road are cut across or damaged, they shall be mended and restored to the original specification.

Concrete cable trench

Trench for running cables shall be made of cement concrete base and brick masonry walls with inside plastered and neat cement finished. Cement concrete shall be constructed with a mixture prepared with 1 part cement, 2 parts sands of specified FM and 4 parts stone chips of appropriate grade. Brick walls should be constructed with first class bricks and cement mortar of proportion 1 part cement and 4 parts sand of specified FM. Plaster should be done with the same type of mortar. Trench shall be constructed with a slope of about 1" in 50'-0" starting from some midpoint of the trench for disposal of sewage, if any, at out side the building including taking proper care for final disposal of the sewage. Material specifications, construction methods and procedures etc. for brick masonry, cement concrete and plaster work shall conform to the requirements stated under the relevant Sections/Sub-sections of the 'Standard Specifications for Building and Allied Works' used by the LGED.

Trench shall have cover with slip resisting checkered steel plates of minimum 12mm thickness without any corrosive surface. Cover plates shall be of stiffened type of sufficient strength to take care of the vehicle load. Cover plates shall be placed in such a way that those can easily be opened and surface level remains in the same plane of the floor having smooth finishing.

Cable laying

The cable route shall be as direct as possible and shall receive the Engineer's approval before excavation.

All cable bends shall have a radius of not less than two times the diameter of the cable drum or 20 times the diameter of the cable, whichever is greater.

G.I pipes shall be provided for all road and drain crossings. These pipes shall be laid direct in the ground without any sand bed, sand layer, brick or cable covers.

Cables shall always be laid out or laid into the ground through G.I pipe of suitable size as decided by the Engineer. The length of the pipes over the ground shall not be less than 1.22m. No extra payment shall be paid for such pipes. The exposed end of the pipes shall be sealed using PVC or wooden plugs.

Cable Installation

Where cables are not buried directly in the ground, but laid in floor trenches or Drawn into ducts, they shall, unless otherwise agreed by the Engineer be supported on hangers or by cleats, secured on tray or enclosed in conduit or similar. Areas in which the type of installation requires particular attention are indicated on the Drawings.

Every cable whether in or out of sight shall neatly be run vertically, horizontally or parallel to adjacent walls, beam or other structural members.

Spacing of climbs, saddles and cleats shall be such as to prevent sagging of the cables at all times during their installed life.

The method of fixing clip etc. shall be by means of non-corrosive screws installed into an approved wall fixing.

All cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting, so treated as to withstand site conditions without corroding.

Where a number of cables are terminated at any particular item of equipment, special care shall be taken to ensure the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

Where the building structure incorporates built-up covered trench systems, distribution cables may be laid on the floor of the trench, but control and instrumentation cable shall be segregated and installed on supporting steel work or cable tray secured to the walls of the trench.

Where the building structure incorporates general service trenches containing pipe-work, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls.

Crossovers shall be kept to a minimum and where possible cabling shall be taken above wet service pipe-work.

The cables shall be spaced as necessary to maintain current ratings and to restrict interference between power and signal circuits. Cables shall be run at least 150mm clear of plumbing (and below) and hot water pipe-work.

Where cables are laid direct, the bottom of the trench shall be free of sharp stones and such like and 75mm of sieved soil or sand laid below the cable. After cable laying 75mm of sieved soil or sand shall be laid above the cable.

Unless otherwise agreed by the Engineer, cables at voltages up to and including 1000V shall have a minimum cover of 500mm. Cables at voltages in excess of 1000V and all cables passing under roadways shall have a minimum cover of 1.00m. These depths may be varied in certain circumstances due to the proximity of other cables or services.

Where cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables. Control and communication cables shall not be laid closer than 1000mm to high voltage cables.

Armoured cables laid direct shall have a layer of protective inter locking earthenware or concrete cable tiles laid 150mm above the buried cable or alternatively an approved marker tape may be used where specified. Cable tiles and marker tape shall read 'Danger-Electric Cable'.

Concrete cable route markers shall be installed at changes of direction and at 50m intervals on straight runs, each fitted with a suitably inscribed metal plate indicating the voltage of the cable being marked. Marker posts shall also be installed to identify any joint locations on cable runs.

Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts, shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds, or by other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes.

The Contractor shall exercise great care in handling the cables and avoid forming "KINKS". The cable drums shall preferably be conveyed on wheeled cable-drums carried and unrolled and laid directly from the drum carrier. Carrying by trailer or trucks can be allowed only if proper care is taken during unloading the drums and unrolling is done after placing the drum on drum-jacks and spindle. The cables shall be unrolled in the directions indicated on the drum by the manufacturer.

G.I cable marker is to be installed at every point of the trench.

After the cable is laid, it shall be tested by the Contractor in presence of the Consultant/ Engineer. If the test is unsatisfactory, all repairs and replacement shall be made by the Contractor at his/her/their own cost.

All surplus earth shall be removed to the indicated places by the Contractor at his/her/ their own cost. No extra charge shall be entertained for this work.

Any damage done to any other services by the Contractor for cable laying operations shall be made good by the Contractor at his/her/their own cost.

All chasings and passages, necessary for laying of cables indoor, shall be done by the Contractor and the same shall be made good to the satisfaction of the Engineer by the Contractor without any extra charge to the Employer.

When trenches are left open overnight and where road is to be cut, the Contractor shall exhibit suitable danger signal such as banners, red flags and red lamps at his/her/their own cost. Temporary arrangement, by placing wooden sleepers/sheet steel etc. across the road cutting for vehicular traffic are also to be made by the Contractor at no extra cost. The Contractor shall be wholly responsible for any accident which may occur due to his/her/their negligence.

All road excavations shall be filled up in layers with earth and suitably watered and rammed in such a manner that after completion of the work there is no land subsidence. The road top shall be reconstructed to match the existing road pavement.

No trench shall be dug until all cables meant for laying have been procured and transported at site store. Cost of any centering or shuttering and shoring of trench require to be done shall be borne by the Contractor without any additional cost.

Jointing cable

While laying the cables, it shall be so arranged that cables to be jointed overlapping each other by about 450mm to provide ample length for jointing. Metal serving and armoring shall be removed from both cables to conform to the dimension of the box. The lead sheath (if there be any) is then to be cut off from both cables to box dimension. The belt paper shall be removed to within 25mm of the lead sheathing at each and exposing the insulated core. The insulation shall be removed to the required length. All points shall be sheathed, wiped clean and properly insulated.

At least 25mm clearance shall be allowed between the center of each pair or joints. A wad of impregnated tape shall be provided between each core and in 'T'-joints, the armoring shall be properly bound and the box shall be replaced in the filling holes. Necessary tapping up shall be carried out after the compound has cooled.

Cables are to be terminated with the cable glands or end box as the case may be with the cable lugs of appropriate size and ratings.

Markers shall be provided along the cable routes at each turning point of the trench.

Markers shall be made of 3mm thick MS sheet welded to MS angle as shown in the Drawing or shall be made of cast iron.

Insulation test

Insulation test of the whole installation shall be carried out using 500 V Megger in presence of the authorized representative of the Employer and result submitted to the Engineer for approval.

Cable tray

The cable tray shall be installed in accordance with the applicable layout Drawings.

The location of tray in the Drawings shall be considered as approximate and it shall be incumbent upon the Contractor before installation of the tray to study all pertinent Drawings and obtain precise information from the architectural schedule, scale drawings, large scale and full size details of finished and approved Shop Drawings of other trades. Trays incorrectly located be properly located at the Contractor's own expenses.

3.26.4 Measurement

Measurement for payment shall be in linear meter of cables, cable trays and trenches in place for vertical and horizontal run as applicable. The lengths shall be rounded to nearest meter and calculated from the 'As built' Drawings.

3.26.5 Payment

The quantity of completed and accepted work measured as provided above shall be paid for at the Contract unit price per meter, which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of materials, providing all incidentals and consumables necessary to complete this item of work including the installation tests.

Payment shall be :

Clause	Description	Unit of Measurement
3.26	Cable work	Linear meter

3.27 JUNCTION, PULL BOXES AND OUTLET BOXES

Junction and pull boxes

Where indicated in the Drawings and Specifications or where necessary for compliance with code requirement for cable installation, junction and pull boxes of the proper sizes shall be provided.

Junction boxes and pull boxes shall conform to BS 4662 and shall be made of minimum 18 SWG sheet steel galvanized or any other materials as directed by the Engineer depending on where it is installed and to match with the existing construction in which these are installed. The circular boxes shall be of PVC. The cover of the metallic boxes should be fixed by using countersunk brass screw or galvanized machine screw. Box ears shall be at least 14 SWG. Each box (except circular boxes) must have an earth block of copper or brass of minimum size 9.5mm x 9.5mm x 9.5mm with 4.76mm drilled hole being for one earthing lead and 3.2mm machine screw (tapped for 24 t.p.i.) where earth continuity conductors shall be screwed in. The circular boxes shall have at least 12mm long hub.

Where boxes are set flushed with walls and ceiling, cover screws shall be flat head type and properly counter sunk. Cover shall be arranged to completely cover openings in building finish.

Where suitable standard outlet boxes may be used as junction and pull boxes.

If required by the building construction, junction and pull boxes of special sizes and shapes determined from field measurements shall be provided in order to make neat installations.

Should the utility company or any other agency require carriers between groups or feeders in pull boxes, they shall be provided at no additional cost.

If feeders and other wiring following the same routing are indicated on the plans as running through separate pull boxes, it shall be understood that it is intended to maintain a segregation of the wires and cables. Separately indicated pull boxes may be incorporated into single boxes only on condition that segregation is maintained by means of approved asbestos carriers.

Pull boxes having any single horizontal dimension larger than 150mm shall be filled with cable support racks consisting of 19mm diameter steel pipes with flanged ends bolted to the sides or frame of the pull boxes. Each pipe support shall be filled with a continuous fibre-insulating sleeve.

Where a junction or pull box is installed in a furred ceiling or space and where due to building finish the sheet metal cover of the pull box exposed to view is not acceptable, approved access panel with suitable frame and supports in the furring in front of the pull boxes cover shall be provided.

Outlet boxes

Outlet boxes shall be provided as hereinafter specified, where shown on the Drawings, and all locations where required. When installing outlet boxes, particular attention shall be given on the following considerations:

- ☐ Outlet boxes shall be of such sizes and depth as to allow for easy wire pulling and installation of wiring devices, and shall comply with code minimum capacity requirements.
- ☐ All mild sheet steel and cast boxes shall have suitable knockouts.
- ☐ All cast boxes shall be provided with properly drilled and tapped holes.
- ☐ There shall be no more holes in any outlet boxes than required for the circuitry entering the same unused opening in boxes shall be provided with approved cast threaded plugs.
- ☐ The sheet steel boxes shall have threaded ears for fixing the covers.

- ☐ Sheet steel boxes used for flush outlets in walls or partitions shall be set such that not more than 3mm exists between the front edge of the boxes and the rear surface of the device plates which will be finally installed.
- ☐ Sheet steel outlet boxes and covers shall be hot dipped galvanized and cast iron boxes and covers shall be Electro galvanized.
- ☐ In case of non availability of galvanized sheet steel outlet boxes, 18 SWG thick MS sheet made outlet boxes, spray painted with two coats of synthetic enamel paint over a prime coat, may be accepted subject to prior approval of sample by the Engineer.
- ☐ In case of non availability of C.I. circular boxes, cast brass circular boxes may be accepted subject to prior approval of samples by the Engineer.

3.27.1 Measurement

Measurement for payment shall be made by units of Junction, pull boxes and out let boxes installed in place and accepted by the Engineer.

3.27.2 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the Contract unit price per each unit which payment shall constitute full compensation for furnishing all materials, consumable, accessories, tools and labours including storage, handling and transport of all materials and accessories, fitting, fixing as well as all incidentals necessary to complete this item of work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.27	Junction, pull boxes and out let boxes	Each

3.28 WIRE AND CABLES INSTALLATION

Wiring

Wires and cables for installation in conduits/ raceways for operation at less than 600 volts shall conform to the following:

- ☐ Conductors shall be of soft copper properly refined and shall have a minimum conductivity of 90% with PVC insulation.
- ☐ All wires and cable insulation, except as specifically noted elsewhere, shall be rated for 600 volts and shall conform to BS Specification.
- ☐ All portion of electrical system utilizing PVC insulated conductors shall be guaranteed against grounds, shorts and other insulation failures for a period of 5 years regardless of any other indication with regard to the guaranteed period for electric work.
- ☐ Wires and cables shall be delivered to the site of the projects in original package or in factory reels, fully identified with tag or levels, indicating the manufacturer's name and the date of manufacturing.
- ☐ Wires and cables shall bear repetitive marking along the entire length of their outer covering, indicating conductor size, insulation type, voltage rating etc. as necessary for compliance with code requirements.
- ☐ The outer covering of wires and cables shall be colour coded by means of factory applied approved code methods so as to provide a clear differentiation between each phase and neutral. The phases and neutral shall be colored red, yellow, blue and black respectively. In case of single phase two wire system, red or yellow or blue shall be for the phase line and black for the neutral.

Installation

The maximum number of conductors in any conduit shall be as per the Drawing conforming to the regulations of I.E.E. No joints in the conductor will be made throughout the installation and looping system shall be followed.

The conductor shall be tested for continuity and insulation before energizing and conform to the standard laid down by the Engineer.

Generally, single core cable (non-sheathed) is to be installed in metal conduits. The conduit sizes shall be as specified in the Drawings. It must be ensured that the cables are not damaged during pulling. For long lengths, pull boxes must be used even if not indicated in the Drawings. Cables shall not be drawn round more than two 90° bends between drawing in boxes and any single bend must not be less than 90°.

The cable upto 2.6mm². shall be solid conductor and jointing are to be done through porcelain connector and the connection shall be wound with PIB tape before placing in the boxes. Termination of cable upto 2.6mm² shall be done by making a hook at the end and brass cable termination must be used for higher sizes. Tee off joints in the cable to lighting point, switches, etc. should not be made. Looping in system of wiring is to be followed for recessed and surface wiring and the joints are to be made in the switchboards only. All 3 to 4 core PVC cable shall be terminated using brass cable glands of proper size.

3.29 EXPOSED INSTALLATION

Raceways or other wiring methods shall be run exposed only in the following circumstances:

- ☐ In specially assigned electric riser closets, shafts or switch board room.
- ☐ In mechanical equipment spaces.
- ☐ Where specially indicated on the Drawing or otherwise, with the expressed permission of the Engineer.

Exposed raceways of other wiring method shall be run parallel to the building walls, column lines, etc. throughout.

All exposed heavy conduits are to be fastened to masonry walls, floor or partitions. Use of wooden plugs will not be permitted and rowel plugs should be used instead. Metal saddles of approved type, not more than 0.6m apart, shall be used for fixing exposed conduit.

Composition supports of cables installed in vertical raceways shall be provided where indicated on the Drawings and as otherwise necessary to meet the code requirements.

Routing

Every effort shall be made to route raceways or other wiring so as to prevent wiring from being subject to high ambient temperature condition. Minimum clearance from heated pipes, ducts or surface such as breaching, flush, etc. shall be maintained in the following manner:

☐ Crossing non-insulated pipes or ducts	75mm
☐ Crossing insulated pipes or ducts	25mm
☐ Running parallel to non-insulated pipes, ducts or surfaces	0.9m
☐ Running parallel to insulated pipes, ducts or surfaces	150mm

Any routing shown on the places, raceways or other wiring method, shall not run exposed over a boiler or embedded in construction under a boiler unless special provisions for wiring through these specific high ambient temperature areas have been indicated.

Raceways or other wiring methods, run in suspended ceiling, may be installed as the draw files except that where such raceways etc. are being installed prior complete information regarding the final layout of all trade occupying the suspended ceiling plenum. They shall be installed in a coordinated 'Square' manner so as to minimize future conflicts.

Under no condition raceways or other wiring methods are installed in elevator shafts and hoist ways. Where outlets are being provided for such items as tri-cables, pit lights, run by lift, etc., only the outlet boxes themselves shall be located within the confines of the shaft.

Miscellaneous Requirements

The installation of raceways or other wiring methods requiring the notching, cutting or drilling of structural elements shall be coordinated with the other trades to ensure that no weakening of the structure is caused.

Except as otherwise noted in raceways intended for the pulling in wires or cables, no more than four 90° bends will be permitted between outlets boxes, pull boxes or other points. When fishing or snaking raceways to set up for pulling in wires and cables, fish tapes with ball types means shall be used.

Wires and cables shall not be pulled into raceways until

- ☐ The project has procedures, which are not likely to injure electrical wires or cables.
- ☐ The project has progressed to a point where raceways are dry and moisture is no longer likely to get into them.
- ☐ Wires or cables shall be pulled into raceways utilizing a suitable brush followed by a 85% diameter ball mandrel ahead of the wires or cables in the pulling assembly.

The only permissible pulling lubricant is powdered soapstone.

Sufficient slack shall be left on all rooms or wires and cables to permit the proper connection of devices, equipment etc.

Mounting Height

Mounting height of outlet and fixtures shall be in accordance with the following list of bottom line dimension above finished floors unless otherwise shown on Drawings.

Items	From finish floor level on wall	From finish level
Light and fan switch boards	1.22m	-
Wall bracket light	2.44m	-
Socket outlet on wall	2.29m	-
Call bell outlets	0.77m	-
Call bell indicator	2.44m	-
Ceiling Fan	2.59m	-
Television antenna outlet	-	225mm
Ceiling suspended Fluorescent Light fitting	-	2.59m

Wiring methods

General wiring methods permissible for the various parts and elements of the system operating at 600 Volts or less shall be as hereinafter specified.

Rigid standard weight metallic conduit shall be used for feeders and sub feeders and appliance branch circuiting throughout.

Rigid standard weight metallic conduit shall be used for lighting and appliance branch circuiting throughout.

Where non-flexible wiring methods are specified it shall be understood that the following exceptions are to be made for final connections without claiming any extra cost.

- ☐ Final connections to motors and motor operated equipment, shall be made with 38mm diameter flexible metallic conduit.
- ☐ Final connection to recessed lighting fixtures shall be made with not more than 0.52m long flexible metallic conduit or flexible wire.

Surface wiring

Conduit for surface wiring shall be secured with wall ceiling or any other structure by means of saddle at a distance of 0.61m center to center c/c, and all the bends will be made by mechanical bender. No elbows will be allowed. Where necessary, specified pull boxes or Inspection Boxes shall be used.

Surface wiring on batten will be seasoned Garjan/Chittagong Teakwood properly secured to the wall or ceiling by rowel plug. Batten shall be fixed on proper alignment with the ceiling and wall.

Brass link clip shall be fixed to the batten to hold the wire @ 100mm center to center.

Twin core cable with E.C.C. of proper grade shall be used without making any joint between switch board and individual outlet. The switch shall be on phase wire not on neutral wire.

3.30 FEEDERS, LIGHTING AND APPLIANCE CIRCUITRY

Sizing and other pertinent data regarding main feeders, sub feeders, branch feeders, operating at 600 volts or less and any branch circuitry protected by different ratings, circuit breakers are fully delineated on the plans. All such feeders and circuitry shall be provided in accordance with the indication on the plan and shall be connected for correct phase sequence and proper operation of the equipment served.

Each individual lap of a feeders which is called with multiple cables per phase shall be arranged so that all of the feeders are connected to the corresponding phase leg of the individual lap.

General circuitry operating at less than 600 volts and called for or indicated without specific details as to sizing, etc. shall be understood to be lighting or less. Such circuitry is to be provided in accordance with the ground rules hereinafter specified.

Where lighting and appliances outlets are shown on the Drawings without fully delineated circuitry such shall be provided in accordance with the "Ground Rules" listed below.

All lighting and appliance branch circuitry protected as 20 amp or less shall be performed in accordance with the following ground rules unless there are specific indications to the contrary.

Unless otherwise noted minimum conductor size shall be No. 16 SWG diameter copper.

Conductors for circuitry operating in the range of 230 to 250 volts to neutral and extending in excess of 200 Feet from the point of supply to the last outlet or fixture tap, shall be No. 10 SWG diameter copper throughout.

Raceway sizes shall be adequate for the number of conductors contained as required by the Code.

Unless otherwise noted, circuitry shall be multi wise utilizing common neutrals arranged so that no neutral conductor acts as common wire more than one circuit conductor connected to the same phase leg of the supply system.

Circuit shall be balanced on phases at supply point as evenly as possible.

Except as hereinafter differently specified, standard type of metallic outlet box shall be provided for each and every wiring device, lighting fixtures, etc.

Where more than one switch is shown on the plans or a single location, their switches shall be gang mounted to a single suitable outlet box.

A switch and receptacle shall not be gang mounted in a single outlet box unless the plan specifically indicates such a communication.

Where buried in outlet boxes are required by the Code to separate wiring devices, wire of different phase legs of the supply system to separate wiring of different voltage system or for other reasons, such barriers shall be provided at no additional cost.

Under no condition shall any switch break any neutral conductor.

Outlet boxes for switches shall be located at the strike side of the doors. Door swing indicated on the plans are subject to field modification. Outlet boxes for switches shall be located on the basis of the final door swing arrangement.

Unless made accessible by other means, boxes for recessed ceiling fixture be mounted near to the ceiling fixture.

Final connection from the outlet boxes to the recessed ceiling fixtures shall be by means of suitable flexible fixtures pigtails not less than 1.22m and not more than 1.83m long. In all cases, enough slack shall be left in pigtails to permit removal of fixtures from the ceiling for inspection with disconnection.

Where the specifications for Drawing indicate no specific requirement as to the loading or connection of outlets in lighting and appliance branch circuit, the following maximum limitations as indicated below shall be followed:

No more than 12 outlets of 1650 Watts shall be applied to any single 10 Amps circuit and no more than 24 outlets of 400 total Watts to any single 20 Amps circuit in the range of 230 to 250 Volt to neutral.

At any location where lighting and appliance branch circuitry is provided extending from a flush mounted panel board to a suspended ceiling immediately above, at least four 25.4mm empty conduit shall be provided (in addition to those required for active circuitry) to permit future wiring escape from panel board. The empty conduit shall extend up from the panel and shall terminate in a threaded conduit cap immediately after turning out into the hung ceiling planer space.

Emergency wiring shall be run in a completely separate raceway conduit system containing no wire of 'Normal' lighting and appliance.

Wire for exterior lighting fixture and/or receptacle not mounted on the building shall be having a neat moisture resisting rubber insulation and poly chloropene jacket of sufficient thickness to ensure its adequacy for direct burial installations. The PVC double-coated wire shall be in GI pipe with two coats of waterproof bitumen compound installed at minimum 0.46m below the ground.

3.31 ELECTRICAL FITTINGS AND ACCESSORIES

3.31.1 Scope

All electrical fittings and accessories shall be supplied and fitted conforming the requirements as shown on the Drawings, the Schedule of Works and as directed by the Engineer. Appropriate samples for every item shall be submitted to the Engineer for his/ her approval. No fittings or accessories shall be installed prior to the approval of the Engineer.

3.31.2 Light fittings

General

The Contractor shall be responsible for the supply and installation of all the various types of lighting fittings. Lighting fittings shall be complete with starters, chokes, sockets, power factor correcting capacitors, tubes, lamps, shades, reflectors, etc. The Contractor shall also be responsible for the replacement of all the consumable components of the fittings within the warranty period.

Each surface mounted lighting fitting shall terminate at a standard junction box having entries to conduit and shall include connectors of adequate capacity and size for the connection of the number of wires at that point.

Each fitting mounted on a suspended ceiling shall have the standard mounting brackets or clips for the type of ceiling in question. The fittings shall include the necessary connectors and heat resistant cable for connection between the fittings and the terminal box.

All suspended fittings shall be suitable for servicing and maintenance from the underside of the fittings. Fittings installed directly to the underside of the non-fireproof ceiling shall be provided with a 12mm gap between the fittings and the ceiling for ventilation.

All light fittings shall be provided with an earthing terminal, which shall be connected to the earth continuity lead of the final sub-circuit. Fittings for external use shall be weather proof and insect proof.

Materials

The Light fittings shall be constructed as per the Schedule of Works and shall comply with the relevant requirements of the applicable BS including BS 4533.

Switches shall be provided for control of every lighting fitting. A switch may control an individual point or a group of points. Where control at more than one point is necessary for a lighting fitting or a group of lighting fittings, as many two-way or intermediate switches may be provided as the required number of control points.

Where a lighting fitting is to be supported by one or more flexible cords, the maximum weight to which the twin flexible cords may be subject are shown in the Table below

Maximum permissible weight to which twin flexible cords may be subject

Nominal cross-sectional area of twin flexible cord (mm ²)	Number and diameter (mm) of wires	Maximum permissible weight (kg)
0.5	16/0.2	2
0.75	24/0.2	3
1.0	32/0.2	5
1.5	48/0.2	5.3
2.5	80/0.2	8.8
4	128/0.2	14

No flammable shade shall form part of lighting fittings unless such shade is well protected against all risks of fire. Celluloid shade or lighting fitting shall not be used under any circumstances.

The chokes, if applicable, shall comply with the requirement of BS 2818, shall be Philips/Seimens/GEC or of equivalent quality and shall have appropriate power factor correction capacitor (250 volt 3.5 f for 20W and 40W tubes if used with Seimens/GEC chokes, for other chokes of approved quality the improved p.f. shall not be less than 0.90).

The starters shall be of 91W lamp type and shall have built-in radio interference suppressor capacitor.

Electronic ballast complying appropriate standard shall be used, if specifically mentioned elsewhere or if directed by the Engineer.

All incandescent light fittings, except where specifically stated otherwise, shall have un-switched brass holders for BC 22/25 x 26 lamp caps complying with BS 52 : 1963 (1978).

Installation

The light fittings shall be installed in accordance with the applicable fittings layout Drawings.

All pendent fittings shall be supported from brass ceiling base plate with at least 9.5mm screw-hub.

The location of outlets shown on conduit layout and wiring plans shall be considered as approximate and it shall be incumbent upon the Contractor, before installation of outlet boxes, to study all pertinent Drawings and obtain precise information from the architectural schedule, scale drawings, large scale and full size details of finished rooms and approved Shop Drawings of other trades. It shall be understood that any outlet may become necessary to be relocated at a distance not exceeding 4.57m from the location shown on the Drawings. In entering outlets, due allowance shall be made for overhead piping ducts, window and door trim, variation in thickness of furring, plastering, etc. as erected, regardless of conditions which may be otherwise shown on small scale Drawings. Outlets incorrectly located shall be properly relocated at the Contractor's expense.

3.31.3 Measurement

Measurement for payment shall be made by units of lights installed in place and accepted by the Engineer. Each fitting, complete with all accessories and consumables, shall be considered as one unit.

3.31.4 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the Contract unit price per unit number (each) which payment shall constitute full compensation for furnishing all materials, consumable, accessories, tools and labours including storage, handling and transport of all materials and accessories, fitting, fixing as well as all incidentals necessary to complete this item of work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.32	Light fitting	Each

3.32 CEILING FAN/EXHAUST FAN

3.32.1 Fan in general

Ceiling fans including their suspension shall conform to BDS 818. Fans shall not be placed, relative to the positions of lighting fittings, in such a way that shadows are thrown on the working planes.

Where ceiling fans are provided in large buildings, the module sizes also play an important part. In general purpose office/commercial building, for every part of a module to be served by the ceiling fans, it is necessary that the module shall be so designed that the required number of fans could be suitably located in it, to avoid creation of ill-ventilated pockets. In general, fans in large halls may be spaced at 3 to 3.5m in both the directions. If building modules do not lend themselves to proper positioning of the required number of ceiling fans, other types of fans, such as air circulators or bracket fans would have to be employed for the areas uncovered by the ceiling fans. In such cases, necessary electrical outlets shall have to be provided for the purpose.

Exhaust fans are necessary for spaces, such as toilets, kitchens, canteens and godowns to provide the required air changes. Since the exhaust fans are located generally on the outer walls of a room, appropriate openings in such walls shall be provided right from the planning stage.

3.32.2 Ceiling fan and exhaust fan

Materials

Ceiling fan

Fans of approved quality shall be provided and shall be complete with suspension rod of required length, canopy, speed regulators etc. Speed regulators shall be of electronic type with non-stop increasing/decreasing speed and off position. General requirements of the fans to be provided are as follows:

Sweep	1400mm	1200mm
Air Delivery at full speed (CFM)	10000	7000
Speed (RPM)	270	300
Power Consumption (Watt)	65	50
Power factor	0.95	0.95
A.C Power Supply (Volts)	220/230	220/230
Frequency (C/S)	50	50

Fan clamps

The U-type fan clamps shall be made of at least 12mm diameter M.S rod. The ceiling rose shall be of molded plastic of approved quality.

Exhaust Fan

Fans of approved quality shall be provided and shall be complete with steel frame louver, shutter etc. General requirements of the fans to be provided are as follows:

Sweep	300mm
Air Delivery at full speed (CFM)	670
Speed (RPM)	950
Power Consumption (Watt.)	35
Power factor	0.95
A.C Power Supply (Volts)	220/230
Frequency (C/S)	50

Installation

The ceiling fans shall be installed in accordance with the applicable fan layout Drawings. If otherwise not mentioned in the Drawings and specifications, all fans shall be suspended at a minimum height of 2.59m from the finished floor level.

Fan clamps shall be installed as detailed on the Drawings. Circular box with ceiling rose for fan outlets, shall be at the center of the clamps. The clamp shall be installed in such a manner that clamps, ceiling rose, etc. shall be completely concealed by the fan canopy.

The exhaust fans shall be installed in accordance with the applicable for layout Drawings. If otherwise not mentioned on the Drawings and specifications, all fans shall be installed at a minimum height of 2.13m from the finished floor level or above lintel level as directed by the Engineer.

3.32.3 Measurement

- i. Measurement for payment shall be made by units of Fans/Exhaust fans installed in place and accepted by the Engineer. Each fan/exhaust fan complete with all accessories and consumables shall be considered as one unit.
- ii. Measurement for payment shall be made by units of clamps installed in place and accepted by the Engineer. Each fan clamp complete with all accessories e.g. ceiling rose, etc. shall be considered as one unit of fan clamp.

3.32.4 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the Contract unit price per each unit which payment shall constitute full compensation for furnishing all materials, consumable, accessories, tools and labours including storage, handling and transport of all materials and accessories, fitting, fixing as well as all incidentals necessary to complete this item of work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.32	Fan	Each

3.33 DISTRIBUTION BOARDS / EMERGENCY DISTRIBUTION BOARDS/SUB-DISTRIBUTION BOARDS / EMERGENCY SUB-DISTRIBUTION BOARDS.

Materials

The DB/EDB/SDB/ESDB shall be safely dead-front fixed type having Circuit Breakers. The Distribution Boards shall have three phase energy meter, ammeter and voltmeter with phase selector switch (in case three phase meters are provided), on/off indication bulb etc. The meters shall be installed in a separate compartment in the distribution boards and provision shall be made such that the meters can be read directly without opening the front cover of the Boards by providing glass/clear perspex covering on the meter opening or by installing the meter scales flushed with the door. Panels shall be designed for operation on a 240/415V, 50 Hz, 3 phase, 4 wire system. Breakers shall have inverse time tripping with thermal magnetic trip elements. All Circuit Breakers shall be trip-free and shall be of the indicating type. The panels shall have the phase clearly marked and must have solid copper bus bar (TR & N) of appropriate rating and size. The panels shall be constructed fully in accordance with the requirements and shall comply with the relevant specifications and requirements of the applicable B.S including B.S 4649 where applicable and would be painted with two coats of grey Duco to B.S 381C shade with standard concentric knockouts of required sizes all around. The panels shall have directory frames and printed directory on the inside of the door. The door is to be provided with flush lock and handle. All doors are to be keyed alike. All hinges shall be concealed.

Each board shall have an earthing block of copper/brass 150mm x 38mm x 12mm with 8 numbers 9.52mm drilled holes and 8 numbers 3.18mm machine screw tapped holes for 24 t.p.i.

The MCB/MCCBs shall be quick make, quick-break type and shall have inverse-type limit characteristics with instantaneous magnetic trip elements functioning on overloads above the normal operating range. All circuit breakers shall be "trip-free". Ratings and frame sizes of breakers shall be in accordance with the requirements. All lugs must be of the solderless mechanical type. The Miniature Circuit Breakers (MCB) must comply with B.S 3871:part 1 (1965) category M4 (5A-60A). Rated voltage 240/415V A.C. 50 Hz, interrupting capacity 4000 Amp. capable of providing overload and short circuit protection through thermal and magnetic trip actions respectively; temperature rating 40°C, tropicalised (moisture, fungus, corrosion treated) with contacts of silver alloy. The MCCB must comply with B.S. 3871:part 2 (1966). Rated voltage 600V A.C 50 Hz with overload and short circuit protection with thermal and magnetic tripping action, interrupting capacity as indicated in the Schedule of Works, temperature rating 40°C, tropicalised (moisture, fungus, corrosion treated).

Installation

The Board shall be installed in accordance with the instruction of the Engineer or as shown on the applicable layout Drawings. Minimum height to bottom of the Boards from the floor level shall be 0.76m and maximum height of any circuit breaker/switch shall be 1.83m from the same level, or as shown on the detailed Drawings.

The location of DB/EDB/SDB/ESDB shown on the layout Drawings shall be considered as approximate. It shall be incumbent upon the Contractor before installation of DB/EDB/ SDB/ESDB to study all pertinent Drawings and obtain precise information from the architectural scale drawings, large scale and full size details of finished rooms and approved Shop Drawings of other trades. It shall be understood that any DB/EDB/SDB/ ESDB may be relocated at a distance not exceeding 4.57m from the location shown on the Drawings. In centering DB/EDB/SDB/ESDB due allowance shall be made for overhead piping, ducts, window and door trim, variations in thickness of furring, plastering, etc. as erected, regardless of conditions which may otherwise be shown on the small Drawings. DB/EDB/SDB/ESDB incorrectly located shall be properly relocated at Contractor's expenses.

3.33.1 Measurement

Measurement for payment shall be made by units of DB/EDB/SDB/ESDB installed in place completely wired, connected to the circuits and accepted by the Engineer. Each DB/EDB/SDB/ESDB complete with all accessories and consumables shall be considered as one unit.

3.33.2 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the Contract unit price per each unit which payment shall constitute full compensation for furnishing all materials, consumables, accessories, tools such as DB/ EDB/SDB/ESDB cubicle breaker, bus bar, equipment and accessories fabricated angle-iron platform, pipe supports cable gland etc. including storage, handling and transport of all materials and accessories, fitting, fixing, all labours as well as all incidentals necessary to complete this item of work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.33	Distribution Boards/Emergency distribution Boards/Sub-distribution Boards/Emergency Sub-Distribution Boards	Each

3.34 METER BOARD

Materials

All Meters and Circuit Breakers are of ratings, given in the Schedule of Works, shall be fixed in with 14 SWG sheet steel box with locking arrangement. The box must be hammer painted. The Meter Board shall be installed, if only meters are not provided in the LT distribution panels of the Sub-station.

Installation

The Meter Board shall be installed in wall with lower end of the board at a height of 1.22m from the finished floor level or it will be installed as per the Engineer's written instruction. If not specified, the board shall be installed at the location shown on the Drawings.

The boards shall be concealed and cover plates shall be flushed with the finished surface of the wall.

3.34.1 Measurement

Measurement for payment shall be made by units of boards completely installed in place connected to the circuits and accepted by the Engineer. Each board complete with sheet steel box, meter, MCCB/MCB and locking arrangement etc. complete with all accessories and consumables required to complete the work.

3.34.2 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the Contract unit price per each unit which payment shall constitute full compensation for furnishing all materials, consumables, accessories, tools including meter, MCCB/MCB, sheet steel box, all equipment and accessories etc. including storage, handling and transport of all materials and accessories, fitting, fixing, all labours as well as all incidentals necessary to complete this item of work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.34	Meter board	Each

3.35 SWITCH BOARDS AND FAN REGULATOR BOARDS

Materials

Switch Boards and Fan Regulator Boards shall have rocker/piano Switches and/or fan regulators (Electronic type). The rocker/piano Switches shall be vertical single pole (1-way/2-way) 5A A.C architrave rocker/piano operated Switches white (or as approved by the Engineer) in colour in accordance with the requirements of B.S 3676:1963, complying with the test requirement for inductive or resistive loads specified and satisfy the best requirements of the circuits up to the ratings of these Switches as set out in B.S. 3676, Amendment 3:1969. The Switches must have a minimum clearance

of 3mm between the contacts and a similar minimum creepage distance. All contacts shall be faced with pure silver/silver-cadmium oxide alloy. The Switch operating member shall pivot independently of the rocker, making the speed of 'make' and 'break' independent of the speed at which the rocker is operated. Terminal capability of minimum 2 numbers 2.5mm² conductors for each appropriate samples shall be submitted prior to installation of the Switches.

Each board shall have an earthing block of copper/brass 50mm x 9.5mm x 9.5mm with 4 numbers 4.8mm drilled holes and 4 numbers 1.6mm machine screw tapped holes for 24 t.p.i. The box of the Switch/Regulator Boards shall be made of 16 SWG sheet steel and shall be painted with three coats of approved anticorrosive grey paint. Box ears shall be adequate to accommodate at least 14 SWG ground wires.

Installation

The Switch Boards and Fan Regulator Boards shall be installed on wall at a height of 1.22m, if not specified otherwise, from the floor and at locations shown on the applicable layout Drawings. The Regulators shall be installed inside the box with Regulator's knob projected over the covering, if not specified otherwise. The phase wire shall be connected to the Switches and the neutral wire shall be kept solid in all Switch connections. The Earth Continuity Conductor (ECC) shall be connected to the earth point inside the Switch Board. The approved size steel boxes shall be installed at the time of construction of the wall to avoid chasing in wall.

The location of boards shown on the Conduit Layout and Wiring Plans shall be considered as approximate and it shall be incumbent upon the Contractor, before installation Switch Board/Regulator Board Boxes, to study all pertinent Drawings and obtain precise information from the architectural schedules, scale drawings, large scale and full size details of finished rooms and approved Shop Drawings of other trades. It shall be understood that any Switch/Regulator Board may be relocated at a distance not exceeding 4.57m from the location shown on the Drawing. In centering the boards, due allowance shall be made for overhead piping, ducts, window and door trip, variations in thickness of furring, plastering, etc. as erected, regardless of conditions which may be otherwise shown on the small scale Drawing. Switch Boards/Regulator Boards incorrectly located shall be properly relocated at the Contractor's expenses.

3.35.1 Measurement

Measurement for payment shall be made by units of Switch Boards and/or Fan Regulator Boards completely installed in place and accepted by the Engineer. Each Switch Board or Fan Regulator Boards with cover, switches, sheet steel box etc. shall be considered as one unit.

3.35.2 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the Contract unit price per each unit which payment shall constitute full compensation for furnishing all materials, consumables, accessories, tools and equipment and all installation materials including Switch Board/Fan Regulator Board complete with plate, Switches, Regulators and other accessories, including storage, handling and transport of materials, fitting, fixing, all labours as well as all incidentals necessary to complete this item of work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.35	Switch board and fan regulator boards	Each

3.36 SOCKET/MCB/MCCB OUTLETS

3.36.1 Materials

All socket outlets shall be MK type, white (or as approved by the Engineer) in colour, conforming BS 546:1950 (3 pins) and BS 372:part 1:1930 (2 pins). The socket tubes shall be self-adjusting for pitch with a non-expanding size-limiting entry to protect the internal contacts from distortion. All socket, switches (where applicable) shall have pure silver/silver-cadmium oxide alloy contacts in which contact pressure shall be permanently maintained by subsidiary helical compression springs. All

moldings shall be made of amino-plastic urea molding powder conforming BS 1322:1956 or amended and shall possess high track resisting qualities. These shall be supplied with countersunk cadmium plated fixing screws and mounted inside sheet box made with 16 SWG sheet hammer painted having brass earth point as per the Drawing or as directed by the Engineer.

The controlled sockets of MCB/MCCB, if applicable, shall be un-switched and the box shall have earth point. Specifications of MCB/MCCB have been stated earlier.

The lift indicator outlets shall be made of 16 SWG sheet steel hammer painted.

3.36.2 Installation

The Sockets of MCB/MCCB shall be installed on walls with the lower end of the face plates at a height of 150mm/225mm from the floor i.e. at the skirting level, if not specified otherwise and the locations shown in the applicable layout Drawings.

The controlled outlet (socket or black box) of MCB/MCCB shall be on the walls with the lower end of the face plate 150mm above the upper edge of the lintel, if not specified otherwise.

The fixing of the units on the outlet boxes shall be done by means of flat head cadmium plated screws. The flat head of the screw shall be sunk in the plates so as to finish flushed with the surface of the cover. The earth wire shall be connected to earth point of the boxes to the 3rd pole of the 3-pin sockets. 2-pin socket outlets on switch boards are for light loads only.

Conditions set out in the relevant portions of the Sub-section on 'Light Fittings' shall also apply.

3.36.3 Measurement

Measurement for payment shall be made by units of sockets/MCB/MCCB indicator outlets completely installed in place and accepted by the Engineer. Each socket/MCB/ indicator outlet complete with sheet steel box, socket, controlling MCB/MCCB, cover, etc. (where applicable) shall be considered as one unit.

3.36.4 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the Contract unit price per each unit which payment shall constitute full compensation for furnishing all materials, consumables, accessories, tools and equipment and all installation materials including socket/MCB/MCCB outlets, sheet steel box, covers and other accessories, including storage, handling and transport of materials, fitting, fixing, all labours as well as all incidentals necessary to complete this item of work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.36	Socket/MCB/MCCB outlets	Each

3.37 EARTHING

3.37.1 General

The object of an earthing system is to provide a system of conductors, as nearly as possible at a uniform and zero, or earth, potential. The purpose of this is to ensure that, in general, all parts of equipment and installation other than live parts shall be at earth potential, thus ensuring that persons coming in contact with these parts shall also be at earth potential at all times.

3.37.2 Circuit and system earthing

The purpose of circuit and system earthing is to limit excessive voltage from line surges, from crossovers with higher voltage lines, or from lightning, and to keep non current carrying enclosures and equipment at zero potential with respect to earth. Earthing the system helps facilitate the opening of over-current protection devices in case of earth faults.

Earthing associated with current carrying conductors is normally essential for the security of the system and is generally known as system earthing, while earthing of non-current carrying metal work and conductor is essential for the safety of human life, animals and property and it is generally known as equipment earthing.

The earthing arrangements shall be such that :

- the value of resistance from the consumer's main earthing terminal to the earthed point of the supply, or to earth, is in accordance with the protective and functional requirements of the installation and expected to be continuously effective.
- earth fault currents and earth leakage currents likely to occur are carried without danger, particularly from the point of view of thermal, thermomechanical and electromechanical stresses.

Precautions shall be taken against the risk of damage to other metallic parts through electrolysis.

Where a number of installations have separate earthing arrangements, protective conductors running between any two of the separate installations shall either be capable of carrying the maximum fault current likely to flow through them, or be earthed within one installation only and insulated from the earthing arrangements of any other installation. In the latter circumstances, if the protective conductor forms part of a cable, the protective conductor shall be earthed only in the installation containing the associated protective device.

3.37.3 Methods of earthing

The usual method of earthing is to join the exposed metal work to earth via an earth continuity conductor connected to an electrode buried in the ground. In conjunction with a fuse, or other similar device, this then forms a protective system. Thus if a live conductor accidentally comes into contact with an exposed metal, the fuse or protective device operates. As long as the overall resistance of the protective system is low, a large fault current flows which blows the fuse. This cuts off the supply and isolates the faulty circuit, preventing risk of shock, fire, or damage to equipment/installation.

The three main elements required for an earthing system are earth conductors, earthing lead and earth electrodes. The method of connecting earth wires, earthing lead and earth electrodes is as important as the selection of the main elements because poor connection will render the earthing system ineffective.

3.38 EARTH CONTINUITY CONDUCTORS

3.38.1 Materials

In all cases the grounding conductor shall be made of copper or galvanized steel or other metals or combination of metals which will not corrode excessively and, if practical, shall be without joints or splice. If joints are unavoidable, they shall be made and maintained so as not to materially increase the resistance of the earthing conductor and shall have appropriate mechanical and corrosion resistant characteristics. Where the earth conductor is to be buried underground in corrosive soil, use of insulated cable as earth conductor is to be preferred.

Aluminum or copper clad aluminum conductors shall not be used for final connections to earth electrodes.

The earth conductor shall have a short time capacity adequate for the fault current which can flow in the grounding conductor or conductors for the operating time of the system protective device. In case of copper wire being used as earth conductors, the size of the wire shall not be less than half the area of the largest current carrying conductor supplying the circuit.

Earth continuity conductors shall be electrolytic annealed copper of 100% conductivity at 20°C (International Annealed Copper Stranded) with weight resistivity of 0.15328 ohm-gram/m² at 20°C and density of 5.746 gram/mm³ meeting the requirements of BS 6360:1969 or its metric adoption.

The minimum sizes of copper earth conductors corresponding to the sizes of associated copper circuit conductors have been shown in the following Table. No size smaller than 14 SWG (3.243mm²) shall be used anywhere as earth conductor.

Minimum cross-sectional area of Copper Earth Conductors in Relation to the Area of Associated Phase Conductors

Cross-sectional Area of Phase Conductor(s) (mm²)	Minimum Cross-sectional Area of the Corresponding Earth Conductor (mm²)
Less than 16	Same as cross-sectional area of phase conductor but not less than 14 SWG.
16 or greater but less than 35	16
35 or greater	Half the cross-sectional area of phase conductor.

3.38.2 Installation

The earth continuity conductor and earthing lead shall be run in accordance with the Drawings and directions of the Engineer. All metal fittings shall be earthed with continuity conductors. All the earth continuity conductors from the various circuits, switch boards, sockets, etc. shall be connected to the earthing block located in the DB/EDB/SDB/ESDB. All DB/EDB/SDB/ESDB shall be inter-connected with earth continuity conductor. The earth continuity conductor shall be drawn along with the cables and no joint shall be allowed from earthing block to the respective earth point. Light and fan points, except where indicated otherwise, shall not be earthed.

3.38.3 Measurement

Measurement for payment shall be made by linear meter of earth continuity conductor in place for vertical and horizontal run and accepted by the Engineer. The lengths shall be rounded to nearest meter and measured from the 'As built' Drawings.

3.38.4 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the Contract unit price per meter which payment shall constitute full compensation for furnishing all materials, consumables, accessories, tools and equipment and all installation materials including termination of copper wire and all accessories, fitting, fixing, all labours as well as all incidentals necessary to complete this item of work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.38	Earth continuity conductors	Linear meter

3.39 DISTRIBUTION SYSTEM EARTHING

3.39.1 Materials

Earth Electrode

The earth electrode shall, as far as practicable, penetrate into permanently moist soil preferably below ground water table. The resistance of earth electrodes shall not be more than one ohm.

Earth Electrodes, as recognized by the Code, are as follows:

- ☐ Copper rods.
- ☐ Copper plates.
- ☐ Galvanized iron pipes.

The following is a guideline for electrode size:

- ☐ Copper rods shall have a minimum diameter of 12mm.
- ☐ GI pipes shall have a minimum diameter of 50mm.
- ☐ Copper plates shall not be less than 600mm x 600mm in size, with 6mm thickness.

Pipe Electrode (where Applicable)

This earth electrode shall be of GI pipe of 38mm diameter and minimum 12m long with two 3mm diameter holes across the pipe diameter at every 1.22m length of the pipe.

Plate Electrode (where Applicable)

This earth electrode shall be cold rolled single/double copper plate of size 600mm x 600mm x 12mm having provision for connecting the earthing lead as shown on the Drawing, as per the Schedule of Works or as directed by the Engineer.

Earthing Lead

Earth lead is the link which provides connection between the earth conductor(s) and the earth electrode(s). The earth conductors shall be brought to one or more connecting points, according to size of installation; the copper wire earthing leads shall run from there to the electrodes.

Earthing lead can either be of copper wire or of copper strip. Normally it shall consist of copper conductor of 2 x 1/0 SWG with material specification as stated under the relevant portion of the Sub-section on 'Earth Continuity Conductors' of this Specifications. All terminal lugs shall be of copper and nut/bolts of brass. Other materials like aluminium can also be used.

Conductors for interconnection between the electrodes in any group and between groups shall have twin conductors with a combined rating of 20 KA for 3 seconds.

Earthing conductors shall be of annealed high conductivity copper and shall be stranded in accordance with IEC 228 Table-VII Class-2. They shall be protected with an extruded PVC sheath of 1000 volts grade.

Earthing leads shall be run in duplicate down to the earth electrode so as to increase the safety factor of the installation.

Earthing Block

The earthing block shall be of solid electrolytic copper, cast and machined to the size as mentioned in the Schedule of Works or as shown on the Drawings, having at least 15 Nos. 6.35mm drilled holes for accommodating the terminal of the earth continuity conductor. Requisite number of brass nuts and bolts shall also be provided.

Earth Inspection Pit (if necessary)

Bricks used shall be of 1st class. Only approved quality cement shall be used. For R.C.C cover slab, 12mm diameter rods @ 150mm center to center with two 9mm diameter M.S. rod hook of 50mm shall be provided in the cover slab. Material specifications for bricks, sand, cement, aggregate, water and reinforcement shall fully conform to the provisions made under the Section on 'Building Materials' of the 'Standard Specifications for Building and Allied Works' used by the LGED.

3.39.2 Installation**Earth Electrode****Pipe Electrode**

The pipe earth electrode shall be buried below the ground level by tube-well sinking method in accordance with the provisions of the Schedule of Works. The earthing lead from the distribution board to the main earth electrode shall be installed in G.I. pipe of specified diameter. The terminal connected to the earth electrode shall use a brass clamp. After making the connection, the clamp shall be covered with hot bitumen poured and covered with jute cloth.

Plate Electrode

The plate earth electrode (if applicable) shall be buried below the ground level in accordance with the provisions of the Schedule of Works and installed in an upright position and completely surrounded by a bed of at least 300mm of charcoal mixed with sodium chloride salt, lined and packed hard as per

specifications shown on the Drawings. Distance between any two earth electrodes shall be at least 7.62m or as per direction of Consultant/Engineer.

Earthing Leads

The earthing lead from the earth electrode shall be connected to the earthing block near DB/EDB/SDB/ESDB. A double run of specified copper conductor shall be brought out as earthing lead for the earth electrode through G.I. pipe from the electrode and connected to the earth blocks. There shall be no joint in the copper earthing lead. All earthing lead shall follow the shortest and most direct route to earth electrode and sharp bends and joints shall be avoided. The earthing leads shall be connected to the earth electrode as per drawings. The joints shall be made mechanically strong and electrically continuous with minimum of resistance.

Earth Inspection Pit (if necessary)

The earth inspection pit shall be constructed as per the provisions of the Schedule of Works and direction of the Engineer.

The slab shall have smooth and leveled surface and the pit shall have well formed regular sides. All specifications and construction procedures shall fully conform to the provisions made under the Sections titled 'Brick Masonry and Brick Works', 'Concrete Work' and 'Reinforcing Steel' of the 'Standard Specifications for Building and Allied Works' used by the LGED.

Maximum Earth Loop Resistance

The maximum earth loop resistance from any point in the installation including earthing lead to the earth electrode shall not exceed the resistance of 1ohm or specified in the schedule, or that indicated by the Engineer. The Contractor must ensure that the leads are efficiently bonded to all metal works other than the current carrying parts, so that the above resistance level is not exceeded. It will be the responsibility of the Contractor to provide earth tester, test the installation in presence of the authorized representative of the Employer and submit earth test report to the Engineer for approval.

3.39.3 Measurement

Earth Electrode

Measurement for payment shall be per set/per each (as applicable) of earth electrode(s) installed in place as described in the Schedule of Works and as shown on the Drawings or as directed by the Engineer and accepted by him/her.

Earthing Lead

Measurement for payment shall be made by linear meter of earthing lead installed in place including necessary pipes, terminal lugs, nuts, bolts, etc. as described in the Schedule of Works and as shown on the Drawings or as directed by the Engineer and accepted by him/her.

Earthing Block

Measurement for payment shall be made by units of earthing block installed in place complete with all accessories, connections, consumable, etc. as described in the Schedule of Works and as shown on the Drawings or as directed by the Engineer and accepted by him/her.

Earth Inspection Pit

Measurement for payment shall be made per unit of earth inspection pit installed in place or as described in the Schedule of Works and as shown on the Drawings or as directed by the Engineer and accepted by him/her.

3.39.4 Payment

The amount of completed and accepted work measured and as provided above shall be paid for at the corresponding Contact unit price per unit/per set/per meter as applicable which payment shall constitute full compensation for furnishing all materials, labour, tools, equipment including storage, handling and transport of materials at site, supply of all accessories, including consumables, fitting, fixing as well as all incidentals necessary to complete this item of work including carrying out the necessary tests, commissioning, etc.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.39	Earth electrode	Per set
	Earthing lead	Linear meter
	Earthing block	Each
	Earth inspection pit	Each

3.40 INSPECTION AND TESTING

3.40.1 General

Every installation shall on completion and before being energized, be inspected and tested in accordance with the requirements of IEE Regulations 611 to 614 of Fifteenth Edition 1981 to verify, as far as practicable, that the requirements of these Regulations have been met.

The methods of test shall be such that no danger to persons and property or damage to equipment can occur even in the case of circuit tested defective.

The cost of the tests shall be deemed included in the rates of the items of installation.

3.40.2 Visual inspection

A visual inspection shall be made to verify that the installed electrical equipment is

- in compliance with the applicable British Standards of IEC or any other Standard mentioned in the specification.
- correctly selected and erected in accordance with these Regulations.
- not visibly damaged so as to impair safety.

Note: Appendix 14 of IEE wiring regulation lists the principal features of an installation to be visually inspected in order to verify compliance with the Regulations.

3.40.2 Testing

General

The following items, where relevant, shall be tested in the sequence indicated whether not mentioned in any part of the specification as installation and Sub-station and in addition to those tests mentioned elsewhere in the specification. Standard methods of testing, in respect to some of the tests are given in Appendix-15 of IEE wiring regulation. The use of other methods is not precluded provided that they give no less effective results.

- Continuity of ring final circuit conductors.
- Continuity of protective conductors including main and supplementary equipotential bonding.
- Earth electrode resistance.
- Insulation resistance.
- Insulation of site-built assemblies.
- Protection by electrical separation.
- Protection by barriers or enclosures provided during erection.

- Insulation of non-conducting floors and walls.
- Polarity.
- Earth fault loop impedance.
- Earth continuity conductor.
- Operation of residual current devices.

In the event of any test indicating failure to comply, that test and those preceding, the results of which may have been influenced by the fault indicated, shall be repeated after the fault has been rectified.

Continuity of ring final circuit conductors

A test shall be made to verify the continuity of all conductors (including the protective conductor) of every ring final circuit.

Continuity of protective conductors

Every protective conductor shall be separately tested to verify that it is electrically sound and correctly connected. This test shall include all conductors and extraneous conductive parts used for equipotential bonding.

Earth electrode resistance

Where it is necessary to measure the resistance of an earth electrode, the test method described in Item-4 of Appendix-15 of IEE regulation 15th edition shall be used.

Earth resistance tests shall be made on the system, separating and reconnecting each earth connection.

The electrical resistance of the earth continuity conductor together with the resistance of the earthing lead measured from the connection with the earth electrode to any other position in the completed installation shall not exceed 1ohm.

Where more than one earthing sets are installed, the earth resistance between two sets shall be measured by means of resistance bridge instrument. The earth resistance between two sets shall not exceed 1ohm.

Insulation resistance

The tests described in regulations 613-6 to 613-8 shall be made before the installation is permanently connected to the supply. For these tests, installations may be divided in to groups of outlets, each containing not less than 50 outlets. For the purpose of this regulation, the term 'Outlet' includes every point and every switch except that a socket outlet, appliance or luminary incorporating a switch is regarded as one outlet. A.D.C. Voltage not less than twice the nominal voltage of the circuit concerned (r.m.s. value for an A.C. supply) shall be applied for the measurement of insulation resistance, provided that the test voltage does not exceed 500 V.D.C. for installations rated up to 500V or 1000 V.D.C. for installations rated above 500V up to 1000V.

- a) When measured with all fuse links in place, all switches (including, if practicable, the main switch) closed and except for TN-C systems, all poles or phases of the wiring electrically connected together, the insulation resistance to Earth shall be not less than 1mega ohm.
- b) When measured between all the conductors connected to any one phase of the pole of the supply and in turn, all conductors connected to each other phase or pole, the insulation resistance shall be not less than 1mega ohm. Wherever practicable, all lamps shall be removed and all current using equipment shall be disconnected and all local switches controlling lamps or other equipment shall be closed so that all parts of the wiring may be tested. Where the removal of lamps and/or the disconnection of current using equipment is impracticable, the local switches controlling such lamps and/or equipment shall be opened. Particular attention shall be given to the presence of electronic devices connected in the installation and such devices shall be isolated so that they are not damaged by the test voltage.

- c) Where equipment is disconnected for the tests prescribed in regulation 613-7 and the equipment has exposed conductive parts required by these regulation to be connected to protective conductors, the insulation resistance between the exposed conductive parts and all live parts of the equipment shall be measured separately and shall comply with the requirements of the appropriate British Standard for the equipment. If there is no appropriate British Standard, the insulation resistance shall be not less than 0.5mega ohm.

Insulation of site-built assemblies

- a) Where protection against direct contact is intended to be afforded by insulation applied to live parts during erection in accordance with the regulation 412-2, it shall be verified that the insulation is capable of withstanding, without breakdown or flash over and applied voltage test equivalent to that specified in the British Standard for similar factory built equipment.
- b) Where protection against indirect contact is provided in supplementary insulation applied to equipment during erection in accordance with the regulations 413-18 to 413-26, it shall be verified by test.

Test the insulating enclosure affords a degree of protection not less than IP2X (see BS 5490) and that the insulating enclosure is capable of withstanding, without breakdown is capable of withstanding, without breakdown or flashover, an applied voltage test equivalent to that specified in the British Standard for similar factory built equipment.

Electrical separation of circuits

Where protection against electric shock is provided by safety extra-low voltage (Regulations 411-2 to 411-10) or by electrical separation (Regulations 413-35 to 413-39) the electrical separation of the separated circuits shall be inspected and/or tested.

Where the source of the separated circuit is other than a safety isolating transformer complying with BS 3535 or a source independent of a higher voltage circuit, it shall be verified that the source provides a degree of safety equivalent to that of a BS 3535 safety isolating transformer, if necessary by performing the applicable tests of insulation resistance and electric strength specified in BS 3535.

It shall also be verified that live parts of the equipment of the separated circuit, other than cables, have a degree of electrical separation from other circuits not less than that between the input and output windings of BS 3535 safety isolating transformer Regulations 411-6 and 413-37 (iv), if necessary by performing the applicable tests of insulation resistance and electric strength specified in BS 3535.

For cables of separated circuits, Regulations 411-7 and 413-37 (iii) of IEE regulation 15th edition shall be followed.

Protection against direct contact by barriers or enclosures provided during erection

Where protection against direct contact is intended to be afforded by barriers or enclosures provided during erection in accordance with Regulations 412-3 to 412-6, it shall be verified by test that the enclosures of barriers afford a degree of protection not less than IP2X or IP4X as appropriate, where those regulations so require.

Insulation of non-conducting floors and walls

Where protection against indirect contact is to be provided by a non-conducting location intended to comply with Regulations 413-27 to 413-31 and 471-19, the resistance of the floors and walls of the location to the main protective conductor of the installation shall be measured at not less than three points on each relevant surface, one of which shall be not less than 1m and not more than 1.2m from any extraneous conductive part in the location. Any insulation or insulating arrangement of extraneous conductive parts, intended to satisfy Regulation 413-31 (a) Item (iii) shall be able to withstand a test voltage of at least 2 KV and shall not pass a leakage current exceeding 1 mA in normal conditions of use.

Polarity

A test of polarity shall be made and it shall be verified that all fuses and single pole control devices are connected in the phase conductor only, that centre contact bayonet and Edison-type screw lamp holders in circuits having an earthed neutral conductor have their outer or screwed contacts connected to that conductor and that wiring has been correctly connected to socket outlets.

Earth fault loop impedance

Where protective measures are used which require knowledge of earth fault loop impedance, the relevant impedance shall be measured, or determined by an equally effective method.

Earth continuity conductor

Earth continuity conductor of the entire earthing network shall be tested to verify the earth continuity.

Operation of residual current operated devices

Where protection against indirect contact is to be provided by a residual current device its effectiveness shall be verified by a test simulating an appropriate fault condition and independent of any test facility incorporated in the device.

Operating tests

Current load measurement shall be made on equipment and on all power and lighting feeders. The current reading shall be taken in each phase wire and in each neutral wire while the circuit or equipment is operating under actual load conditions. Clip-on ammeters may be used to take current readings. All light fittings shall be tested electrically and mechanically to check whether they comply with the standard specifications. Fluorescent light fittings shall be tested, so that when functioning no flickering or choke singing is felt.

3.40.3 Inspection of the installation

On completion of wiring a general inspection shall be carried out by competent personnel in order to verify that the provisions of the Code and that of the Electricity Act of Bangladesh have been complied with. Items to be inspected are detailed in the following sections.

Medium voltage installation

In medium voltage installations, it shall be checked whether:

- ☐ All blocking materials that are used for safe transportation in switchgears, contactors, relays, etc. are removed;
- ☐ All connections to the earthing system are feasible for periodical inspection.
- ☐ Sharp cable bends are avoided and cables are taken in a smooth manner in the trenches or alongside the walls and ceilings using suitable support clamps at regular intervals.
- ☐ Suitable linked switch or circuit breaker or lockable push button is provided near the motors/apparatus for controlling supply to the motor/apparatus in an easily accessible location.
- ☐ Two separate and distinct earth connections are provided for the motor apparatus.
- ☐ Control switch fuse is provided at an accessible height from the ground for controlling supply to overhead travelling crane, hoists, overhead bus bar trunking.
- ☐ The metal rails on which the crane travels are electrically continuous and earthed and bonding of rails and earthing at both ends are done.
- ☐ Four-core cables are used for overhead travelling crane and portable equipment, the fourth core being used for earthing and separate supply for lighting circuit is taken.
- ☐ If flexible metallic hose is used for wiring to motors and other equipment, the wiring is enclosed to the full lengths and the hose secured properly by approved means.
- ☐ The cables are not taken through areas where they are likely to be damaged or chemically affected.

- ☐ The screens and armours of the cables are earthed properly.
- ☐ The belts of belt driven equipment are properly guarded.
- ☐ Adequate precautions are taken to ensure that no live parts are so exposed as to cause danger.
- ☐ Ammeters and voltmeters are tested and
- ☐ The relays are inspected visually by moving covers for deposits of dusts or other foreign matter.

Overhead lines

For overhead lines, it shall be checked whether:

- ☐ All conductors and apparatus including live parts thereof are inaccessible.
- ☐ The types and size of supports are suitable for the overhead lines/conductors used and are in accordance with the approved Drawing and Standards.
- ☐ Clearances from the ground level to the lowest conductor of overhead lines, sag conditions, etc. are in accordance with the relevant Standard.
- ☐ Where overhead lines cross the roads or cross each other or are in proximity with one another, suitable guarding is provided at road crossings and also to protect against possibility of the lines coming in contact with one another.
- ☐ Every guard wire is properly earthed.
- ☐ The type, size and suitability of the guarding arrangement provided is adequate.
- ☐ Stays are provided suitably on the overhead lines as required and are efficiently earthed or provided with suitable stay insulators of suitable voltages.
- ☐ Anti-climbing devices and Danger Board/Caution Board Notices are provided on all HT supports.
- ☐ Clearances along the route are checked and all obstructions such as trees/branches and shrubs are cleared on the route to the required distance on either side.
- ☐ Clearance between the live conductor and the earthed metal parts are adequate and
- ☐ For the service connections tapped off from the overhead lines, cutouts of adequate capacity are provided.

Lighting circuits

The lighting circuits shall be checked to see whether:

- ☐ Wooden boxes and panels are avoided in factories for mounting the lighting boards, switch controls, etc.
- ☐ Neutral links are provided in double pole switch fuses which are used for lighting control, and no fuse is provided in the neutral.
- ☐ The plug points in the lighting circuit are all 3-pin type, the third pin being suitably earthed.
- ☐ Tamper proof interlocked switch socket and plug are used for locations easily accessible.
- ☐ A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipment.
- ☐ Proper connectors and junction boxes are used wherever joints are in conductors or cross over of conductors takes place.
- ☐ Cartridge fuse units are fitted with cartridge fuses only.
- ☐ Clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary.

- ☐ The polarity has been checked and all fuses and single pole switches are connected on the phase conductor only and wiring is correctly connected to socket outlets.
- ☐ Spare knockouts provided in distribution boards and switch fuses are blocked.
- ☐ The ends of the conduits, enclosing the wiring leads, are provided with ebonite or other suitable bushes.
- ☐ The fittings and fixtures used for outdoor use are all of weatherproof construction, and similarly, fixtures, fittings and switch gears used in the hazardous area are of flameproof application.
- ☐ Proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals.
- ☐ Flat ended screws are used for fixing conductor to the accessories.
- ☐ Flat washers backed up by spring washers are used for making end connections.

3.41 CERTIFICATE

Following the inspection and testing required by this Article, a completion certificate shall be given by the Contractor or other person responsible, or by an authorized person acting on his/her behalf, to the Employer. The certificate shall be in the form set out in Appendix-16 of IEE Regulation 15th Edition or in any other suitable form the required by the Employer/Engineer. A sample certificate format on inspection of the installation has been provided at Appendix-A. Any defect or omission revealed by inspections or tests shall be fully corrected complying in its entirety with the Specifications before a Completion Certificate is issued.

3.42 BUS BAR TRUNKING SYSTEM

3.42.1 Bus bar rising main

Description

Low impedance pre-fabricated Bus-way system conforming to following requirements:

HDHC copper Bus bar rising mains completely sleeved and insulated, installed in 16 SWG sheet steel/aluminium fabricated Bus duct adequately insulated.

The Bus bar rising main shall be for 3 phase 4 wire full capacity neutral, 415V rated voltage. Allowable temperature rise of 50oC over ambient temperature of 40oC. The unit shall be complete with all accessories, fittings, etc. to complete the work in all respect including the expansion joints, earthing terminal and continuity, incoming cable entries, supporting clips, expansion units, and end covers, bends, etc. to meet the requirements as shown on the Drawings or as per the direction of the Engineer. Plug in tapping provisions shall be kept at every 600mm or at every floor level.

General

- a. Standard : UL 857, NEMA G8-2 or IEC 439.
- b. Climatic Test : As per the requirements of UL 857, NEMA G8-2 or IEC 439.
- c. Ambient temperature : 40oC.
- d. Degree of protection : IP 42.
- e. Colour : Grey.
- f. Rated insulation voltage : 600V, A.C.
- g. Frequency : 50 Hz
- h. Rated current : 800 A, 225 A.
- i. Short circuit rating (RMS) : 75 KA, 30 KA.
- j. Feature : Single bolt clamping.

- k. Busbar materials : Copper conductors completely sleeved and insulated.

Normal supply Bus-way:

800 A, TPN+E, Plug-in Bus-way including supply of the following:

- ☐ 800 A Switch Board connection unit.
- ☐ 800 A Elbow.
- ☐ 800 A Tee/Cross (as per site requirement)
- ☐ 800 Feed-in (if required)
- ☐ 800 A End Cover
- ☐ Tap off Box (plug-in Bus plug) – 6 Nos. (approximately) consisting of 4 Nos. 100 A TP MCCB and 2 Nos. 60 A TP MCCB.

Emergency supply Bus-way:

225 A, TPN+E, plug-in Bus-way including supply of the following:

- ☐ 225 A Switch Board connection unit.
- ☐ 225 A Elbow
- ☐ 225 A Tee/Cross (as per site requirement)
- ☐ 225 Feed-in (if required)
- ☐ 225 A End Cover
- ☐ Tap off box (plug-in Bus plug) – 6 Nos. (approximately) consisting of 4 Nos. 50/40/30/20 A TP MCCB and 2 Nos. 5 A SP MCB.

It should be noted that the Bus riser must have provisions for expansion to accommodate power supply to at least another found floors in future. Therefore, the Contractor must keep adequate provisions and facilities to expand the system to another required number of floors. A scheme with Shop Drawings for installation of Bus riser showing provisions for future expansion must be submitted for prior approval of the Engineer before installation.

3.42.2 Installation

The Bus bar rising main for normal and emergency supply must be installed in concrete Bus duct including all other necessary accessories. All other consumables required for the complete Work shall also be supplied by the Contractor. The Work shall be complete with all internal wiring and electrical connections. After complete installation of the Bus bar rising main for normal and emergency supply, the Contractor shall carry out necessary tests, trial run and commissioning as per manufacturer's, instructions specifications and directions and to the complete satisfaction of the Engineer.

3.42.3 Measurement

Measurement for payment shall be made per set for complete set of Bus bar rising main for normal and emergency supply, supplied, installed, tested and commissioned to the satisfaction of the Engineer.

3.42.4 Payment

The quantity of completed and accepted work measured as provided above shall be paid for at the Contract unit rate per set of Bus bar rising main which payment shall constitute full compensation for furnishing all labour, tools, equipments, materials, including supply of all accessories, consumables including transportation, handling and storage of all materials and equipment at the work site as well as all incidentals to complete the Work in all respect including testing, trial run and commissioning etc.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.42	Bus bar trunking system	Per set

3.43 WATER PUMPS AND MOTORS

3.43.1 Pump-motor set

3.43.1.1 Introduction

Types of pumps

Pumps are broadly divided into three main types: Reciprocating, Rotary and Centrifugal. In the reciprocating type a piston (or plunger) alternatively draws water into the cylinder on the intake stroke and then forces it out on the discharge stroke. Reciprocating pumps are used for the highest pressure and the smallest quantities.

In the rotary type two rotating pistons or gears mesh together and draw water into the chamber and force it practically continuously into the discharging pipe. Rotary pumps are used for small quantities and medium pressures.

The centrifugal pump has an impeller with radial vanes rotating swiftly to draw water into the center of the pump and discharge it by centrifugal force. Centrifugal pumps are used for almost all quantities and pressures.

For the purpose of this Specification, the centrifugal type of pump be only discussed.

Centrifugal pumps

A centrifugal pump consists of a rotating impeller or runner (which has a number of spiral vanes) keyed on to a central shaft which is driven by a power unit housed in a circular casing; water is admitted at the centre and discharged at the periphery. It utilizes the centrifugal force imparted to the water by the rapidly rotating runner. The impeller rotates rapidly sucking in water at the centre of the runner (or eye) through suction pipe, and which is whirled out and discharged at its outer periphery by centrifugal force. By passing the water in stages successively through a series of impellers any desired lift can be obtained.

A single-stage pump is one in which the total head is developed by one impeller. A multi-stage pump has two or more impellers acting in series in one casing and on one shaft in order to generate a greater head than can be obtained from a single-stage pump. The shaft may be vertical or horizontal and the pumps are correspondingly known as vertical or horizontal pumps. Horizontal pumps are cheaper, easily maintainable and are more popular.

A centrifugal pump is relatively low in initial cost and also maintenance, compact, simple in construction and simple to operate, light in weight, occupies small floor space for its foundation and is very dependable and durable. It starts quickly and is suitable for both electric and steam turbine drive. The rotor may be driven by belt directly coupled to an electric motor. A centrifugal pump is capable of delivering large quantity of water as compared to its size and can handle sandy, gritty and muddy waters without injuring the pump. The clearance between the impeller and the casing are varied to suit the conditions for which the pump is to be made. For clear water pumping the clearances are kept as fine as possible as that gives maximum efficiency.

In a centrifugal pump the volume of water that can be handled or pumped and the head or pressure developed depends upon the speed of the impeller and the width of the blades and the clearance between the blades and the casing. The horse-power absorbed is proportional to the cube of the speed. High lifts can be obtained with small pumps running at high speeds or with large pumps running at slower speeds. A centrifugal pump works at a maximum efficiency if the head does not fluctuate. These pumps have efficiencies of 55 to 85%, the large pumps being more efficient. Single-stage centrifugal pumps are used for largest quantities against low and medium heads. For high heads and relatively small volumes, either high speed or multi-stage pumps have been used. Multistage pumps are much used in deep wells where the impeller diameter must necessarily be small for submerged operations.

Ordinary single-stage centrifugal pumps have lifts limited to 18m, depending on the speed of the motor (but generally 12m in estimated). Multi-stage pumps are used for high lifts, usually the head is increased 30m-45m per stage. Special design single-stage pumps can be had for about 36m lift. Placing appropriate number of stages side by side in the pump casing, they can be made for lifts even up to 300m.

A foot valve is fixed at the foot of the suction pipe. It is a one way check valve, its function being to admit water into the suction pipe but prevents it flowing back. Where the pump has been out of operation for long periods, it may not work for air that have accumulated in the pump, casing; in that case all the air-cocks be opened and the pump be primed with water. Where the pump is placed below water level, no priming is required and no foot-valve needs to be fixed. A self-priming pump is advantageous since the foot-valve can be dispensed with.

While selecting a centrifugal pump, the head against which it has to operate (total pumping head-suction lift, discharge head etc.) and the discharge required must be accurately determined and also possible variations in head due to variations in the water level of the supply and variation in pressure in the discharge pipe system. Pumps are generally selected by standard sizes, brake horse-power and speed. The size of a centrifugal pump is specified by the diameter of the discharge pipe.

Points to be Observed when Starting a Centrifugal Pump

A centrifugal pump should not be run dry but must be 'primed' i.e., filled with water, before it is started or the impeller will merely rotate in the air without drawing in any water. For priming, the delivery sluice valve is opened slightly and also the air-cock which is kept open until all the air has been expelled and the water has started flowing freely when both the air-cock and the delivery sluice valve are closed. Self-priming pumps with automatic priming devices are now available.

Submersible Pumps (Bore-hole or Deep Well Turbine Pumps)

The submersible pump is a compact sealed-in unit which is lowered into a bored tube-well casing pipe while the motor is located at ground level and drives a vertical shaft extending down to the pump. This pump is often used for Drawing water from drilled wells in which the water level is at a considerable depth below the ground. Deep-well pumps are generally multi-stage centrifugal turbine pumps having two or more impellers of relatively small diameter with discharge column extending to the top of the well and suction piping can be eliminated. These pumps are made for diameters as small as 100mm, although 150mm is the recommended minimum, upto 330mm and the usual length of the pump is 200mm to 600mm. Bore-hole pumps are electrically driven and are quick starting, require no priming, have high efficiencies, produce large volume of water from a small well than any other type and are very popular in modern well installations. The cost of installation and running of a bore-hole pump is higher than an ordinary pumps; is not suitable for shallow depths of water as the pump requires adequate submergence.

3.43.1.2 Scope

All component parts of the Work shall, unless otherwise specified, comply with the provisions of this Specification herein or be subjected to the approval of the Engineer.

Complete pump set shall be supplied and installed by the Contractor.

3.43.1.3 Standard to be used

The pumping unit shall comply with the latest provision of B.S. ISO or equivalent Standard as approved by the Engineer.

The manufacturer shall comply with ISO 9001 or equivalent Standard for the design and manufacturing process.

3.43.1.4 Materials of pumping unit

The materials for the pumping unit shall be as follows:

Pump and motor body	-	Cast iron
Pump/motor shaft, bearing sleeve	-	Stainless steel

Impeller	-	Stainless steel
Casing wearing ring, bearing bush	-	Bronze

3.43.1.5 Marking of pumping unit

The following information shall be engraved or embossed on a bronze or Type 316 stainless steel plate, which is to be permanently attached to the pump body:

- ☐ Manufacturer's name;
- ☐ Date of manufacture;
- ☐ Pump type, serial number;
- ☐ Suction and discharge pipe diameter;
- ☐ Discharge and head; and
- ☐ Motor data: operating voltage, rated current, frequency, power factor and rpm.

3.43.1.6 Data and specifications

Detailed specifications and data for the pumping equipment, power drive assembly, parts, devices and accessories forming a part of the equipment shall be submitted, covering performance and materials for construction. Data and specifications for the equipment shall include the following:

- i. Pump curves indicating total dynamic head, flow rate, brake horsepower, impeller eye velocity, shutoff head, net positive suction head, and efficiency.
- ii. Motor data which inter-alia include the manufacturer; the minimum guaranteed efficiency and power factor at full load, $\frac{3}{4}$ load, and $\frac{1}{2}$ load; locked motor current in amps; full load current in amps; the motor speed in rpm; and mounting details.

All pumping equipment furnished under this section shall be (i) of a design and manufacture that has been used in similar applications and (ii) be demonstrated to the satisfaction of the Engineer that the quality is equal to the equipment made by those manufacturers' specifications, if named herein.

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration. The pumps shall not load the motors within the limits of stable pump operation as recommended by the manufacturer. To insure vibration free operation, all rotational components of each pumping unit shall be statically and dynamically balanced.

Excessive vibration shall be the cause sufficient for rejection of the equipment. In any case, the amplitude of vibration, measured at any point on the pumping unit, shall not exceed limits set for in the latest edition of the Hydraulic Institute Standards. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection and operation.

The completed units, when assembled and operated, shall be free of cavitation, vibration, noise and oil or water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty. It shall be the sole responsibilities of the Contractor for proper operation of the complete pumping system, which includes pump and motor.

Strength

Castings, fabrications, machined parts and drives shall conform to the industry standards for strength and durability and shall be rated for continuous duty over the entire operating range.

Bearings

Bearings shall be of the antifriction type designed for 20000 hours B-10 life per NFBMA test procedures.

Cast Iron

All cast iron used in pump construction shall be closed grained grey cast iron conforming to the requirements of ASTM designation A 48.

Fabrications

Fabrications shall conform to the requirements of ASTM designation A 36 for fabricated steel.

Flanges

Pump suction and discharge nozzles shall be provided with BS 4504 Table 'E' flanges.

Guards

Guards shall be provided at all exposed couplings, drives and shafts.

Gauges

Each and every pump shall be provided with discharge pressure gauge.

Nameplates

The pump shall have a bronze or type 316 stainless steel plate permanently attached to the pump frame into which the following information shall be impressed, engraved or embossed: Manufacturer's name, pump size, serial number, manufacturing date, impeller, capacity, head rating and speed.

3.43.1.7 Catalogue and O&M Manual

A set of catalogues and operation and maintenance manuals, for each of the pumping units, shall be supplied by the Contractor with details of the pump, motor and accessories. Pump characteristic curves, showing discharge versus head, BHP, efficiency, NPSH, etc. shall be submitted for each pump set installed.

Five copies of the operation and maintenance manual shall be submitted at the time of delivery of Materials.

The catalogues and manuals shall be printed in the English language or accompanied by an English translation.

All pumping units shall be supplied complete, as indicated on the Drawings, listed in the Schedule of Works and specified herein, including pumps, bases, motors, anchor bolts, controls, and necessary appurtenances.

3.43.1.8 Pump details, construction requirements and operational procedures

The pump shall be vertical discharge centrifugal type complete with electrically driven motor and starter. The pump shall be highly volute type with flange discharge branch. The suction cover shall be supplied with flange pipe connection. The pump shall have integrated self priming system.

Impellers shall be of the enclosed type, perfectly balanced and securely fitted to the pump shaft in such a manner that the impellers can be easily removed without damage to the pump.

The impeller shall be of highly efficient shrouded single suction type fitted with scaling collars back and front. The impeller shall be statically balanced to ensure smooth operation. Stuffing box shall be packed with high quality gland packing and incorporate a wear resistant pressure reducing bush.

Impellers shall be manufactured from stainless steel, smoothly finished on all surfaces and secured to the shaft by a taper bush or other locking device of corrosion resistant material.

The shaft shall be constructed of high quality stainless steel alloy and shall have sufficient strength so as not to vibrate at any speed within the operating range of the pump.

Bearing shall consist of two heavy duty ball bearing, firmly located within strong metal frame and effectively sealed against ingress of dust or moisture. All bearings shall be lubricated by the pumped media and where rubber type bearings are used, the bearing material shall be securely bonded to a metal housing and positively locked to prevent the possibility of the bearing rotating in its housing.

All pump components shall be readily dismantled for routine maintenance purposes. Fixing bolts, nuts and washers shall be manufactured from stainless steel.

The pump shaft, impellers and bowl elements shall be fitted with replacement sleeves or wear rings.

The opening of the suction casing, located between the pump and motor, shall be of the proper size and shape to avoid any eddy current formation. The suction casing shall be fixed with a strainer having suitable thickness to avoid entry of foreign material.

A non-return valve, of appropriate size, shall be fitted to the pump discharge. The valve shall have flanges complying with BS 4504 to facilitate connection of the pump to the riser pipe side.

All rotating components of the pump shall be statically and dynamically balanced at high speed with each part identified and marked to ensure re-assembly after maintenance.

The pump shall have a non-loading performance characteristic and its efficiency shall be highest at the duty point and remain at a reasonable high level over the whole duty range.

A suction inlet strainer of minimum area of 4 times the eye of the impeller shall be fitted, manufactured from Grade 304 stainless steel.

The total pumping head shall not be less than 50m.

The pump body, manufactured from cast iron to BS 1452, Grade 14 or better, shall have separate sections for each stage, the matching faces machined and spigotted to allow for accurate location and alignment. The motor body should be painted with anti-corrosive paint.

Unless otherwise specified, Grade 304 stainless steel shroud shall be supplied with each pump to ensure an adequate flow of cooling water over the motor surface.

Where the length and weight of the pump set do not permit manual handling, the pump motor shall be packed separately.

The pumps sets shall be complete with pump motor, starter discharge and suction companion flanges, rigid steel base plate, holding bolts, heavy guards, vibration isolator etc. and complete maintenance tool kit.

Automatic controller shall be suitable to operate pump automatically when predetermined water level of roof water reservoir dropped down, the water supply pump in sequence shall start and pump panel shall indicate empty signal of overhead tank. Pump shall continue to pump water from basement reservoir to overhead tank until water level crosses the predetermined upper level. Pump remains stop until water level crosses the lower level in overhead tank. To avoid dry operation of pump, controls shall be provided not to operate pump when underground water reservoir is empty and panel will provide a continuous audio-visual signal until it is resettled.

The pump shall be suitable for operating on 3 phase 415 V, 50 Hz, supply.

The pump shall be installed on R.C.C foundation constructed by the Contractor. Foundation bolt shall be of minimum 19mm diameter M.S. rod. Inlet and outlet pipe connection work shall be done by the Contractor with the specified type of joints. Electrical connections and control wiring shall be done in accordance with the Drawings or as directed by the Engineer.

Discharge Assembly

The discharge assembly shall comprise a GI short pipe section, steel riser pipes and a MS base plate.

The GI short pipe section shall not be less than 300mm in length, with a minimum of 7mm wall thickness and single flanged with one end threaded. The threaded end shall be for connection with the female end of the pump discharge pipe and the flanged end for connection with the riser pipe. The diameter of the short pipe section shall be as per field requirements for a 125mm nominal bore and 30 Horse Power pump discharge rating.

The riser pipe shall be flanged seamless steel of 125mm diameter in 3m length and with a minimum wall thickness of 4.8mm and shall be supplied with rubber gaskets and all requisite nuts and bolts.

The MS base plate shall be of not less than 10mm thickness and shall be assembled into two sections with a customized screw capped 50mm diameter x 1500mm length GI observation/measurement vent welded into place on the upper face of the base plate.

3.43.2 Measurements

Measurement for payment shall be made per set upon complete pump-motor set installation, testing and commissioning as per specifications, Drawings and direction and acceptance of the Engineer. The Contractor shall bear the full responsibilities for all supplied materials and equipment.

3.43.3 Payment

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit price per set which payment shall constitute all skilled and unskilled men, materials, all consumables, and providing all incidentals which ever needed for the successful installation and commissioning of the pump-motor set and where applicable including the connecting suction line to the ground water reservoir and the discharge line to the supply riser pipe with suction and delivery conventional pump fittings, including storage, handling and transport of all materials, etc. necessary to complete this item of work including all installation tests and commissioning of the pump- motor set.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.43	Water pump and motors	Per set

3.44 ELECTRICAL CABLE, CONTROL WIRING

3.44.1 Scope of work

Supplying, fitting and fixing of all electrical cables, control wiring etc. complete with M.S. conduit ECC pull box, junction box etc. for providing electrical power to pump from pump panel and all control cables required for pump interlocking, sensor on over-head and under-ground reservoir shall be under this item.

3.44.2 Construction requirements

Power cable from panel to pump motor shall be as per Eastern Cable or equivalent which shall meet the requirements stated under the Sub-section on 'Cable Work' of this Specification. All control cables shall be 1 C 1.5mm² NYY. M.S. conduit of approved size shall be used which shall also meet the requirements stated under the Sub-section on 'Pipe Work' of this Specification.

M.S. conduit shall be complete with bends, tees, sockets, junction box, pull box, etc. as per direction and recommendation. Conduit shall be properly clamped to wall or floor or hanged from roof by using 6mm² U-bolt or approved type of fixing devices at an interval not more than 3m.

3.44.3 Measurement

Provisions for electrical cable, control wiring shall not be measured.

3.44.4 Payment

The payment shall be made on lump sum basis upon completion of the whole work as described in the Schedule of Works and as accepted by the Engineer, which among others shall constitute the full compensation for installation work and energizing the system.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.44	Electrical cable, control wiring	Lump Sum

APPENDIX-A : COMPLETION CERTIFICATE FORM

I/we certify that the installation detailed below has been installed by me/us and tested and that to the best of my/our knowledge and belief, it complies with the requirements of Bangladesh National Building Code and the Electricity Act of Bangladesh (as modified up to 1987).

Electrical Installation at _____ Voltage and system of supply _____

Particulars of Works:

- a) Internal Electrical Installation
- | No. | Total load | Type or system of wiring |
|-----------------|------------|--------------------------|
| i) Light point | | |
| ii) Fan point | | |
| iii) Plug point | | |
| 3-pin 5 A | | |
| 3-pin 15 A | | |
- b) Others
- | Description | hp/kW | Type of starting |
|-----------------|-------|------------------|
| 1) Motors | | |
| i) | | |
| ii) | | |
| iii) | | |
| 2) Other plants | | |
- c) If the work involves installations of over head line and/or underground cable
- 1) i) Type and description of over head line
 - ii) Total length and number of spans
 - iii) Number of street lights and its description
 - 2) i) Total length and size of underground cable
 - ii) Number of joints
 - End joint
 - Tee joint
 - Straight through joint
- d) Earthing
- i) Description of earthing electrode
 - ii) Number of earth electrodes
 - iii) Size of main earth lead

Test Results:

- a) Insulation Resistance
- i) Insulation resistance of the whole system of conductors to earth _____ mega ohms
 - ii) Insulation resistance between the phase conductor and neutral
 - Between phase R and neutral _____ mega ohms
 - Between phase Y and neutral _____ mega ohms
 - Between phase B and neutral _____ mega ohms

iii) Insulation resistance between the phase conductors in case of polyphase supply.

Between phase R and phase Y _____ mega ohms
 Between phase Y and phase B _____ mega ohms
 Between phase B and phase R _____ mega ohms

b) Polarity test
 Polarity of nonlinked single pole branch switches

c) Earth continuity test
 Maximum resistance between any point in the earth continuity conductor including metal conduits and main earthing lead _____ ohms.

d) Earth electrode resistant

Resistance of each earth electrode

i) _____ ohms
 ii) _____ ohms
 iii) _____ ohms
 iv) _____ ohms

e) Lightning protective system

Resistance of the whole of lightning protective system to earth before any bonding is effected with earth electrode and metal in/on the structure _____ ohms.

 Signature of Supervisor

 Signature of Contractor

Name and Address _____

Name and Address _____

MISCELLANEOUS:

3.45 LIME TERRACING

3.45.1 Lime Terracing

3.45.1.1 Description

This item of work shall consist of placing a waterproofing and drainage course on roof slabs by providing lime concrete of specified thickness and proportion in accordance with the requirements as shown on the Drawings, as stated in the BOQ and these Specifications or and as directed by the Engineer.

3.45.1.2 Materials

Lime

Lime to be used for lime terracing shall be slaked lime and shall conform to the requirements of ASTM C 5 and ASTM C 207.

Lime shall not contain more than 5% of impurities. It shall dissolve in soft water when water is added in sufficient quantity. Stone lime available in Sylhet, meeting the above requirements, may be used.

A good hydraulic lime shall have an ultimate tensile strength of at least 7kg/cm² for a mortar prepared with 1 part of lime and 3 parts of sand. A pure surki mortar gives a breaking strength of about 5.6 to 6.3 kg/cm² when left in dry air and 21 to 25 kg/cm² when left immersed under water.

Surki

Surki shall be made only by grinding 1st class well-burnt (but not vitrified) bricks or brickbats. Surki shall not be made from under-burnt or over-burnt bricks nor bricks containing high proportion of sand. Surki shall be perfectly clean and free from dust, sand or any other particles and shall be ground to such a fineness as would pass through 3.35mm sieve with at least 50% of it passing through 1.7mm sieve.

Brick chips

Brick chips (khoa) shall consist of 20mm down-graded angular fragments of broken or crushed well burnt (but not vitrified) 1st class bricks. Porous brick chips or showing signs of salt petre shall not be used for lime terracing.

Water

Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other substances that may be deleterious and shall not contain any visibly solid material. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. All other requirements shall be similar to what have been stated under the relevant Sub-sections of the Sections on 'Concrete Work' and 'Building Materials' of this Specification.

3.45.1.3 Construction methods

Mixing

The approximate proportion of the mixture shall be 2 parts lime to 2 parts surki to 7 parts brick chips, all having specifications as stated above and as stated under the relevant Sub-sections of the Section on 'Building Materials' of this Specification.

The mixing shall be done on a clean platform. The lime and surki, in specified quantities, shall be first mixed dry till it takes a uniform colour. The mixture then shall be laid on the top of stack of specified quantity of previously wetted brick chips. The whole shall be turned over once without adding water and twice by gradually adding small quantities of water for tempering itself for 24 hours. The mix shall then be allowed to age for at least 7 days. During this period the mixture shall be turned by spading twice a day by adding further lime water to prevent drying up. The lime water shall be prepared with 1

part lime and 10 parts water. The process shall be repeated throughout the period of aging until the mix attains the desirable consistency.

The mixing shall be done invariably on the ground on a brick platform at the designated place.

The mixing shall not be allowed on the roof deck whatever may the case arises.

Installation

The roof slab, on which the mixture will be laid, shall be cleaned and washed accompanied by scrubbing, if necessary. The prepared mixture shall then be laid evenly on the cleaned roof slab to proper slope and grade in thickness 25mm more than the required compacted thickness as shown on the Drawings, as required by the Bill of Quantities or as directed by the Engineer.

Beating of the laid mixture shall then be undertaken which shall be done by two rows of workers sitting in rows that will traverse the length of the roof backward and forward beating with wooden mallets. Beating shall continue until the mixture has almost set and the mallets rebound from the surface. Beating shall usually be continued for 5 or 6 days. Before beating starts, a lime slurry shall be sprinkled on the top and allowed to soak well. The lime slurry shall be continually sprinkled on the concrete to keep it wet while being beaten. The surface shall never be allowed to dry. The mortar, which comes to the surface during the beating is to be rendered smooth and finished off with a cement grout prepared with 1 part lime and 2 parts surki, but no plaster shall be given to the surface.

The work shall be cured for 3 weeks by covering with a 50mm layer of moist earth mixed with 3% straw or hay. This layer shall be moistened from time to time as required. On expiry of the curing period, the layer of earth shall be removed and the entire roof area shall be swept clean.

Good care shall be taken not to clog roof drains.

Where lime concrete roofing cannot be placed all in one day, each day's work shall be terminated on a straight line with 1:2 slope. Joining of new work to previous day's work shall be accomplished by applying a bonding paste of lime-surki mortar to the slope before placing the new lime concrete. The composition of the lime-surki mortar shall be 1 part of lime and 1 part of surki mixed with requisite quantity of water.

Turn-up along parapet shall be provided as per the requirements of the Drawings and finished in a manner similar to roof.

3.45.2 Measurement

Measurement for payment shall be made in cubic meter of volume actually built by computing the actual area multiplied by the average thickness of the lime concrete installed in position as per specifications of this item and as shown on the Drawings and accepted by the Engineer.

3.45.3 Payment

The amount of completed and accepted work as measured above shall be paid for at the Contract unit price per cubic meter. The payment shall constitute the full compensation for furnishing all materials, equipment and labour including storage, handling, transport, slaking of lime, making platform, mixing, laying and consolidating of lime concrete and all incidentals necessary to complete the Work as per specifications and requirements described under this Sub-section the Bill of Quantities, as shown on the Drawings and as directed by the Engineer.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.45	Finished lime terracing on the roof slab	Cubic meter

3.46 TWIN PIT WATER-SEAL LATRINE

3.46.1 Scope

This item of work shall consist of construction of Twin Pit Water-seal Latrine in accordance with the details as shown on the Drawing, as per the BOQ and these Specifications or as directed by the Engineer.

3.46.2 Components and Construction Methods

The Twin Pit Water-seal Latrine shall consist of (i) a squatting pan with a steep bottom slope (25o to 30o to the horizontal) and a 20mm water seal 'P' shape trap of 70mm diameter with foot rest, set in a cement concrete floor or with pre-cast concrete slab (ii) two leach pits and (iii) a 'Y'-junction for directing excreta from squatting pan to either of the two leach pits.

Squatting pan

Details of the squatting pan and trap shall be as per the Drawing details. The horizontal length of the pan should be at least 425mm. The pan can be of ceramic, fibre-glass reinforced plastic (GRP), PVC, mosaic or cement concrete. Ceramic or GRP pans have many advantages over the concrete ones. They are smooth, require less water for flushing and are more aesthetic. A GRP pan is cheaper, lighter and easier to transport than a ceramic one. The concrete pans are heavy, difficult to transport and get roughened and unattractive after use due to the action of uric acid, but initially they are less expensive fibre-glass pans are most commonly used.

Trap

P-shaped trap fixed in the floor of the lavatory should be as shown on the Drawing. It should be of 70mm diameter with a 20mm water seal. Ceramic, GRP or PVC traps are smooth and need less water for flushing than concrete ones, but initially cost more.

The trap should be connected to the pits either by a pipe or a covered drain. If a pipe is used, a junction chamber called Y-junction, which is octagonal in shape, should be provided at the junction point.

Y-junction

Y-junction is an important element of a Twin Pit System. It may be a pre-cast in mortar or concrete or fabricated on Site with Brick Masonry. In case of LGED's programmes, the Brick Masonry is commonly considered. The Y-junction is octagonal in shape with each arm of 150mm in length with 125mm brick work and cement mortar of proportion 1 part cement and 4 parts sand of specified F.M (minimum FM 1.2). The depth of the junction is 375mm. It is covered with a top slab made with R.C.C. The R.C.C consisting of a cement concrete mixture prepared with 1 part cement, 2 parts sand of specified F.M (minimum FM 1.8) and 4 parts brick chips (12mm down graded) with reinforcement comprising 10 BWG wire at 125mm center to center both ways. The floor of the junction chamber is constructed with 75mm thick cement concrete made with a mixture having a proportion 1 part cement, 3 parts sand of a specified F.M (minimum FM 1.8) and 6 parts brick chips (12mm down graded) over a layer of Brick Flat Soling. The inside walls are covered with 12mm thick cement plaster prepared with cement mortar 1 part cement and 2 parts sand of specified F.M (minimum FM 1.2) including neat cement finishing. The chamber is provided with one inlet and two outlet holes. Soil pipe from the pan enters the Y-junction at the inlet and connects the two pits through the outlets. There are two slots to block or open the pipes to the pits. The stopper is used to stop or start the operation of the pits alternately.

Material specifications, construction methods and procedures etc. for Brick Masonry work, Cement Concrete work and R.C.C shall conform to the requirements stated under the relevant Sections/Sub-sections of the 'Standard Specifications for Building and Allied Works' used by the LGED.

Leach pits

Shape of leach pits may be circular, square, rectangular or even triangular depending on the shape and size of the Site. For easy emptying and possibility of ground water pollution, it is desirable that the pits be shallow in depth. In most areas in Bangladesh pits should not exceed 1.8m. The inlet in to the

pit should be at least 0.5m above the highest ground water level. In low lying or flood prone areas, the pits should be constructed on elevated earthen mounds with at least 1.5m earth covering all around the pits.

Pits may be lined with burnt clay, concrete or asbestos rings, Brick Masonry, or even bamboo. Honeycomb brick with 25mm horizontal open brick joints should be provided about 0.6m below the top of the pit. RCC ring lining below 60cm from the top should be perforated with small holes 15cm on centers both ways. R.C.C ring shall be made with 25mm thick lining and may have proportion, like 1:4:8, 1:3:6 or 1:2.5:5 for ring diameters from 75cm to 100cm.

Bottom of pits should, as far as possible, remain undisturbed and unsealed.

Clear distance between the two pits shall be, at least, equal to the effective depth of pits. Effective depth is measured from the inlet pipe to the bottom of the pit. Where two pits are combined into one or the pits have to be placed closer than the minimum distance, a non-permeable barrier between the pits should be provided.

Safe distance between pits and a tube well shall be minimum 3m, preferably more than 4.5m in case of alluvial soil or soils finer than fine sand.

In alluvial soil or soils finer than fine sand, tube-wells can be located at a distance of 3m from leach pit and dug/open wells at a distance of 10m. In case of coarse grained soils (sand), a fine sand envelope of 0.5m with may be provided all around the pits.

Permeability of surrounding soil is important for function of the pit latrines. Sandy or silty soil is considered ideal. For pits in compacted clayey soil of low permeability, such as in the Barind Tract, a sand envelope of at least 0.3m shall be provided around the pits.

Material specifications, construction methods and procedures etc. for Brick Masonry work, Cement Concrete work and R.C.C shall conform to the requirements stated under the relevant Sections/Sub-sections of the 'Standard Specifications for Building and Allied Works' used by the LGED.

3.46.3 Measurement

1. Measurement of payment for the volume of excavation and back fill for the Y-junction and the pits shall be made in cubic meters of excavated material in accordance with the dimensions as shown on the Drawing or as stated in the BOQ.
2. Measurement of payment shall be made for the actual number of Squatting Pan of specified size installed including P-trap with all fittings, taken as complete unit and accepted by the Engineer.
3. Measurement of payment for Y-junction shall be made for the numbers actually constructed in accordance with the specifications as shown on the Drawings and the BOQ and these Specifications and accepted by the Engineer.
4. Measurement of payment for R.C.C rings actually supplied, fitted and fixed in accordance with the dimensions and specifications as shown on the Drawings and the BOQ and these Specifications and accepted by the Engineer.

3.46.4 Payment

1. The amount of completed and accepted work measured as provided above under Item No. 1 shall be paid at the Contract unit price per cubic meter which payment shall constitute full compensation for all excavation and back-filling for the pit and the Y-junction including supply of all equipment, labour, tools, as well as all incidentals necessary to complete the Work.
2. The amount of completed and accepted work measured as provided above under Item No. 2 shall be paid at the Contract unit price per number of Squatting Pan including the trap which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of all materials, placing, fixing of pan and the trap including all fittings as well as all incidentals necessary to complete the Work.
3. The amount of completed and accepted work measured as provided above under Item No. 3 shall be paid at the Contract unit price per number of Y-junction which payment shall

constitute full compensation for brick work, cement concrete work, R.C.C work, brick flat soling, cement plaster with neat cement finishing, inlet and outlet pipes with stoppers which will involve furnishing all materials including storage, handling and transport of materials at Site, racking out joints for the brick work, curing of all brick masonry cement concrete and R.C.C works, all tools and equipment, all labours as well as all incidentals necessary to complete the Work.

4. The amount of completed and accepted work measured as provided above under Item No. 4 shall be paid at the Contract unit price per number of the R.C.C ring which payment shall constitute full compensation for furnishing all materials, equipment and labour including storage, handling and transport of all materials, placing and fixing the rings as well as all incidentals necessary to complete the Work.

Pay Items shall be:

Clause	Description	Unit of Measurement
3.46	Excavation and back-filling	Per cubic meter
	Supplying fitting, fixing of Squatting Pan	Each
	Construction of Y-junction	Each
	Supplying, fitting and fixing of R.C.C rings	Each

3.47 BRICK ON END ENDING

3.47.1 Description

This work consists of provided and placing brick on end edging along the road adjacent to the side of the pavement of single layer brick flat soling and herringbone bond brick or of water bound macadam and bitumen carpet.

3.47.2 Materials

The materials shall consist of First Class or Picked Jhama Bricks which should meet the requirements given below.

(a) Bricks

First Class Bricks shall be made from good brick earth free from saline deposits, and shall be sand moulded. They shall be thoroughly burnt by coal without being vitrified, of uniform and good colour, shall be regular and uniform in size, shape and texture with sharp square edges and parallel faces. They must be homogeneous in texture and emit a clear metallic ringing sound when struck one against the other. They shall be free from flaws, cracks, chips, stones, modules of lime or canker and other blemishes. A first Class Brick shall not absorb more than 16% of its weight of water after being soaked for one hour, and shall show no sign of efflorescence on drying.

Picked Jhama bricks are those which are so over burnt as to become vitrified. Those bricks may be broken and used for aggregate in road works provided the vitrified mass has not become porous or spongy as a result of over burning and the aggregate satisfies the requirements of those Specifications.

First Class Bricks should have the following dimensions after burning: 250mm x 120mm x 70mm. Picked Jhama Bricks may have dimensions slightly below those for other brick but not less than 235mm x 110mm x 70mm. The unit weight of First Class Bricks shall not be less than 1100 kg per m³ and the unit weight of picked Jhama Bricks shall not be less than 1200 kg per m³.

The crushing strength of bricks shall be tested in accordance with ST 7.9. The average crushing strength of Bricks shall not be less than 17 N/mm²

3.47.3 Construction methods

Bricks shall be laid on end edging with their longest side vertical and 125mm side across the road including necessary excavation filling and ramming to the satisfaction of the Engineer. The completed work shall be true to line and level and grade as indicated on the Drawings. Interstices between brick edging and adjacent paving or soling shall be filled by brushing in sand until voids are filled; the edging shall be sprinkled then with water.

3.47.4 Measurement

This item shall be measured in linear metres of completed brick on end edging.

3.47.5 Payment

This work shall be measured as provided above and shall be paid for at the Contract unit price per unit of measurement. The prices and payment shall be full compensation for preparation of the edging including excavation, furnishing and placing of materials, backfilling, ranging including provision of labour, equipment, tools and incidentals necessary to complete the works as specified in this Section.

Pay item shall be:

Clause	Description	Unit of Measurement
3.47	Brick on end edging	Linear metre

3.48 SINGLE LAYER BRICK FLAT SOLING**3.48.1 Description**

This item consists of providing single layer brick flat soling on the subgrade or improved subgrade as directed by the Engineer.

3.48.2 Materials

The materials shall consist of First Class or Picked Jhama Bricks which meet the requirements of Article 3.3.2a of these Specifications.

3.48.3 Construction methods

The bricks shall be laid flat in one layer or as specified on the consolidated and prepared surface. Bricks shall be laid in a regular and uniform manner. Interstices of bricks shall be filled with sand of FM 0.8 and water shall be applied by sprinkling. No bricks shall be laid on a foundation or any surface until the same has been inspected and approved by the Engineer. The gaps between two adjacent bricks should not exceed 10mm. The pattern and placing of the bricks shall be as indicated in the drawings.

3.48.4 Measurement

Brick flat soling shall be measured in square metres for areas covered by the same.

3.48.5 Payment

This item of work shall be measured as provided above and shall be paid at the Contract unit price. The price and payment shall include all costs for completion of the work and supply of all required materials, including cost of all labour, equipment, tools and incidentals necessary to complete the works' as specified in this section.

Pay item shall be:

Clause	Description	Unit of Measurement
3.48	Single layer brick flat soling	Square metre

3.49 HERRINGBONE BOND BRICK PAVEMENT

3.49.1 Description

This work shall consist of a base composed of bricks, laid on edge in a herringbone pattern, placed on a prepared single layer brick flat soling in accordance with these Specifications and to the lines, grades levels, dimensions and cross sections shown in the Drawings and as required by the Engineer.

3.49.2 Materials

The materials shall consist of First Class or Picked Jhama Bricks which meet the requirements of Article 3.3.2a of these specifications.

3.49.3 Construction methods

3.49.3.1 Laying the bricks

A sand cushion of 25mm thickness (minimum) with sand of F.M. not less than 0.8 would be placed over the brick flat soling. The brick then shall be laid on edge with 125mm across the surface in a single layer in a herringbone pattern to the lines, grades, levels, dimensions and cross section shown on the Drawings and as required by the Engineer. The edge of the layer shall be made with cut bricks to produce a line which is compatible with brick edging. The joints shall be filled with sand of FM 0.8 brushed in and the completed layer shall be sprinkled liberally with water.

3.49.3.2 Surface tolerance

In those areas in which pavement are to be placed, any deviation in excess of five millimeters from the specified surface within 3 metre shall be corrected by removal, reshaping and relaying.

3.49.3.3 Measurement

This item shall be measured in square metres of material in place and accepted.

3.49.3.4 Payment

The work measured as provided above shall be paid for at the Contract unit price per square metre. The price and payment shall include all costs for completion of the work including all materials, labour and equipment necessary to complete the work prescribed under this section.

Pay item shall be:

Clause	Description	Unit of Measurement
3.49	Brick pavement (HBB only) excluding soling and edging	Square metre

3.50 GRASSING/TURFING

3.50.1 Description

This work shall consist of supplying turf and sods as required and planting them to give a healthy, stable covering of grass over all embankment slopes and earth shoulders which will maintain its growth in any weather and prevent erosion of the material in which it is planted.

3.50.2 Materials

Grass shall be of species native to Bangladesh, harmless and inoffensive to persons and animals and not of a kind recognized as a nuisance to agriculture. It shall be free of disease and noxious weeds, deep-rooted and sufficiently rapid growing and spreading to give complete cover over the planted area within the Defects Liability Period.

The term "grass" embraces turf and sods and, if the Engineer permits, may include plants of other types capable of giving effective protection.

Fertilizer shall be approved cow dung or mixtures of plant nutrients or both.

3.50.3 Construction Method

Grassing/turfing shall be done by planting sods or turf to give continuous cover over the whole area. They shall be planted with their root system substantially undamaged, well buried in firm material, and packed around with moist earth in which they have grown.

Grass shall be planted as soon as possible to protect completed embankment works. The work shall be done at such a time, and in such a way that areas to be grassed are substantially covered with healthy, well established, firmly rooted grass and the planted area is free from erosion channels, prior to issue of the Certificate of Completion.

The surface to be planted shall be trimmed in such a way that the ground surface after planting shall be as shown on the Drawings.

Fertilizer shall be added at the time of planting if necessary to ensure good ground cover within the required time.

3.50.4 Measurement

This work shall be measured for payment as the area in square metres of turfed or sodded surface whether horizontal or sloping, of required and accepted grassing well established in place.

3.50.5 Payment

The work measured shall be paid for at the Contract unit price per square metre. The payment will be full compensation for supplying all materials including fertilizer, labour, equipment, tools and incidentals necessary to complete the work.

Pay item shall be:

Clause	Description	Unit of Measurement
3.50	Grass Turfing	Square meter

3.51 DRAINAGE REPAIR

3.51.1 Description

The work shall consist of carrying out necessary repairs to existing drains and drainage structures at locations and to the direction given by the Engineer. The repairs may include deepening and reshaping of drainage channels; repairs to parts of cross-drainage structures like parapets, head walls, wing walls, abutment walls, apron etc.; or repairs to any other roadside structures affecting proper drainage of the road.

3.51.2 Materials

Materials for repairing structures shall be cement, sand, bricks, stones, aggregates etc. as required at individual locations.

3.51.3 Construction Methods

3.51.3.1 Deepening and reshaping of drains shall be carried out at locations and to lines, levels and cross-sections indicated by the Engineer. The bed of drains shall be prepared to uniform slope to avoid water logging.

3.51.3.2 Repair to structures shall be to the instructions of the Engineer. Filling of cracks in masonry shall be by cement filling in structural concrete shall in general be in epoxy resin or epoxy resin mortar to the directions of the Engineer.

3.51.4 Measurement and Payment

This item shall be measured in linear meter of work done as specified in the Bill of Quantities.

Repair to members of cross-drainage structures shall be paid for on Day Work basis.

Pay item shall be:

Clause	Description	Unit of Measurement
3.51	Drainage repair	Linear meter

3.52 EXCAVATION OF SIDE DRAINS

3.52.1 Description

The work shall consist of the excavation, removal and disposal of materials for the formation of roadside drains in accordance with these Specifications and as shown on the Drawings or as directed by the Engineer. The work will include excavation of the lead-offs to allow the water to flow freely away from the road.

3.52.2 Materials

Excavated materials declared suitable for incorporation in the works shall be stock piled while those declared unsuitable shall be disposed of, all at the direction of the Engineer.

3.52.3 Construction Method

The side drain works shall be set out and excavated to the lines, levels, grades and cross-sections, and in the locations as shown on the Drawings, or as directed by the Engineer, including the lead-offs. The drains shall be excavated to ensure that water flows freely away from the side of the road. The Contractor shall not excavate outside the slopes or below the established level, or loosen any material outside the limits of excavation. Any excess depth excavated below the established level shall be made good at the cost of the Contractor with suitable material and compacted.

The slopes and base of the drain shall be trimmed.

3.52.4 Measurement

Roadside drains shall be measured in linear meters of length excavated complete and accepted. Measurements shall be made along the center-line of the drain.

3.52.5 Payment

The work as measured shall be paid for at the Contract unit price for each linear meter of side drain excavated. Payment shall be full compensation for carrying out the operations required including setting out, hauling of excavated material, trimming slopes and base, and all labour, tools, equipment and incidentals necessary to complete the work.

Pay item shall be:

Clause	Description	Unit of Measurement
3.52	Excavation of Side Drain	Linear meter

3.53 BRICK LINING OF SIDE DRAINS

3.53.1 Description

The work shall consist of brick lining and plastering of excavated side drains in accordance with these Specifications and as shown on the drawings.

3.53.2 Materials

Bricks shall be First Class.

3.53.3 Construction Method

The placing of the brick lining shall not commence until the excavated and prepared side drain has been accepted by the Engineer.

The brick lining shall be laid as brick flat soling with frogs downward as shown on the Drawings. Plastering shall be of 12mm thickness or as shown on the Drawings.

3.53.4 Measurement

This work shall be measured in linear meters of side drain brick-lined complete and accepted. Measurements shall be made along the center-line of the drain.

3.53.5 Payment

The work as measured shall be paid for at the Contract unit price for each linear meter of side drain brick-lined. Payment shall be full compensation for carrying out the operations required including materials, all labour, tools, equipment and incidentals necessary to complete the work.

Pay item shall be:

Clause	Description	Unit of Measurement
3.53	Brick-Lining of Side Drain	Linear meter

4 SPECIFICATION FOR ENVIRONMENTAL MITIGATION WORKS

[THE ENVIRONMENTAL CODES OF PRACTICE (ECP): The prime objective of the ECP is to define methods and / or procedures to be followed by LGED district and Upazila Engineers, Consultants, designers and contractors for the avoidance or mitigation of adverse environmental effects that may arise out of Building Construction. It is desirable that all people involved in the planning, design, and implementation of subprojects associated with LGED are aware of the need for the ECP, practice the procedures established therein, and implement systems for the prevention or mitigation of adverse environmental effects of the subproject interventions. The ECP shall be followed for the planning, design and implementation of all subprojects works to be carried out under LGED.]

4.1: CONSTRUCTION CAMPS

4.1.1 OBJECTIVES

The main objective of this ECP is to provide guidelines on the selection, development, maintenance and restoration of construction camp sites in order to avoid or mitigate against significant adverse environmental effects, both transient and permanent.

SALIENT FEATURES	- Secure the campsite with galvanized posts and wire mesh fence at least two meters height. - Provide a minimum of one water sealed latrine, one urinal and one appropriate bathing place per ten personnel employed on the works. - Provide separate toilet facilities for male and female employees. - Maintain all camp facilities in a safe clean and / or appropriate condition. - Provide adequate first aid facilities for attending injuries of workers. - Dismantle camp facilities and remove them from the site, and restore the camp site to similar condition to that prior to the commencement of works or to a condition agreed to with the owner of the land. - Carefully remove all oil or fuel contaminated soil from the site and dump in waste soil disposal areas.

4.1.2 SITING

During planning of the works consideration shall be given to the location of construction camps for the subproject. Construction camps and areas identified that may be suitable for the development of such camps shall be raised in the course of public consultation. Areas those are not suitable for reasons such as environmental, cultural or social sensitivity shall also be identified.

Wherever possible, construction camps shall be planned in areas that will have minimal adverse environmental effects. In identifying such areas particular care shall be taken to evaluate the adverse affects of water, noise and air pollution, which, although transient, will preclude the use of some areas as construction camp sites.

4.1.3 LOCATION

Construction campsites shall be located such that permanent adverse environmental effects can be avoided or mitigated against and transient adverse environmental effects are minimized. Campsites shall not be located in areas identified during the planning stage as unsuitable for such use. The site or sites shall be selected such that mitigation measures stipulated in this ECP can be implemented with reasonable facility.

4.1.4 PRIVATE LAND

Where construction camps are to be located on land outside the building premises, the contractor shall obtain the approval of the landowner to establish the campsite on such land and pay agreed compensation. Environmental protection measures established by this ECP shall apply to all land regardless of ownership.

Unless otherwise specified the contractor is at liberty to make his own arrangements with landowners to establish construction camps. Prior to the development of such camps the contractor shall submit to the Engineer the signed authority of the landowner for the contractor to establish the construction camp on any land.

The contractor shall also submit to the Engineer the following information signed by the landowner and the contractor: details of compensation to be paid, agreed period of tenure, any specific requirements of the landowner, photographs of the site in its original condition, and details of proposed and agreed site restoration after completion of the project works.

At the completion of the contract works the contractor shall submit to the Engineer a signed statement from the landowner confirming that the compensation has been paid and that the landowner is satisfied with the restoration of the site. If such a statement is not submitted the Engineer may withhold moneys owing to the contractor in a sum sufficient to pay for the compensation and the site restoration, if necessary.

4.1.5 CONSTRUCTION CAMP FACILITIES

The construction camp shall be provided with the following minimum facilities:

- A perimeter security fence at least 2 m in height constructed from appropriate materials.
- Ablution block with a minimum of one water sealed latrine, one urinal and one appropriate bathing place per 10 personnel engaged either permanently or temporarily on the project. Separate toilet and wash facilities shall be provided for male and female employees.
- A sick bay and first aid box.
- Areas for the storage of fuel or lubricants and for a maintenance workshop shall be bunded and have a compacted / impervious floor to prevent the escape of accidental spillage of fuel and or lubricants from the site. Surface water drainage from bunded areas shall be discharged through purpose designed and constructed oil traps. Empty fuel or oil drums may not be stored on site.
- Low cost sanitation facilities to provide treatment for wastewater discharges from toilets, washrooms, showers and the like. The standard of treatment to be achieved at all times is Biochemical Oxygen Demand (BOD5) less than 30 ppm, Suspended Solids less than 50 ppm.
- Storm water drainage system to discharge all surface run off from the camp site to a silt retention pond which shall be sized to provide a minimum of 20 minutes retention for storm water flow from the whole site.
- All discharge from the silt retention pond shall be channeled to discharge to natural water via a grassed swale at least 20 meters in length with suitable longitudinal gradient.
- All camp facilities shall be maintained in a safe clean and or appropriate condition throughout the construction period.

4.1.5.1 Construction camp development plan

A development plan of the construction camp shall be prepared describing perimeter fence and lockable gates, workshop, accommodation, ablutions, water supply, wastewater treatment and disposal system, bunded fuel storage area, proposed power supply and all proposed weather surfaced areas.

Within 14 days of the commencement date the contractor shall submit to the Engineer for approval a detailed layout plan for the development of the construction camp showing the relative locations of all temporary buildings and facilities that are to be constructed together with the location of site roads,

storage areas and drainage facilities. The contractor shall also submit brief specifications for the materials to be used for the construction of all buildings and facilities and defining the standard of construction for all works to be undertaken on the campsite.

The contractor shall comply with the government medical or labor requirements at all times and provide, equip and maintain dressing stations where directed and at all times have experienced first aid personnel available throughout the works for attending injuries.

4.1.6 SITE RESTORATION

At the completion of the construction work the contractor shall dismantle and remove from the site all facilities established within the construction camp including the perimeter fence and lockable gates. The whole of the construction campsite shall be grassed and if trees originally grew on the site they shall be replaced with similar tree species. At the completion of restoration the site shall be restored to its condition prior to commencement of the works or to an agreed condition with the landowner.

All oil or fuel contaminated soil shall be carefully removed from the site and transported and buried in waste soil disposal areas.

4.2: MATERIALS STORAGE, TRANSPORT & HANDLING

4.2.1 OBJECTIVE

The main objective of this ECP is to provide guidelines for safe storage, handling, and transfer of materials to minimize any adverse impacts on the environment due to such operations.

SALIENT FEATURES	• Do not release potential contaminants on the ground surface. • Store Petroleum, Oil and Lubricant (POL) products on impermeable floor that slopes to a safe collection area in the event of a spill or leak. • Prevent any POL product from being spilled. • Use absorbent material to collect spilled petroleum product. • Make safe disposal of absorbent materials. • Refuel or service equipment and vehicles at least 30 meter away from any watercourse. • Do not wash out tankers near the watercourses. • Provide appropriate protection for discharge of liquid asphalt to a watercourse during chip-sealing of a bridge.

4.2.2 GENERAL

Activities related to materials storage, handling, and transfer that are considered to potentially have negative environmental effects include:

- storage, handling, and transfer of petroleum, oil, and lubricant (POL) products;
- storage and handling of hazardous materials other than POL products; and

Some materials used during implementation of subprojects may have potentially hazardous effects on the environment if not properly stored and handled.

4.2.3 ENVIRONMENTAL CONCERNS WITH MATERIALS USED FOR CONSTRUCTION AND MAINTENANCE OF SUBPROJECTS

Concerns are related to accidental releases into the environment, such as spills, refueling losses, and leakage from equipment that could result in contamination of soil, groundwater, or surface waters. Groundwater may transport the contaminants off-site to down-gradient aquifers or water supplies, or discharge them into surface waters. Therefore, release of potential contaminants on the ground surface could have significant environmental impacts that could ruin groundwater (well supplies).

4.2.3.1 Petroleum, oil, and lubricants

The toxic effect of a petroleum product in the aquatic environment varies considerably due to the different chemical composition of each petroleum product. The toxicity of petroleum products is related largely to its solubility in water. Petroleum pollution from accidental spills may affect aquatic birds, fish and vegetation. The effect of oil on birds' feathers (loss of insulation) is an important cause of death.

Oil polluting the water may also be toxic to birds if they ingest it. Plants in marshes or in wetlands (haor, baor, ponds and others) and streams may die off for short periods. Long-term impacts of spilled petroleum products are associated with the portion, which sinks and becomes incorporated into bottom sediments. This causes the petroleum products to degrade very slowly and they may persist for many years.

Petroleum products can stick to the gills of fish and interfere with normal respiration. Under relatively mild pollution, fish may produce mucus as a defensive mechanism to remove the oil. However, in heavy pollution, this mechanism is inefficient and the oil tends to accumulate on the gills and smother the fish. Petroleum products contain soluble materials, which can be ingested by fish. The flavor of the fish flesh may, therefore, become tainted, or if ingested in enough quantity, may become lethal. Groundwater sources contaminated with petroleum products may have potentially toxic effects on consumers.

4.2.3.2 Other hazardous materials

The following hazardous materials are used in structures construction or maintenance activities and have potential environmental concerns:

- paints;
- solvents; and
- fresh concrete and admixtures.

Paint materials, which are lead or oil-based, may affect aquatic life if significant amounts enter a watercourse. Specific concern exists with lead, as this compound may have a direct toxic effect on young fish. Toxins can accumulate over time in aquatic fish, bugs, and plants. Upon consumption by animals such as birds and small mammals, some metals could be transferred to the consumer and affect their health.

Some solvents used for cleaning purposes may contain components, which are toxic to aquatic life, wildlife, and humans. If solvents enter a watercourse / water supply, and significant concentrations occur in the water, this could be harmful to users.

Concrete, which is typically made up of aggregates, cement, water, and possibly admixtures, is very alkaline because of its calcium (lime) content. If concrete enters a watercourse in significant amounts, the pH of the water may be affected locally over the short-term. If the pH of the receiving water is altered, this may cause physiological stress in fish, which may result in death.

4.2.4 STORAGE, TRANSPORT AND HANDLING OF POL PRODUCTS

Care must be taken with the storage, transfer, handling of POL products to prevent potential environmental damage. All empty containers and drums shall be returned to the maintenance depot. It shall be ensured that all drums and containers are closed and not tipped over and all waste oil, lubricants, and solvents shall be stored in closed containers.

4.2.4.1 Storage

Any container, drum, or tank that is dented, cracked, or rusted will probably eventually leak. Make sure all containers, drums, and tanks that are used for storage are in good condition. Check for leakage regularly to identify potential problems before they occur. The proper storage of materials will greatly reduce the risk of accidental spills or discharges into the environment.

For temporary outdoor storage, put containers and drums in clearly marked areas, where they will not be run over by vehicles or heavy machinery. The area should preferably slope or drain to a safe

collection area in the event of a spill. Tanks should have appropriate secondary containment (i.e. double-walled or surrounded by a dyke) that will collect spilled material in case of a leak.

Permanent storage areas for containers or drums should be on an impermeable floor that slopes to a safe collection area in the event of a spill or leak.

4.2.4.2 Transport and handling

At all times when products are being handled or transported, care must be taken to prevent any product from being spilled, misplaced, or lost and possibly entering and contaminating the soil or a natural waterway.

When equipment and vehicle maintenance or repair is required in the field, it should be undertaken at least 30 m away from any watercourse. Minimize the potential for entry of hydraulic fluids or oil into a watercourse by using absorbent materials to collect spilled petroleum products. Return all used absorbent materials to the appropriate storage yards for safe disposal.

Return all diesel or fuel used to wash asphalt emulsion pumps to the maintenance depot for safe storage or disposal. Also return all solvents used to wash spray-painting or other equipment to the appropriate storage yards for safe disposal.

Wash equipment in maintenance areas equipped with oil / water separators so that any petroleum products can be removed prior to discharge of the wastewater. Oil / water separators are only effective if they are properly maintained. At sites without oil / water separators, minimize the amount of wash water used and wash in areas where the potential for entry of wash water into a waterway is minimized by proper grading or curbing.

Do not wash out tankers near watercourses. Wash out where the potential for entry of wash water into a waterway is minimized by proper grading or curbing.

Refuel or service equipment and vehicles at least 30 m away from any watercourse. Refueling over liner material with an absorbent pad (e.g. sand bed) will help to contain potential spills. If refueling is done from a bulk tanker, the hose / nozzle assembly should be replaced to its proper position upon completion.

4.2.5 SPILLS AND SPILL CLEANUP

Quick action in the event of a spill of hazardous materials is important in order to prevent environmental damage.

4.2.5.1 What to do when a spill occurs

1. Identify the material involved and make a quick assessment:
 - How extensive is the spill?
 - Are there any watercourses nearby?
 - Are the watercourses down-gradient from the spill?
 - Are there drainage systems down-gradient from the spill which lead to a nearby watercourse?
2. Stop the flow of product, if it can be done safely.
3. Notify the Engineer and authorities immediately.
4. Control and contain spilled product until expert help arrives, if it can be done safely.

4.2.5.2 How to control and contain a spill

When a limited oil spill occurs on level land, scoop up the affected soil and dispose at a site approved by the Engineer and the Department of Environment. When an extensive oil spill occurs on level land, dig sump hole and pump excess oil into a temporary container. The remaining contaminated soil must be scooped up and disposed of at a site approved by the Engineer and the Department of Environment. When an extensive spill occurs on a slope or hillside, a trench can be dug downhill from the spill to intercept the spilt material. Should petroleum products reach a watercourse, several temporary spill containment measures can be used to help stop the spreading of products.

4.2.6 STORAGE AND HANDLING OF DANGEROUS MATERIALS

Workers may be at risk from exposure to dust particles or toxic fumes from chemicals used in construction works and materials testing. Specific measures to reduce risks include limiting time of exposure to dust particles, chemicals and noise; enhancing safety and inspection procedures; and improving materials safe handling.

The Contractor shall safely handle and store hazardous materials in accordance with the following requirements:

- Hazardous materials shall be stored above flood level and at least 30 m from any watercourse;
- Hazardous liquid substances (e.g. petrol, diesel, oils) shall be stored on top of sealed plastic sheets in a secure, flat enclosed area. Bund walls shall be at least 25 cm high.
- All empty containers and drums shall be returned to the maintenance depot. It shall be ensured that all drums and containers are closed and not tipped over and all waste oil, lubricants, and solvents shall be stored in closed containers.
- The Contractor shall have an emergency procedure and will seek directions from the Engineer regarding the disposal of hazardous materials. Used lubricants and oils shall be collected and disposed of or recycled without causing pollution or a hazard to worker safety. Spills of hazardous materials within or outside enclosed storage areas shall be cleaned up immediately. Contaminated and torn or worn plastic sheets shall be disposed of appropriately.
- At all times when products are being handled or transferred, the Contractor shall take all precautions to prevent any product from being spilled, misplaced, or lost and possibly entering and contaminating the soil or a natural waterway.
- The Contractor shall not wash out tankers near watercourses. The Contractor shall refuel or service equipment and vehicles at least 30 m away from any watercourse. Refueling over liner material with an absorbent pad (e.g. sand bed) will help to contain potential spills. If refueling is done from a bulk tanker, the hose / nozzle assembly shall be replaced to its proper position upon completion.

4.3: BRICKFIELDS AND BRICK CRUSHING YARD

4.3.1 OBJECTIVE

The main objective of this ECP is to prescribe the specific requirements for the development and operation of brickfields and brick crushing yards for the building construction as well as to define procedures and works that shall be used for mitigation against adverse environmental effects.

SALIENT FEATURES	• Use non-agricultural or less productive land for use as brickfields or brick crushing yard. • Procure bricks only from those manufacturers who use alternative fuel such as coal or natural gas. • Strip and stockpile the topsoil to a depth of 15 cm, and thereafter extract soil / clay up to a further depth of 30 cm for brick manufacturing. • Spread back on the land the stockpiled topsoil. • Do not use the brickfields and / or brick crushing yards that are located within 500 meter of any identified archaeological, religious or cultural sites. • Maintain desired slope gradient of the bed level of the brickfields and crushing yards for efficient drainage. • Rehabilitate brickfields / brick crushing yards as per provisions of approved rehabilitation plan.

4.3.2 PLANNING AND DESIGN

During the planning of subprojects, potential brickfields and brick crushing yards may be identified in consultations with the local community. Alternatively, environmental and social criteria may be stipulated that need to be satisfied by the Contractor while selecting brick fields and brick crushing yards.

4.3.3 IMPLEMENTATION

4.3.3.1 General principle

Brickfields: The brickfields in which soil and clay are extracted and fired are a form of strip mining. In many areas, plots strip-mined in this fashion are eventually returned to agricultural use and fertility is returned to the soil through successive flooding and silt deposits. In many areas, however, this is not the case. Brickfields un-restored / un-rehabilitated by either man or natural action are evident throughout the area, particularly in the northern, drier, and less flood-prone areas. The environmental impacts due to operation of the brick kilns are well known in Bangladesh. As the Government has already banned the use of firewood for this purpose, practice needs to be discontinued to stop further degradation of forest / tree resources.

Brick Crushing: The cumulative impacts of crushing bricks for use in building construction are significant. The accumulation of the inert, inorganic nature of brick residue will result in patches of unproductive land where crushing has taken place. Agricultural land or areas where residue may be flushed onto agricultural land or sensitive ecosystems should be avoided. Residue that finds its ways into closed waterways will eventually impact on aquatic flora and fauna, in particular fish populations. Residue containing silica will be particularly dangerous in this respect. No brickfield using firewood as fuel shall be used. All bricks for the use of building construction shall be procured only from those manufacturers who use alternative fuel such as coal or natural gas. The right to use brickfields and brick crushing yards is generally negotiated between the contractor and individual brickfield / land owners. All efforts shall be made to use non-agricultural or less productive land for use as brickfields or brick crushing yards.

The Contractor in consultation with the community and landowners shall identify brick kilns using coal or natural gas and appropriate locations for brick crushing yards outside the road reserve. A brick crushing yard management (development, operation and rehabilitation) plan should then be prepared. The plan shall be approved by the Engineer before commencing work. Before using additional crushing yards, operating yards shall be closed by the Contractor as per the agreed rehabilitation plan. The following principles for location, depth and drainage of brickfields and brick crushing yards shall be followed:

Clay and sand for the brick manufacturing should be obtained:

- from barren land or land without tree cover outside the road reserve;
- by excavating land and creating new water tanks / ponds;
- from high lands acquired temporarily;
- from excavation of derelict tank;
- from river bed (in accordance with River Sand Extraction Management)

To ensure efficient drainage, the bed level of the brick fields and crushing yards shall, as far as possible, slope down progressively towards the nearest cross drain, if any, and shall not be lower than the bed of the cross-drain.

When it becomes necessary to use temporarily acquired cultivable lands, the depth of soil /clay extraction shall not exceed 45 cm. The topsoil to a depth of 15 cm shall be stripped and stockpiled for later rehabilitation of the pit. Thereafter, soil / clay may be extracted up to a further depth not exceeding 30 cm for brick manufacturing. Subsequently, the stockpiled top soil shall then be spread back on the land.

Brickfields and / or brick crushing yards shall not be located within 500 m of any identified archaeological, religious or cultural sites.

Sediment shall be controlled at each site by ensuring that base of the brick crushing yard drains into a sediment trap prior to discharging from the site.

After obtaining approval from the Engineer, the Contractor shall locate and peg out the full extent of proposed brick crushing areas prior to its use. For location, depth and drainage of brickfields / crushing yards, the principle criteria mentioned above shall be followed by the Contractor. Once the proposed brickfields and breaking yards have been identified by the contractor in consultation with the local community, they will be inspected by the Engineer. The brickfields / brick crushing yard areas shall be rehabilitated as per the provisions of the approved rehabilitation plan.

4.4: OCCUPATIONAL HEALTH AND SAFETY

4.4.1 OBJECTIVE

The main objective of this ECP is to provide guidelines and increase awareness of occupational health and safety (OH&S) issues that affect construction workers, building users and communities living in the vicinity of works areas. Contractors need to be made aware of their responsibilities to workers and the environment and conversely, workers also have a responsibility to OH&S.

SALIENT FEATURES	• Keep arrangements for adequate first aid facilities at accessible location with trained personnel in administering first aid. • Do not put workers at risk from long exposure to dust particles or toxic fumes from chemicals used in construction / maintenance works. • Provide adequate information, instruction and training in relation to safe working practices.

4.4.2 PROVISION OF FIRST AID FACILITIES

In the event of an incident, it is important that first aid is readily available on site. This means that adequate first aid facilities should be located in an accessible location and that a designated person has been trained in administering first aid and has responsibility for maintaining such facilities. All workers should be advised of the location of first aid facilities and procedures in the event of an incident.

4.4.3 STORAGE AND HANDLING OF DANGEROUS MATERIALS

Workers may be at risk from exposure to dust particles or toxic fumes from chemicals used in construction / maintenance works and materials testing. Specific measures to reduce risks include limiting time of exposure to dust particles, chemicals and noise; enhancing safety and inspection procedures.

4.4.4 OPERATION OF MACHINERY

Risks are involved in the operation of machinery close to traffic, slopes, power lines and watercourses. Workers may also be at risk from the collapse of trenches. The contractor has responsibility to ensure that all machinery is in good working order and that all operators are qualified to use the equipment. Workers should also be advised of their responsibility to adhere to correct work procedures to minimize incidents from occurring. Many of the risks to workers outlined above can be limited by clearly defining procedures for handling materials, conducting tests, paving, operating equipment and constructing trenches. All workers must receive adequate and appropriate information, instruction, training and supervision in relation to safe working practices appropriate to the work performed.

4.5: PLANNING, DESIGN, CONSTRUCTION AND OPERATION FOR BUILDING WORKS

4.5.1 GENERAL

State the selection criteria in brief.

4.5.2 OBJECTIVE

The main objective of this ECP is to establish the general guidelines for managing and minimizing the potential environmental (including social) impacts of building works by outlining principles and minimum standards which shall be taken into account in the planning, design, and implementation of Building Construction.

SALIENT FEATURES	• Select the most practicable methods for minimizing the release of sediment and other pollutants into the environment. • Schedule major work activities to “off-function” hours to minimize disruptions to normal operation. • Minimize tree-branch trimming, or other environmental disturbance to that necessary to establish line of sight. • Ensure that stockpiles of top soil, humus, mulch, fill and waste materials, and brick aggregates or other construction materials are not located within 10 m of a watercourse. • Stockpiles of materials shall not provide a source of dust generation. • Ensure vehicles and plant parking or refueling and maintenance facilities are not located within 30 m of a watercourse. • Do not direct storm water from construction sites into the building or into nearby areas supporting high quality indigenous vegetation including watercourses. • Provide bins and ensure all litter including oil cans, hoses and machinery parts are disposed in a responsible manner. • Protect sites having cultural or heritage values.

4.5.3 GENERAL DESIGN PRINCIPLES

The following general principles constitute good practice environmental management procedures for planning, design and implementation of market improvements:

- Take into account the issues and concerns of affected communities and stakeholders;
- Decide, in consultation with stakeholders, the values which should be given priority;
- Identify and discuss with the Engineer any mitigation measures, which could have a major cost implication;
- Consider appropriate construction methods that will minimize environmental risks while taking into account the goals of sustainable development. The most practicable methods for minimizing the release of sediment and other pollutants into the environment shall be selected;
- Specify that construction phases are sequenced, timed, and managed to minimize disturbance to the environment. This includes minimizing the extent of area to be worked, and area of bare earth exposed at any one time;
- Specify that the program of construction shall be prepared to show that areas to be re-vegetated or re-paved are completed progressively as sections of the work are completed;
- Identify and set out the relevant clauses of the ECP into the Building construction contract and bid documents to ensure that environmental standards and guidelines are implemented;
- Provide in the contract documentation the operational and maintenance procedures to preserve the mitigation measures in good condition and effective operation.

4.5.4 ENVIRONMENTAL GUIDELINES FOR PLANNING AND DESIGN

For the planning and design phases, the designer shall follow the general guidelines set out hereunder:

4.5.4.1 Contractor's environmental management plans

A Contractor's Environmental Management Plan (CEMP) has to be prepared by the contractor and approved by the Engineer-in-Charge before commencement of construction works. The CEMP shall set out the specific mitigation measures, and monitoring requirements that will be put into place during the subproject implementation. The CEMP shall:

- Establish the chain of responsibility for managing the environmental aspects of the project.
- Identify the records to be maintained which demonstrate compliance.
- Establish the mitigation and contingency measures for at least the following:
 - Maintenance of building utilities such as power and water supply during construction
 - Vegetation management
 - Excess spoil disposal
 - Slope protection works
 - Borrow area management
 - Dust control
 - Water collection management
 - Noise control
 - Specify the temporary storm water management devices, their locations, and the maintenance program for all such devices.

4.5.4.2 Field surveys

The building area needs careful and complete mapping of all important terrain features. Other relevant data like land use, infrastructure, cultural sites, fragile slopes, drainage lines, ponds, community trees, tube wells, irrigation and or drainage channels etc. must also be mapped. In addition, potential campsites, spoil locations, brick-breaking sites, borrow pit sites have also to be mapped.

4.5.4.3 Disposal of excess material

In consultation with the affected (adjacent) community, identify and implement the best practicable option for the disposal of excess cut and unsuitable materials. In these context materials means non-toxic materials. Any toxic materials shall be disposed of by a method or methods that comply in all respects with the laws of Bangladesh.

4.5.5 ENVIRONMENTAL GUIDELINES FOR CONSTRUCTION

For the construction phase, the contractor shall follow the general guidelines as set out below:

4.5.5.1 General

- All reasonable steps shall be taken to ensure minimum nuisance to adjacent land during construction.
- At all times reasonable and useable access is maintained to the market area and any adjacent private land that may be affected by construction activities.
- Disruptions to building utilities such as power and water supplies should be avoided or at least minimized by scheduling major work activities to Off-functioning hours.
- Plants and seedlings used for re-vegetation should wherever possible be taken from the immediate area and from as close as possible to the restoration site.

- Management plans shall be prepared for subproject activities that are not considered during the planning and design stage.
- No equipment shall be moved onto a site, or works undertaken, prior to the completion of the CEMP established by the contract documents.

4.5.5.2 Survey

Follow the process for consultation and land access for survey and investigation. Minimize tree-branch trimming, or other environmental disturbance to that necessary to establish line of sight.

4.5.5.3 Dust control

Dust control measures by dampening shall be detailed in the CEMP, and shall include where the water shall be collected from (i.e. whether from ponds or local watercourses), and the number of watering trucks required. All care shall be taken to ensure excess water does not find its way to waterways.

4.5.5.4 Stockpiles

Ensure that stockpiles of top soil, humus, mulch, fill and waste materials, and brick aggregates or other construction materials are not located within 10 m of a watercourse, or in ecologically sensitive areas or where they cause major disruption to market operation.

Stockpiles of materials shall not provide a source of dust generation.

4.5.5.5 Refueling and maintenance areas

Ensure that vehicle and plant parking or refueling and maintenance facilities are not located, or activities do not take place, within 30 m of a watercourse, or in ecologically sensitive areas, or in inappropriate market locations such as near food stalls.

4.5.5.6 Site facilities

Site facilities include offices, ablutions, and areas designated for workers, and as such are activities, which have the potential to generate litter and other waste material. These facilities shall not be located within 30 m of a watercourse, or in an ecologically sensitive area.

Ensure regular disposal of rubbish off site at an appropriate location.

4.5.5.7 Re-paving re-vegetation

Grassing and replanting of trees and shrubs or re-paving market areas progressively throughout the construction period is the most effective means of preventing or minimizing erosion.

Consequently contractors shall program and execute their work such that:

- Re-paving re-vegetation of all exposed surfaces shall be specified and shall be undertaken as soon as practicable after completion of construction activities.
- Stockpiles of top soil and mulch or other construction materials comply with the requirements for stockpiles.
- Maintenance of vegetation and erosion control measures shall be specified.

4.5.6 ENVIRONMENTAL MANAGEMENT CONTRACT CLAUSES

LGED shall ensure that all relevant clauses be included in construction contract documentation related to the works. The Contractor is instructed to enter into the spirit of the tasks and will undertake all activities with due diligence to ensure that the environmental resources of the site or area are protected, conserved, and sustained at all times.

4.6: DRAINAGE STRUCTURES FOR BUILDING

4.6.1 GENERAL

An adequate drainage system is essential to ensuring a working environment in a Building. Ponding of water makes the building premises muddy and unhygienic creating inconvenience in carrying out activities. Poor design, operation and maintenance of drainage structures also lead to pollution of the surrounding environment, particularly surface and groundwater resources. A drainage system can be used to dispose of both storm water and washing water from washrooms etc.

4.6.2 OBJECTIVE

The main objective of this ECP is to provide guidelines for the design and implementation of drainage system to improve working conditions and reduce pollution of surface and groundwater resources.

SALIENT FEATURES	• Construct drainage structures as per requirement of the site conditions. • Constructed drains should have self-cleansing velocities at least during flood flows and a reasonable velocity during low flow conditions. • All storm water drainage should be channeled to a retention pond prior to discharge from the market. • No drainage onto private land unless agreement has been reached with the land owner.

4.6.3 PLANNING AND DESIGN

In developing a drainage plan, an integrated approach for the whole market should be adopted, taking into account storm water and other run-off from the adjacent structures, geographical layout, and topography and site hydrology.

A drainage plan shall be prepared which adopts the following guidelines:

- to take advantage of existing gradient for drainage, efforts should be made to develop internal roads and sales structures in such a way that they are not placed across the slope;
- a hierarchy of drains should be maintained to ensure proper distribution of water to be drained to avoid drainage congestion;
- paved surfaces increase the rate of drainage and eliminate a muddy environment. While constructing the internal drains, strips between roads and pathways and building should at least have brick lining;
- drains shall be designed for self-cleansing velocities at least during flood flows and a reasonable velocity shall be maintained during low flow conditions to ensure their effectiveness and to minimize cleaning and maintenance requirements.

4.6.4 IMPLEMENTATION

All drainage structures should be constructed according to an overall drainage plan covering the whole market area. Once constructed, all structures must be regularly cleaned and maintained to ensure their proper functioning at all times. It is preferable not to discharge drainage directly into a natural water course without first passing it through retention / settling pond or diverting flow into undisturbed vegetation to reduce sediment load.

A detailed layout plan should be prepared showing the relative locations of drainage facilities in relation to the buildings. The plan should include the following minimum requirements:

- road and drain facilities shall correspond to the total length of internal road network;
- all drainage structures shall be maintained to their design specifications;
- all storm water drainage from the site shall be channeled or piped to a retention pond prior to discharge from the building site. The retention pond shall be sized to provide a minimum of 20 minutes retention for storm water flow from the whole site that will be generated by a 20 year

return period rainfall having duration of at least 15 minutes. The run-off coefficient to be used in the calculation of the retention pond shall be 0.9;

- all discharge from the retention pond shall be channeled to discharge to natural water via a grassed swale at least 20 m in length with suitable longitudinal gradient;

The retention pond shall be maintained in a safe and clean condition throughout the operation of the building. Trapped silt and soil shall be periodically removed and disposed of in an environmentally acceptable manner.

Under no circumstance shall drainage be discharged onto private land surrounding the building unless agreement has been reached with landowner, and only then if run-off is discharged onto stable surfaces capable of handling concentrated water flow and which provide for efficient sediment trapping such as onto undisturbed vegetation.

4.6.5 COST ESTIMATES

Most of the protection measures shall be included in civil items for drainage works except retention pond. The cost estimates for retention pond shall be prepared based on actual requirement and included in BoQ as environmental protection budget.

4.7: WATER SUPPLY FOR BUILDING

4.7.1 GENERAL

Groundwater is the most common source of water supply for buildings. The depth of the water table and water quality, particularly with respect to arsenic contamination and / or fecal coliform contamination are important issues of concern which need careful consideration during planning and design of the water supply and sanitation facilities for markets and ghats. In Bangladesh the depth of the aquifer to be tapped for a tube well plays an important role in eliminating the risk of arsenic contamination. Iron content in shallow groundwater is also a common problem encountered in using groundwater as a source of potable water and for washing. The use of deep tube wells however, are costly and require skilled laborers to install and maintain while shallow tube wells (which are generally poorer water quality) are economic and more easily maintained.

4.7.2 OBJECTIVE

To provide guidelines and specific design requirements for the provision of potable and non-potable water supplies (washing, cattle watering, etc.) for buildings

SALIENT FEATURES
• Avoid installing tube wells used to supply potable water near any sanitation facilities to prevent water contamination. • Avoid risk of arsenic contamination by sinking tube well to a depth over 300 feet.

4.7.3 PLANNING AND DESIGN

4.7.3.1 Location of tube well

A location plan of tube wells shall be prepared in consultation with local community and taking into account the location of building such as sanitation facilities which can impact adversely on potable water supplies.

A minimum requirement for each building is the provision of at least 2 separate tube wells, one for washing / sanitation purposes and the other for potable (drinking) water supply. Each should be clearly marked for their intended purpose and they should not be located next to each other.

A tube well location plan shall be prepared which adopts the following guidelines:

- o takes into account the needs of building users;
- o tube wells used to supply potable water shall not be located near sanitation facilities to prevent water contamination.

- o a minimum of 2 tube wells shall be located adjacent to the building, one for washing / sanitation purposes and the other for potable water supply
- o each tube well shall be clearly marked for its intended use;

4.7.3.2 Type of tube well

In Bangladesh, the risk of arsenic contamination in groundwater is high and this can be minimized by using tube wells over 300 feet in depth. Deep tube wells also eliminate the risk of contamination by fecal matter from humans and animals. However, they are costly to construct and maintain such that it is more feasible to use shallow tube wells provided the water quality is suitable for the intended use.

The use of a shallow or deep tube well shall be based on the following guidelines:

- the use of the water, whether for washing only (shallow tube well is suitable) or as a potable water supply (water quality sampling required to assess suitability of a shallow tube well);
- if water quality sampling indicates the presence of arsenic and / or iron at unacceptable levels a deeper well is required or an alternative site chosen if the water is to be used for drinking. The World Health Organization guideline for the desirable maximum concentration of arsenic in drinking water is 0.01 mg/l and in Bangladesh the acceptable limit for iron content is up to 5 mg/l for rural water supply. Current technologies, which are effective in removing arsenic, are too expensive or highly technical for rural areas and are not a feasible alternative at present.

The tube well shall be designed such that local surface water run-off will not be able to contaminate the tube well and drainage from the tube well will be diverted into the market drainage system. Tube well design shall be such that it is easy for users, especially women who are the main water collectors, to operate the pump.

The type of tube well design adopted shall be based on the following guidelines:

- o all surface water run-off shall be diverted around the tube well;
- o drainage from the tube well shall be diverted into the building drainage system;
- o the pump mechanism shall be of a conventional type such as a 'moon' hand pump and not the "tara" design which is more difficult to use and unpopular among rural communities (a suitable tube well design can be found in LGED's 1995 "Manual for Growth Centre Planning").

4.7.4 IMPLEMENTATION

4.7.4.1 Ongoing operation / maintenance

Water quality testing should be carried out initially prior to use of the tube well to determine its suitability for its intended use. Thereafter, sampling should be undertaken on a monthly basis and analysis undertaken by a suitably qualified person. Should the water quality be found to be unsuitable for its intended use, users should be immediately informed and remedial measures implemented to rectify the problem. Remedial measures may include treating the water, temporarily closing the tube well until such time sampling indicates it is suitable for use again, using the tube well for another use, or closing it permanently and finding another water source.

A water quality monitoring program shall be implemented. The plan shall include the following minimum requirements:

- an initial water quality sampling will be undertaken prior to the use of the tube well to determine suitability for its proposed use. The minimum parameters to be sampled shall include: arsenic, fecal coliform, fluoride, iron, pH, total dissolved solids (or conductivity) and hardness;
- subsequent sampling shall be carried out monthly and the parameters to be sampled will depend on the use of the tube well;
- a plan of action where water quality is found to be unsuitable for its intended use.

Workers assigned to manage the water quality program shall be appropriately trained in water sampling techniques.

Responsibilities for ongoing maintenance and repair of tube wells as well as the cost of the water quality monitoring program should be decided between LGED and management committee.

4.7.5 COST ESTIMATES

The provision of portable and non-portable water supply to the building is a part of project intervention and associated cost shall be included in this sub-project cost.

4.8: WASTE MANAGEMENT

4.8.1 GENERAL

Indiscriminate disposal of solid wastes in and around a building deteriorates the working environment in it and pollutes the surrounding agricultural land and water bodies. It attracts scavenging animals such as dogs and disease vectors creating a health and safety hazard. It is also a potential source of surface and groundwater pollution and the volume of waste produced can present a problem for disposal where land is limited.

Proper waste handling procedures not only reduce pollution and health and safety issues, but also reduce the area of land required for landfill. It generates an income where recycling measures are implemented. For example, composting of organic wastes turns them into a resource that can be handled, stored and transported with minimal adverse environmental effect, and can be used as organic manure for improvement of soil quality and fertility. Composting is not a new technology to Bangladesh and small scale practice is common in parts of the country.

4.8.2 OBJECTIVE

The main objective of this ECP is to provide design and operation guidelines for the implementation of a solid waste management plan that incorporates recycling of waste and fertilizer generation for growth centre improvement subprojects.

This ECP also prescribes the criteria for siting and design of slaughtering sheds and to provide guidelines for the management of waste from slaughtering sheds to mitigate the adverse environmental effects from such activities.

SALIENT FEATURES	• No indiscriminate disposal of solid waste in and around building • Adequate installation of garbage bins and regular collection of rubbish for either landfill or composting. • Make provision to collect leachate from the landfill and then discharge directly into the drainage system. In doing so surface and ground water contamination from landfill sources can be avoided.

4.8.3 PLANNING AND DESIGN

The initial step in the planning and design stage is to select the type of waste management technology to be adopted in consultation with the community. Dumping of solid waste in rivers, canals, which are common practice, should be avoided since it has the potential to significantly adversely affect water resources. Landfill disposal of solid waste is environmentally, more acceptable if managed properly. Potential solid waste landfill sites should be identified in consultation with management committee.

LGED shall identify, if possible, potential landfill sites that may be used for building. Such potential sites shall be identified on plans drawn to an appropriate scale and the plans shall be displayed and discussed during public consultations. LGED may also specify environmental and social criteria for selecting the landfill sites by the Contractor. Such environmental and social criteria shall take into account the site conditions, community opinions and relevant statutory laws and regulations of Bangladesh. Specifically, the following factors shall be considered:

- o that sufficient land area is available for disposal of solid wastes for a reasonable period of time, preferably greater than one year so that it is economic;
- o cover material should be available at or near the landfill site. Therefore the soil conditions and topography of the site must be considered;
- o climatic conditions, e.g. wind patterns and local surface water hydrology of the area has to be considered because these will have impact on the access to the landfill sites;
- o geologic and hydrologic conditions are the most important factors in establishing the environmental suitability of the area and are required to assess the pollution potential of the proposed site. It is to be ensured that the movement of leachate and the gases from the landfill will not contaminate the groundwater aquifer;
- o extreme care is necessary in the operation of the landfill so that it is environmentally acceptable with respect to noise, odor, dust and vector control. Flying papers and plastics must also be controlled;
- o the issue of the ultimate use of the completed landfill site is to be considered prior to the layout and design of the proposed landfill.

4.8.4 IMPLEMENTATION

4.8.4.1 General principle

Disposal of solid waste through landfill has the potential to pollute surface and groundwater resources if not managed correctly. Proximity to water resources and underlying soil types are critical factors in determining the potential risk of pollution from landfill sites. The siting of landfills and the application of mitigation measures are therefore important in reducing pollution risk.

The Contractor in consultation with the community and landowners shall identify the locations for landfill sites. A landfill management (development, operation and rehabilitation) plan should then be prepared. The Engineer shall approve the plan before commencing work. A new landfill site shall be selected prior to the existing one reaching capacity and once it is operating, the old landfill will be closed by the Contractor as per the agreed rehabilitation plan. The following principles for location of landfills shall be followed:

Landfills should be located:

- o as far as possible from tube wells to prevent pollution of water supplies;
- o in non flood-prone areas and at least 20 m from the bank of a watercourse or natural lake to prevent the risk of bank erosion / failure and contaminated leachate reaching the watercourse;
- o to minimize the risk of groundwater contamination the bed of the landfill should be compacted, preferably with an impervious layer of clay soil or some other suitable material;
- o landfills shall not be located within 100 m of any identified archaeological, religious or cultural site.

After obtaining approval from the Engineer, the Contractor shall locate and peg out the full extent of proposed landfill site prior to its use. For location and drainage of landfill sites, the Contractor shall follow the principle criteria mentioned above. Once the proposed landfill site has been identified by the contractor in consultation with the local community, it will be inspected by the Engineer. A source of soil fill is also required for the operation of the landfill and this need to be identified prior to the use of the landfill.

When a landfill site has reached capacity it shall be rehabilitated as per the provisions of an approved rehabilitation plan.

4.8.4.2 Landfill operation

The building authority will need to assure the adequate installation of garbage bins and the regular collection of rubbish for either landfill. If landfill disposal is used, solid waste should be deposited in 0.6 m layers, in a suitable pit over which a layer of soil should be placed to cover the waste. Once the site is filled it can be used for building area expansion.

4.8.4.3 Site hydrology

To reduce leachate from the landfill contaminating surface and groundwater resources, storm water run-off should be diverted around the landfill site by the provision of perimeter drains which should discharge directly into the building drainage system or into natural water ways via a grassed swale.

5 SPECIFICATIONS FOR SOCIAL ASPECTS

5.1 RULES & REGULATIONS BINDING UPON CONTRACTOR

The rules and regulations of the Government of Bangladesh in relation to environment and social safeguard together with World Bank Policies (OP/BP/GP 4.01) will be binding upon the contractor.

5.2 CHILD LABOUR

In addition, the Contractor shall comply with the applicable minimum age labour laws and requirements of (including applicable treaties, which have been ratified by) the Government of Bangladesh and applicable World Bank Policies regarding hazardous forms of child labour. The World Bank will review compliance with such labour laws, requirements and World Bank policies or, as the case may be, any non-compliance together with the action being taken to ensure compliance. Child labour means the labour who is less than 14 years old.

5.3 GENDER ISSUE

The contractor should follow the equity in wage payment for both the men and women labour for equal level of works as required by the Government of Bangladesh. The contractor should engage women labours on priority basis in the works suitable for them and follow ILO conventions, relevant protocols etc. The contractor must consult the women UP member and others to know about availability of women workers including indigenous women workers in the area to engage them in the suitable work as per their skill.

5.4 EMPLOYMENT OF PAPS/LOCAL WOMEN/INDIGENOUS PEOPLE IN PROJECT WORKS.

The contractor should give priority to PAPs/Local women/indigenous people in employing them to suitable project works as appropriate to their skill. In case of any dispute in this regard, the decision of the Executive Engineer shall be conclusive and binding upon the contractor.

5.5 SAFETY AND SECURITY

The contractor must maintain safety and security of the workers in the working place. In case of injury, the contractor must arrange treatment of the injured workers and the cost of treatment of the injured workers.

5.6 CULTURAL PROPERTIES

The contractor must protect the cultural properties in the project area. The cultural properties include mosque, temple, shrines, old buildings, graveyard, historical place etc.

The contractor must also pay attention to keep its beauty and other elements intact so that it does not get affected by any means or any works.

6 SPECIFICATION FOR SALINITY

6.1 Specification for Anti Salinity and damp-proof treatment inside and outside the brick wall.

Mixing 1 liter Desalt-S 01 with 12 liters water properly or in the proportion of 1:12 and apply the same in the brick wall surface after mixing with 25 ml specified catalyst for 1 liter of desalt as per instruction of Engineer.

The rate of application is 300 sqft/27.88 m²/liter of Desalt and mixture to be used in the surface within 2 hrs after mixing.

6.2 Specification for Anti-salinity of mortar of plastering work.

Mixing 250 ml. Foam Lub with 1 bag or 50 kg cement with required quantity of water at the time of preparing mortar for plastering work as per instruction of Engineer.

Rate of application 80 sqft/7.43 m²/50 kg of cement.

6.3 Specification for Anti-salinity of mortar of plastering surface before painting.

Mixing Desalt SO 1 with water in the proportion of 1:4 and apply the same after mixing with 25 ml specified catalyst on plaster surface. The rate of application is 350 sqft/32.53 m²/liter Desalt SO-1 as per instruction of Engineer and mixture to be applied with in 2 hrs. after mixing.

PART-7: ROADS

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PART-7: ROADS

1 TRAFFIC MAINTENANCE AND PROTECTION OF TRAFFIC

1.1 TRAFFIC MAINTENANCE AND PROTECTION OF TRAFFIC

1.1.1 General

The Contractor shall at all time maintain the traffic flow along the existing roads, rivers and canals. The Contractor shall provide and maintain all detours, temporary roads, temporary bridges, necessary barricades, warning lights' and guide signs as well as other equipment at all hours during the day and night throughout the period of construction.

Upon completion of the work, all temporary roads, temporary bridges, barricades, signs and other equipment shall be completely removed.

1.1.2 Payment

The construction, maintenance and ultimate removal of all temporary constructions as well as provision and maintenance of barricades, signs and other equipment shall be paid for at a lump sum price.

This sum shall cover all earthworks, temporary bridges and culverts, pavement and surfacing materials, warning signs, lights, control of traffic, including single lane working, by day and by night and all other items to ensure the smooth and safe flow of traffic and for their removal after the period of construction.

Partial payments to be inserted in the monthly certificates shall be directly proportional to the value of the completed works. However, payments shall not exceed the lump sum inserted in the Bill of Quantities.

Pay item shall be:

	Unit
Maintenance and Protection of Traffic	Lump Sum

1.2 OFFICE SPACE AND FACILITIES FOR THE ENGINEER

1.2.1 Field Office

In addition to the office space required for his own use the Contractor shall provide and maintain Field Office space with toilet facilities, furniture and office equipment for the use of the Engineer and his staff:

Field Office for the Engineer shall mean a building constructed in 250mm brickwork with C.I. sheet roofing and a protective' ceiling made of hard board and timber to the satisfaction of the Engineer. The floor shall be finished with a layer of brick, patent stone and neat cement finish. No irregularity in the floor surface will be allowed. The foundation of this building shall be to the satisfaction of the Engineer.

Access road to the Field Office, sufficient parking accommodation and hard standing shades for vehicles shall be constructed by the Contractor.

The Contractor shall provide, for each office, office table and four chairs all of a standard approved by the Engineer.

Offices shall be maintained watertight and shall be provided with ventilation. All doors shall be fitted with approved locks.

Windows shall be provided with separate screens and blinds and shall have interior locking devices.

All offices complete with furnishings, fittings, access roads and hard standings shall be ready, for occupation by the Engineer, within four weeks of the date when the Contractor first occupies the site and not later than ten weeks after the issue of the Notice to Proceed.

All offices shall be regularly and properly cleaned as long as they are in use.

All access roads and hard standings shall be maintained in a well drained, conveniently trafficable condition, throughout the contract period.

The general location of the Field Office shall be decided by the Engineer in consideration of the Contractor's work plans. The field office shall be situated at locations that shall not be liable to flooding.

On completion of the contract the field office including furnishing shall become the property of the engineer.

1.2.2 Office Equipment

Minor items of field office equipment such as filing trays, punches, staplers etc. shall be supplied in reasonable quantities as requested by the Engineer.

Consumables such as paper, pens, files etc. shall be supplied in reasonable quantities as requested from time to time by the Engineer.

Upon completion of the Contract, the office equipment listed above shall become the property of the Department.

1.2.3 Sign Boards

The Contractor shall provide and maintain good condition at least two identification sign boards of a size to be specified by the Engineer, to be placed one at each end of the works. Each sign shall show:

- the name of the Project
- the name of the Employer
- all other details as may be required by the Engineer.

1.2.4 Survey Equipment

As per requirement of the programme survey equipment shall be provided on each contract site for use by the Contractor's and the Engineer's staff. List of such survey equipment are given below:

- 1 No. - Optical square
- 1 No. - Spirit level (metal 1 m long)
- 1 No. - Steel measuring tape 25m long
- 1 No. - Steel measuring tape 5m long
- 1 No. - Leveling staff 3m long
- 5 Nos.- Ranging poles
- 1 No. - Surveyor's plumb bob
- 1 No. - Wild T-1A theodolite with tripod (or equivalent).
- 1 No. - Wild NA-2 automatic level with tripod (or equivalent)
- 1 No. - Traversing targets with tripods.
- 1 No. - Measuring wheel.

Miscellaneous tools and minor items of survey equipment such as umbrellas, hammers, knives etc. shall be available on site in reasonable quantities at all times for use by the Contractor's and Engineer's staff.

Consumables such as pegs, stakes, string lines, paint, marking crayons, etc., shall be available on site in reasonable quantities at all times for use by the Contractor's and Engineer's staff.

Upon completion of the Contract, the survey equipment listed above shall remain as the property of the Contractor.

1.2.5 Responsibility for Offices and Equipment

The Contractor shall provide and maintain all the furnishings and equipment detailed and shall replace any equipment which is lost or irreparably damaged subject to the conditions that the Engineer shall ensure his staff to take all reasonable precautions in the handling, operation and transport of such equipment.

The Contractor shall pay all expenses in respect of water, electricity (where available), garbage cleaning etc. necessary for the running of the offices.

The Contractor shall supply all necessary labour such as office boys, cleaners, messengers, road men, and chainmen etc. to assist the Engineer and his staff in the fulfillment of their duties.

1.2.6 Measurement and Payment

Payment for all the Field Office, equipment, sign boards, photographs, services etc. detailed in this article shall be made as described below, where price and payment shall be full compensations for complying with this section of the Specification and the Conditions of Contract.

Payment of the rates for the Pay Items shall be full compensation for supplying, erecting and maintaining the Field Offices for the Engineer, including all furniture and fittings, access roads, office equipment, sign boards, etc. all in accordance with the requirements of the above provisions.

No separate payment shall be made to the Contractor for providing the survey equipment mentioned in Article 1.2.4 and their maintenance and repair, if necessary including the miscellaneous tools and minor items, as well as the mentioned consumables. Compensation for the above shall be deemed to be included in the other pay items in the Bill of Quantities.

Payment of Field Office shall be made by means of the following Pay items

	Unit
Provide, erect and maintain office for the Engineer including consumables	Lump Sum

1.3 MATERIALS TESTING

Notwithstanding the requirements stated in the detailed specifications for individual items, the following minimum tests shall be carried out in the LGED specific laboratories and in the field. In cases the testing facilities are not available in the LGED laboratory, the tests shall be performed elsewhere as directed by the Engineer-in-charge. All test types and quantities described in the following paras 1.3.1 to 1.3.4 are considered "Normal Testing", whereas anything beyond that in type and quantity is considered as "Special Testing". The Engineer may increase the frequency of testing as required.

1.3.1 Embankment and Pavement

1.3.1.1 Earthworks/Embankment Fill

Testing Frequency

The testing frequency shall be as follows:

ITEM & TYPES OF TESTS		TEST FREQUENCY
EMBANKMENT		
i)	Liquid limit/plastic limit	1 per Km but minimum 1 if it is less than 1 Km (Greater than one if soil character changes).
ii)	Maximum dry density (MDD)	1 per Km but minimum 1 if it is less than 1 Km (Greater than one if soil character changes).
iii)	Compaction test	1 per 500m ² per layer
iv)	Laboratory CBR	1 per contract (Greater than one if soil character changes).

1.3.1.2 Improved Sub-grade

Testing Frequency

ITEM & TYPES OF TESTS		TEST FREQUENCY
IMPROVED SUB-GRADE		
i)	Liquid Limit/Plastic Limit	1 per Km. (Greater than one if material character changes)
ii)	Gradation and F.M.	1 per Km (Greater than one if material character changes)
iii)	Laboratory MDD	1 set per Km (Greater than one if material

		character changes)
iv)	Laboratory CBR & Maximum Dry Density relationship.	1 per contract (Greater than one if material character changes)
v)	Field compaction Tests:	
	By Sand Replacement Method/Core Cutter Method or any other method accepted by the Engineer-in-Charge	1 per 100m per layer

1.3.1.3 Sub-Base**Testing Frequency**

ITEM & TYPES OF TESTS		TEST FREQUENCY
(a)	For approval of materials to be used in works the following tests are to be done	
i)	Water absorption	1 per 500m
ii)	AIV (Aggregate Impact Value)/ LAA (Los Angeles Abrasion)	1 per 500m
iii)	Laboratory CBR	1 per Km (Greater than one if material character changes).
iv)	Laboratory MDD	1 per 500m
v)	Gradation Test	1 per 500m (Greater than one if material character changes).
(b)	Field Test (Additional samples may be taken from pavement if necessary)	
i)	Compaction (Sand replacement Method or any other method accepted by the Engineers-in-charge)	1 per 100m per layer

1.3.1.4 Water Bound Macadam base course and hard shoulder**Testing Frequency**

ITEM & TYPES OF TESTS		TEST FREQUENCY
WATER BOUND MACADAM BASE COURSE AND HARD SHOULDER		
(a)	For approval of materials to be used in works the following tests are to be done	
i)	Water absorption	1 per 500m
ii)	AIV (Aggregate Impact Value)/ LAA	1 per 500m
iii)	Laboratory CBR	1 per 500m (Greater than one if material character changes)
iv)	Laboratory MDD (Additional samples may be taken from the pavement if necessary)	1 per 500m
v)	Gradation Test	1 per 500m (Greater than one if material character changes).
(b)	Field Test	
i)	Compaction (Sand replacement Method or any other method accepted by the Engineer-in-charge)	1 per 100m

1.3.2 Sealing and Surfacing**1.3.2.1 Bitumen Manufactures Certificates**

The contractor shall provide the Engineer with Manufactures Certificates relating to separate batches of bituminous material provided for sealing and surfacing operations.

These should include, but may not be limited to the following:

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a)	Penetration Grade
b)	Specific Gravity
c)	Softening Point
d)	Flash Point
e)	Solubility

The contractor shall perform the above tests on bitumen or as directed by the Engineer-in-charge.

1.3.2.2 Bitumen Application Rates

a)	Prime Coat
b)	Tack Coat
c)	Bituminous Surface Treatment
d)	Otta Seal

Testing Frequency:

Manual Spray rates shall be measured in liters for each 10m² of spray area. Mechanical spray rates shall be measured in liters per square meter of spray area.

1.3.2.3 Aggregates

Gradation of Combined Aggregate (Fine and Course)

Testing Frequency:

1 test per 500m (or greater than one if material character changes).

1.3.2.4 Bituminous Carpeting

(a) Bitumen Content

As per specification and on the basis of laboratory tests.

(b) Stability of Mixture

(c) Density of Mixture

As per specification and on the basis of laboratory tests.

1.3.1.5 Temperature Control

(a)	Prime Coat
(b)	Tack Coat
(c)	Bituminous Carpet
(d)	Bituminous Surface Treatment
(e)	Otta Seal Coat

Testing Frequency

- i) Temperature shall be checked during each day Prime Coat or Tack Coat operations as frequently as required by the Engineer.
- ii) For Bituminous Carpeting temperature shall be checked before mixing with aggregates, at the time of laying and also during rolling.

1.3.3 Concrete

1.3.3.1 Cement

- (a) Setting Time
- (b) Strength

Testing Frequency

Tests shall be carried out to determine the setting time and strength for each batch of cement prior to this cement being incorporated into the works.

1.3.3.2 Aggregates

(a) Coarse Aggregate

- (i) Gradation
- (ii) Water Absorption
- (iii) AIV or Los Angeles Abrasion
- (iv) Specific Gravity

Testing Frequency

The above tests shall be carried out for each days casting or per 15m³ of concrete, which ever provides the greater number of tests.

(b) Fine Aggregate

- (i) Grading
- (ii) F.M.

Testing Frequency

The above tests shall be carried out for each days casting or per 15m³ of concrete, which ever provides the greater number of tests.

1.3.3.3 Workability

- (a) Slump

Testing Frequency

The above tests shall be carried out as frequently as required by the Engineer and not less than one per hour during concreting operations.

1.3.3.4 Concrete Strength

- (a) Cube/Cylinder Strength at 7 days and 28 days
- (b) Density/Unit weight

Testing Frequency

At least 6 cubes/cylinders shall be kept from each class of concrete for each days casting or 15m³ of concrete for testing at 7 days and 28 days. The location in the structure of the concrete from which the samples were taken should be recorded.

1.3.4 REINFORCEMENT

1.3.4.1 Properties

- (a) Diameter
- (b) Unit/Weight
- (c) Tensile Strength

Only test Certificates issued by BUET or BIT shall be accepted by the Engineer.

Testing Frequency

The above tests shall be carried out when requested by the Engineer, for each batch and diameter of reinforcing bar provided per structure or as directed by the Engineer.

1.3.5 Payment**1.3.5.1 Normal Testing**

(a)	The cost of providing and transporting samples to the Laboratory specified by the Engineer shall be borne by the contractor.
(b)	The cost of all normal testing as specified in paras 1.3.1 to 1.3.4 are to be borne by the contractor at LGED current Standard Rates, or, if they cannot be carried out by the LGED laboratory, at the rate charges by the respective laboratory.

1.3.5.2 Special Testing

(a)	All tests instructed by the Engineer in type and quantity beyond those specified in paras 1.3.1 to 1.3.4 shall be paid to the contractor.
(b)	The cost of these tests is covered by a provisional sum. Only in case of failure of the test results to meet the required Specifications, the cost will be charged to the contractor.

	Unit
Pay item shall be	Provisional Sum

Note:

In addition to the above Tests thickness of every items on pavements should be checked at an interval of 100m or may be increased as directed by the Engineer-in-Charge.

1.4 CONTRACTOR'S GENERAL OBLIGATIONS**1.4.1 Health and Safety**

The Contractor shall in addition to complying with the specific requirements of the General Conditions and with the national standards of the Government of Bangladesh in respect of health and safety, observe and maintain standards, towards all of his employees, not less than those laid down by his own national standards or statutory regulations.

He should take all reasonable steps including training and safety drill to ensure the safety of all persons on the site, whether in his employ or not. Safety is paramount.

The Contractor shall provide all appropriate protective clothing and equipment for the work to be done and ensure its proper use. Where required safety nets, belts, belts harnesses and life belts and rescue works shall be provided. All safety and rescue equipment shall be fully maintained and available for use at all times.

The Contractor shall provide and maintain in prominent and well-marked positions all necessary first-aid equipment, medical supplies and other facilities. A sufficient number of trained personnel shall be available at all times to render first aid. A suitably equipped room shall be made available with beds and stretchers for emergency medical treatment, and a planned system for removal to hospital for authorized persons requiring further treatment shall be provided by the contractor.

The contractor shall report to the Engineer promptly and in writing particulars of any accident or unusual or unforeseen occurrences on the site, whether likely to affect progress of the work or not.

No payment would be made for services under this clause as the same shall be deemed to have been included in the general obligation of the Contractor.

1.4.2 Safety Relating to Temporary Structures

The contractor must submit complete design calculations plans and technical details of all proposed temporary structure for the Engineer's prior approval before their construction commences. The Engineer's approval will not relieve the contractor of any contractual liabilities.

The contractor must also ensure that all necessary safety regulations and precautions must be complied with during the erection, use and dismantling of temporary structures.

No separate payment will be made for temporary structures which are not scheduled in the Bill of Quantities. They will be deemed to have been included in the rate items listed in the Bill of Quantities.

1.4.3 Safety Relating to Navigable Waterways

The Contractor shall in addition to complying with the specific requirements of the General Conditions and with the national standards of the Government of Bangladesh in respect of navigable waterways, shall comply with all orders and directions given by the Engineer in respect of the safety of navigation and with requirement for marking, watching and lighting any structure, craft or equipment which may be used in the construction of the works.

The contractor shall not lay down or provide permanent moorings for his floating plant. The Contractor's temporary moorings shall be positioned and installed to the approval of the Engineer and the Bangladesh Inland Waterway Transportation Authority (BIWTA). Prior notification of their installation shall be officially given to BIWTA.

Spoil excavated or dredged by the Contractor shall not be deposited in such locations as will infill or cause silting up of existing low water channels.

The Contractor shall without delay raise and remove or recover any material, construction plant (floating or otherwise) or vessel belonging to or hired by him which may be sunk, stranded or gone adrift in the course of construction completion or maintenance of the works, or otherwise deal with the same as the Engineer may direct.

If the Contractor is unable or unwilling at once to fulfill his obligations under these Special Requirements the Employer shall be entitled to employ and pay other persons or entity to carry out such work as the Engineer may consider urgently necessary. The costs so incurred shall be recoverable from the Contractor by the Engineer.

The Contractor shall take all necessary precautions and measures to avoid interruption of services of the existing ferry or navigation as a consequence of his temporary works or construction of the permanent works.

No payment would be made for services under this clause as the same shall be deemed to have been included in the general obligation of the Contractor.

1.4.4 Environmental Requirement

The Contractor shall comply, in addition to the specific requirements of the General Conditions and other parts of these Specifications, with the requirements of the Environmental Monitoring guideline prepared in accordance with the requirement of Statutes/Law of Bangladesh and International standards. In respect of controlling damage to the environment and controlling pollution the Contractor shall be bound to follow the regulation/law of Bangladesh and any statutory bodies or the requirement of such laws of his own home country whichever is more stringent

(1) Specific Environmental Concerns

The specific environmental concerns are:

- *Emissions to air (dust, smoke etc.)*
- *Emissions to land (solid and liquid domestic & industrial waste etc.)*
- *Emission to water (dredge spoil, surface & foul water drainage etc.)*
- *Noise and visual pollution*

These are now described one by one while it will be indicated to which particular contract they are applicable.

(2) Emissions to air

- Generation of dust

The spread of wind blown soil particles derived from unpaved haulage and access roads, reclaimed areas and stockpiles of soil, and dust from rock handling may cause a problem during the dry season if strong winds prevail. Such dust may cause the health risks for the labourers and for the population living nearby.

As part of his obligation to minimize disturbance to other users, the Contractor is required to water unpaved roads under dry weather conditions and impose speed limits on access and haulage roads.

The nature of a major earthworks operation inevitably gives rise to a dust nuisance the effects of which are to be minimized as far as practicable by watering and route and speed control of vehicles. The dust nuisance from the Contractor's crushing plant is to be controlled by the use of water sprays.

- Air pollution

Exhaust emissions caused by the use of vehicles, machinery and other engine driven equipment used by the contractors should not exceed the exhaust emission standards as set forward in the tables below, which are based on the Bangladesh EQS for emission standards for gaseous exhausts.

Emission standard values for Motor Vehicle Exhaust

Parameters determinates	Unit	Standard Value
- Black smoke ⁽¹⁾	Hatridge Smoke Unit (HSU)	65(3)
- CO ⁽²⁾	g/m ³	24
- hydrocarbon ⁽²⁾	percent volume	4 ⁽⁴⁾
- NOx ⁽²⁾	g/m ³	2
	ppm	180
	g/m ³	2
	ppm	600

(1) measured at two thirds of maximum rotating speed

(2) whichever is lower out of two values expressed in two different units

(3) for vehicles more than 5 years old, or that have completed 80,000 km the standard value is 75 HSU

(4) Two and three wheeler vehicles with engine displacement less than cm³ the standard value is 5 volume percentage.

Emission standard values for Black Smoke Emission from boat/ship/vessel

Parameters	Unit	Standard Value
-Black smoke (1)	Hatridge Smoke Unit (HSU)	65 ⁽³⁾

(1) measured at two thirds of maximum rotating speed

The ambient air quality in and around the work site should meet the standard values for ambient air quality described in the following table. Regular maintenance of engines and equipment is considered to be important for reducing emissions. The Bangladesh EQS for air quality are presented in the next table.

Ambient air quality standards for different categories of environments.

Category of Environment	Concentration { µg/m ³ }			
	Suspended Particular Mater	SO ₂	CO	No.
Industrial and mixed use	500	120	5000	100
Commercial and mixed use	400	100	5000	100
Residential and rural	200	80	2000	800
Sensitive	100	30	1000	300

The category of environment of the area surrounding the work site can be characterized as rural. For ambient air quality the standards for residential and rural areas should therefore be met.

- Garbage separation
 - All chemical products must be collected separately from the "normal garbage"
 - Used oil must be collected into "used oil" drums
 - Used batteries must be collected in "used batteries" storage for recycling
 - Used oil fuel filters must be collected in a leakage free drum

Garbage collecting system: The location of the garbage containers will be set out in the plan of the working area and camp area. The garbage from any vessels will be brought ashore.

Garbage discharge: The garbage will be brought to a dedicated area approved for disposal by the Engineer.

 Other environmental procedures:

- Building/construction materials must be ordered from the stores in the exact amounts needed, if possible in the right size, to minimize wastage.
- All materials must be stored in the correct way.
- Leftover material (usable) must be re-used or recycled.
- Discharging or charging of chemicals shall take place above a "leakage bin".
- Cleaning of tools (painting) shall take place in a bin, suitable for handling solvents.
- Causing nuisance shall be kept to a minimum.
- The working area must be kept clean and tidy.
- The gaseous pollutant emissions shall be reduced by proper maintenance of the construction equipment.

(3) Emission to water

The Engineer is required to approve all work method associate with the excavating of soil below water level and subsequent disposal. Locations for disposal of soil excavated from below water level in order of preference are:

- (1) Disposal on land through hydraulic fill;
- (2) Disposal on char land if not occupied for agriculture;
- (3) Aquatic disposal into the deepest channels of the river,
- (4) During construction, the contractor shall ensure that the embankments, construction materials such as fill sand, and gravel are not washed out with the rainwater.

Unless approved otherwise, dredged material shall be deposited on land.

- Land disposal
 - Test have revealed the presence of any toxic or polluting substance in the river bed material.
 - the bunds or embankments for the hydraulic fill are to be of such quality that no spills or breaches occur, damaging neighboring land;
 - to prevent water logging of agricultural areas in the flood plains surrounding hydraulic fill areas, drains shall be constructed around the embankments to evacuate water by gravity to the river;
 - If the fill materials are taken from farm topsoil or upper layer, the contractor shall ascertain that the silt deposition is sufficient to rehabilitate the farmland within three years and the deposited soil is not at the expense of the fertility of adjacent properties.
 - Farmland shall be given the lowest priority in sourcing the fill materials. Farmlands shall be used only if there is no other alternative within 5 km from the construction site.
 - The use of dredge materials from rivers and creeks should be given priority especially if the materials are sandy and relatively free from organic materials compared to farmland topsoil.
 - The second preferred source of fill materials is excavation from pond construction. If the borrow pit is not used for aquaculture, it should be taken care to compact the side of the pit to prevent soil erosion and to introduce fish and other aquatic life to control insects such as mosquitoes.

 Equate disposal

The concentration of suspended sediment in the effluent from the excavation works, discharged into natural or existing water courses shall never exceed 4,000 ppm.

-  Disposal of dredged materials shall only take place on char land if not occupied for agricultural purposes or in the major river channel minimizing the impact on riverine transport and on aquatic (organisms living in or at the river bottom);

(4) Noise and visual pollution

 Visual pollution

The contractor shall ensure all temporary works are kept neat and tidy and the site cleaned regularly.

 Noise pollution

- Dense road side vegetation barriers shall be provided at sensitive sites.
- Good traffic control shall be provided at construction sites to minimize congestion and honking.

The Contractor, in planning his works must recognize the distinction between noise pollution as experienced by the villagers living around the works and noise hazards to the labour working on the construction site.

In the case of villagers the main forms of noise pollution will be:

- pile driving
- crushing plant
- generators
- haulage and compaction equipment
- earth and rock moving equipment is of consideration

These activities should be confined to day time operation and not after 10pm.

In the case of Contractors labour the impact of noise pollution on operators and adjacent personnel could be much more of a problem:

Ear protectors shall be used in any environment where the noise may exceed the level of 80 dB(A).

Notice boards must be placed in areas where the noise exceeds this level and where ear protectors must be worn. Noise levels should be measured if any doubt exists.

Spot checks shall be made by Engineer with the assistance of Department of Environment to verify whether ear protectors (a) are provided by the various contractor and (b) are in fact used by the labour working in the noisy area.

Pay Item shall be:

		Unit
Environmental Monitoring Plan	Provision for environmental monitoring	Km

1.4.5 Security

The Contractor's responsibility for the security and safe working environment of the site commences from the time possession is given to him by the Employer.

As soon as possible after possession has been given, the boundary of the site shall be marked out, and the contractor shall submit to the Engineer for approval his proposals for maintaining the boundary and the security within.

The Contractor's proposals shall include a security control system which shall consist of sufficient equipment and personnel to prevent unauthorized access and which can meet the prevailing circumstances to ensure the safety and security of persons and property on the site.

The Contractor shall erect and maintain at his own expense suitable and approved temporary fencing and gates to enclose certain areas of the works being carried out, the office and accommodation compounds, and other areas of land as may be necessary to implement his obligations under the contract or as directed by the Engineer.

All authorized persons shall be registered by the Engineer and this register shall be provided and maintained by the Contractor.

No payment will be made for services under this clause as the same shall be deemed to have been included in the general obligation of the Contractor.

1.4.6 Cleaning

(1) Description

During the period of construction activity the contractor shall maintain the works free from accumulations of waste, debris, and rubbish, caused by the constructions. At the completion of the works all waste and surplus materials, rubbish, tools, equipment and machinery shall be removed, all sight-exposed surfaces shall be cleaned and the project left in a condition ready for occupancy to the satisfaction of the Engineer.

(2) Cleaning During Construction

-  Execute regular cleaning to ensure that the site works, structures, temporaries, offices and accommodation quarters, are maintained free from accumulations of waste materials, rubbish, and other debris resulting from the site work operations and maintain the site in neat and orderly condition free from environmental hazards at all times.
-  Ensure that the drainage system is maintained free of debris and loose material and in an operational condition at all times.
-  Ensure that grass growing on the existing or newly constructed berms and side slopes is regularly trimmed and maintained.
-  When required, spray dry materials and rubbish with water to prevent blowing dust or sand.
-  Ensure that traffic signs and the like are regularly cleaned free of dirt and other materials.
-  Provide on-site drum containers for the collection of waste materials, debris and rubbish awaiting removal from site.
-  Dispose of waste material, debris and rubbish at designed dumping areas and in accordance with National ordinance and pollution laws.
-  Do not bury rubbish and waste material on the project site without the approval of the Engineer.
-  Do not dispose of volatile wastes such as mineral spirits, oil, or paint thinners in storm or sanitary drains or in places not approved by the Engineer or Statutory Authority having jurisdiction in such matters.
-  Do not dispose of wastes into streams or waterways.
-  Should it come to the Contractor's attention that the side drainage ditches or other parts or the drainage system are being used, whether by the Contractor's employees or by others for the disposal of anything other than surface water he shall immediately report the circumstances to the Engineer and shall take action as directed by the Engineer to prevent any further pollution from occurring.
-  At the completion of the Works the site shall be left clean and ready for use by the Employer. The Contractor shall also restore to original condition those portions of the

site not designated for alternation by the Contract Documents.



At the time of final cleaning, all pavements, curbs, and structures shall be inspected for physical damage before final sweeping. Paved areas of the site and all public paved areas directly adjacent to the site shall be broomed clean. Other surfaces shall be raked clean and all resultant debris shall be completely removed.

(3) Basis of Payment

No separate payment will be made for the Contractor's cleaning operations executed in accordance with this Clause of the specifications, the cost of this work being deemed to be included in the various lump sum pay items or unit rates of the tender for routine maintenance operations as specified in other Clauses of these Specifications.

1.4.7 Sanitation.

The contractor shall provide adequate water-borne sanitation and refuse collection and disposal complying with the laws of Bangladesh and all local By-Laws and to the satisfaction of the Engineer for all Offices, Laboratories, Workshops and houses etc. erected on the site. Adequate sanitary arrangement should be provided for the people working on the site preferably separate arrangement for the women workers.

Part-7: ROADS

2.0 EARTHWORKS

2.1 REPORTING & MONITORING

01. The Contractor shall keep a Site Order Book on site at all times
02. Instructions on the work and all site visits shall be recorded in the Site Order book.

2.2 CLEARING AND GRUBBING

2.2.1 Description

This work shall consist of all clearing and grubbing necessary for the performance of the work covered by the Contract in accordance with the Specification.

The clearing and grubbing shall consist of clearing the designated areas of all down timber, vegetation, rubbish and objectionable materials and shall include grubbing roots and stumps and disposing of all material resulting from the clearing and grubbing. It shall also include the demolition, removal and disposal of structures that obstruct the work except where provided for in Section 2.3 of this Specification.

Clearing shall be confined to the areas enclosed within the Site. Grubbing shall be confined to areas covered by the works.

2.2.2 Preservation of Property

The contractor is responsible for preservation and protection of property, trees, shrubs, gardens and landscape and liable to compensate damage claims, if any.

2.2.3 Methods of Execution

2.2.3.1 Clearing

Clearing shall consist of the removal and disposal of everything above ground level including overhanging branches except those things the Engineer directs are to be left undisturbed. The material to be cleared shall include but not necessarily be limited to trees, stumps, logs, bush, undergrowth, grass, crops, loose vegetable matter and structures unless provided for elsewhere.

Within the limits of earthworks tree stumps shall be completely removed.

Clearing shall also include the removal of existing fences, remnants of buildings, pavements, etc.

2.2.3.2 Grubbing

The original ground surface shall be disturbed as little as possible. Grubbing shall, therefore, be confined to major roots beneath the road embankment, ditches, canal diversions and footing excavations'. Topsoil shall be removed as agreed with the Engineer and will be measured as roadway excavation. Grubbing beneath the embankment shall be as per at the direction of the Engineer.

In agricultural areas where the ground has been formed into ridges of dikes, the ground shall be roughly leveled or graded to form a surface suitable for embankment foundation and to the satisfaction of the Engineer.

2.2.3.3 Ownership of Cleared Material

All cleared material shall, unless otherwise provided for in the Contract, be the property of the Department.

2.2.3.4 Disposal of Cleared Material

Cleared material which is not required will be known as waste. Waste shall be the property of the Contractor. Waste shall be removed from the Site by the Contractor and shall be disposed of by the Contractor at his own expense.

2.2.3.5 Measurement

Clearing and grubbing will not be measured

Neither the work of clearing nor grubbing disposal sites, material sites, nor imported borrow pit sites shall be paid for when such sites are outside the areas designated for clearing or grubbing and the Contractor is permitted to exercise his own option as to whether he elects to use such disposal sites or borrow pit sites.

2.2.3.6 Payment

Clearing and grubbing will be paid at a lump sum price. The payment shall be full compensation for furnishing all labour, materials, tools, equipment and incidental necessary to do the work and for doing all the clearing and grubbing in the designated area or as directed by the Engineer included the removal and disposal of all resulting material.

Pay item shall be:

	Unit
Clearing and Grubbing	Lump Sum

2.3 REMOVAL OF EXISTING STRUCTURE**2.3.1 Description**

This work shall consist of the satisfactory dismantling, removal and disposal or salvage, wholly or in part, of all the existing structures, substructures, bridges buildings, culverts etc., within the Site as indicated on the Drawings or as instructed by the Engineer.

All properties within the Site may have been removed by the owners before the Contractor takes occupation of the site. - All remaining fences, buildings, structures or encumbrances of any character, except those still to be removed or ordered to be salvaged upon or within the limits of the Site, shall be removed by the Contractor and placed carefully on the abutting property, or otherwise disposed of as indicated on the Drawings or as directed by the Engineer. Materials so removed, including any existing steel bridges, drain or pipes of culvert, which the Engineer may order salvaged, shall be carefully removed and shall become the property of the Department.

Where a structure is to be replaced, the existing structure shall be demolished to the level of foundation of the new structure or as directed by the Engineer. All material obtained from the demolished structures shall be removed except as otherwise specified or directed by the Engineer. For all other areas that will be used for any other purpose with the exception of roadways, existing structures shall be demolished to a level lower than the lowest elevation of the finished ground level as indicated on the Drawings or as provided by the Specifications except as otherwise directed by the Engineer.

2.3.2 Materials

Removed materials shall be the property of the Department unless otherwise stated in the Contract. Any materials not required by the Department shall be classed as waste and shall be disposed off by the Contractor at his own expense.

2.3.3 Methods of Execution

If the superstructure any portion of the structure is deemed fit for use elsewhere, the usable portions shall be marked and removed without damage and stockpiled neatly at an accessible point above high water level.

Recovered structural steelwork and Bailey bridge components shall, on the instructions of the Engineer, be removed from site to the XENs office compound as directed by the Engineer. All other usable materials shall be neatly stockpiled within the site at points approved by the Engineer.

All material which is not considered of value by the Engineer shall be removed by the contractor from within the limits of the Site at his own expense. Use of explosives will not be permitted except on direction of the Engineer.

2.3.4 Measurement

The work shall not be measured.

2.3.5 Payment

Removal of existing buildings, bridges, culverts, etc. shall be paid on a lump sum basis

The payment shall be full compensation for dismantling, removal and disposal of all materials including labour, equipment, tools and incidentals necessary to complete the work.

Pay item shall be:

	Unit
Removal of Existing Structures	Lump Sum

2.4 ROADWAY EXCAVATION

2.4.1 Description

The work shall consist of all the requirement excavation within the limits of the Site, the removal, hauling and proper utilization or disposal of all excavated materials and shaping of excavation and preparation of exposed surfaces of excavation on the entire length of the roadway, in accordance with these Specifications and to the lines, levels, grades, dimensions and cross section shown on the Drawings or as required by the Engineer.

Roadway excavation shall include the following:

- (a) All excavation indicated on the Drawings within the faces of the cross sections and excavation of all materials for side roads and intersections.
- (b) The removal and disposal of existing pavement, sidewalks, kerbs or kerbs and gutters within the limits of construction.
- (c) Excavations directed by the Engineer.

2.4.2 Materials

Excavated materials shall be the property of the Department and shall be classified as suitable and unsuitable soil and salvaged materials.

To be suitable as fill material as described above, the soil must not contain roots, sod or other deleterious materials and must conform to the requirements of Article 2.6.2. The Engineer will decide if the soil is suitable or unsuitable.

ifferent type of salvaged materials shall be stockpiled separately on site as directed by the Engineer and the Contractor shall remain responsible for these until such time as they are disposed off by the Engineer.

2.4.3 Construction Methods

2.4.3.1 General

All roadway excavation and embankment construction shall be performed as specified here and shall conform to the required alignment, levels, grades and cross sections. In case of over excavation, the contractor has to refill with suitable materials and compact to its original degree at his own cost.

2.4.31 Excavated Material used in the Works

Suitable soil from the roadway excavation may be used as fill material as shown on the typical cross sections and described in Section 2.6 of these Specifications provided that prior approval is obtained from the Engineer.

All suitable excavated material shall be used so far as practicable in constructing the roadway.

Where necessary, the excavated material to be reused for the Works shall be temporarily stockpiled in a suitable and safe area, in accordance with the instructions of the Engineer.

2.4.3.3 Waste

Unsuitable material and required roadway excavation in excess of that needed for construction of any part of the Works shall be known as waste. Waste material shall be disposed off in accordance with the instructions of the Engineer.

2.4.3.4 Unsuitable Materials

If unsuitable material is encountered at or below subgrade level in cut areas or at or below embankment foundation level in fill areas it shall be excavated to limits as directed by the Engineer and be backfilled in accordance with Section 2.6 of these Specifications.

2.4.3.5 Slopes

All slopes shall be finished in a neat and workmanlike manner and to accuracy appropriate to the material, and care shall be taken that no material is loosened below the required slopes.

2.4.3.6 Drainage

During construction, the road and ditches shall be maintained in such condition as to ensure proper drainage at all times. No excavation will be permitted in areas under water.

Ditches and channels shall be so constructed and maintained as to avoid damage to the roadway section.

2.4.3.7 Preparation of Excavated Area

The surface of the excavated areas shall be neat and workmanlike and shall have the required form, super elevation, levels, grades and cross section.

2.4.3.8 Measurement

All required and accepted roadway excavation including excavation of unsuitable soil shall be measured for payment in its original position and the volume determined in cubic meters by the end area method as computed from the original and final geometric cross sections of the required and completed work.

2.4.3.9 Payment

The quantities of road way excavation measured as specified above will be paid for at the Contract unit price per cubic meter. Such price shall include excavation, shaping and completion of all surfaces and for furnishing all labour, materials, tools, equipment and incidentals to complete the work including handling of excavated materials stock piling and disposing off surplus excavated materials to a place as directed by the Engineer.

Waste roadway excavation shall be the property of the Contractor and shall be disposed off at his cost to the satisfaction of the Engineer.

Excavation in suitable material which is to be used for embankment fill material shall not be measured separately.

Excavation in borrow pits whether within the Site or not shall not be paid under this item but shall be deemed to be included in the relevant fill item.

The above price and payment shall be full compensation for all work involved in performing the roadway excavation completely as shown on the Drawings and as specified in these Specifications and as directed by the Engineer, including the cost of temporary stockpiling, selecting and protecting the materials to be reused.

Pay item shall be:

		Unit
(i)	Road way excavation in any classified material and disposal of spoil to fill in embankment, stockpile or otherwise.	Cubic meter
(ii)	Road way excavation (Picking up flat soling and HBB)	Square meter
(iii)	Road way excavation in Edging	linear meter
(iv)	Road way excavation in sub-base, base, WBM & RCC pavement	Cubic meter

2.5 CHANNEL EXCAVATION

2.5.1 Description

This work shall consist of excavation for channels/ditches and ponds and for discharging water from side ditches where shown on the Drawings, required in the Specifications or directed by the Engineer. The work shall include the proper utilization and hauling or disposal of all excavated materials, and constructing, shaping and finishing of all earthworks.

2.5.2 Materials

Excavated materials shall be classified as unsuitable and suitable soil.

To be suitable as fill material as described above, the soil must not contain muck, roots, sod or other deleterious materials and must conform to be requirements of Article 2.6.2. The Engineer will decide if the soil is suitable or unsuitable and whether such soil can be used in the roadway, or shall be waste for the disposal by the Contractor at his own expense.

2.5.3 Construction Methods

2.5.3.1 Alignment and Levels

Channel work shall be constructed in a neat and workmanlike manner correct to alignments, levels, grades and cross sections required on the Drawings, in the Specifications or by the Engineer

2.5.3.2 Excavation

Deepening and realignment of existing canals and channels shall be carried out in a way to allow free flow of water

During excavation of new channels these shall as far as possible be kept drained.

All suitable materials removed from the excavation shall be used as far as practicable in constructing the roadway.

2.5.3.3 Filling of Obsolete Channels

Any obsolete canals and channels within the embankment area shall be cleaned up and backfilled with sand (FM 0.80) to obtain sufficient stability. When sand fill is at a level of 500mm above water level, compaction shall be carried out as specified in Section 2.6.

2.5.3.4 Waste

Unsuitable material from channel excavations shall be known as waste and shall be the property of the Contractor. Waste shall be removed from the site by the Contractor and disposed off by the Contractor as his own expense and to the satisfaction of the Engineer.

2.5.4 Measurement

Quantities of channel excavation in any material shall be measured in cubic meters determined by end area methods computed from the original and final geometric cross sections of the authorized and completed excavation

Payment for backfilling of existing channels shall be in accordance with Section 2.6.

2.5.5 Payment

This work measured as provided above shall be paid for at the Contract unit price per cubic meter. The payment shall be full compensation for all excavation, for maintaining free flow in the channel where necessary and for all labour, materials, tools equipment and incidentals necessary to complete the work.

The above prices and payments shall be full compensation for all work involved in performing the channel excavation completely as shown on the Drawings and as specified herein and as directed by the Engineer.

Pay item shall be:

	Unit
Channel Excavation in any material and disposal to fill, stockpile or otherwise	Cubic meter

2.6 EMBANKMENT

2.6.1 Description

This work shall consist of the construction of embankment and fill by furnishing, placing, compacting and shaping suitable material of acceptable quality obtained from approved sources in accordance with these specifications and to the lines, levels, grades, dimensions and cross sections shown on the Drawings or as required by the Engineer

The location of borrow pit shall be approved by the Engineer and must be at a distance of 3.0m or 1.5 times the height of the embankment, whichever is higher from the toe to the designed embankment. The depth of excavation in borrow pits shall not exceed 0.8m under normal conditions.

2.6.2 Materials

All fill materials shall be free from roots, sods or other deleterious materials.

Materials for embankments shall be stockpiled outside the working areas. Materials shall be tested and approved by the Engineer.

The selected fill so stockpiled shall satisfy the following criteria:

- Liquid limit of fraction passing 425 micron sieve shall not exceed	50%	STP Sec. 3
- Plasticity index of fraction passing 425 micron sieve shall not exceed	20%	

- The dry density after compaction in embankment layers more than 300mm below subgrade level shall not be less than 90% of the maximum dry density as determined in accordance with STP T4.5 (Standard Compaction).
- The dry density after compaction in embankment within 300mm below the top of the subgrade level (or such greater depth if shown on the plans and drawings) shall not be less than 95% maximum dry density as determined in accordance with STP T4.5 (Standard Compaction).
- Soaked (4 day) CBR greater than 4% at 95% MDD (STD).

- The moisture content at the time of compaction shall be the optimum moisture content (Standard Compaction) : +5%.
- Sampling to be carried out as per STP Section 2 and Sub-section 4.1 .

In case if the embankment material is sand, side slopes and shoulders shall be covered by cohesive soil of PI value In between 8-20%.

2.6.3 Construction Methods

2.6.3.1 Preparation of Foundation for Embankment

Prior to placing any embankment upon any area, all clearing and grubbing operations shall have been completed in accordance with Section 2.2 and excavation under carriageways shall be carried out in accordance with Section 2.4.

The original ground surface should be prepared by scarifying, watering, aerating and compacting. The dry density after compaction shall not be less than 90% of MDD (STD).

Embankments in swamps or water shall be constructed as indicated on the Drawings and as described in these Specifications. The Contractor shall, when ordered by the Engineer, excavate or displace swampy ground and backfill with suitable material (refer to paragraph 2.4.3.4). Such backfill shall be river or beach sand unless otherwise directed by the Engineer.

3.6.3.2 Placing of Embankment

(a) General

Except as otherwise required by the Drawings, all embankments shall be constructed in layers approximately parallel. to the finished grade of the road bed. During construction of embankment, a smooth grade having an adequate crown shall be maintained at all times to provide drainage.

The placing of fill shall be carried out In successive layers for the full width of fill as shown on the Drawings and in 500m lengths unless otherwise directed by the Engineer. The layers shall not exceed 150mm in thickness on completion of compaction.

When embankment fill is placed adjacent to structures it shall be performed in accordance with the direction of the Engineer.

(b) Placing Embankment over Swampy Ground

Where new embankment will overlay existing canals, ditches, ponds or other waterways, these shall be filled in exclusively with sand in accordance with paragraph 2.5.3.3. Prior to filling, cofferdams shall be made to allow pumping and the bed shall left to dry until approved by the Engineer for filling. The works of damming, pumping and drying will not be an item for payment, but will be considered to be included in the rates for earthworks fill.

(c) Widening Existing Embankment

Where embankment fill is being carried out to widen an existing embankment the new fill material shall be fully keyed into the old embankment by means of benching which shall be in steps each not less than 300mm high and 600mm wide. Steps shall be cut in advance of the filling. Material cut in benches may be used as fill if it compiles with Article 2.6.2 above or as directed by the Engineer.

(d) Embankment Fill from Roadway Excavation

Existing Sub-grade within 300mm depth of the existing road level, (or as specified) not having the required percentage of compaction, shall be excavated out.

Provided the excavated material is in accordance with article 2.6.2 then it shall be reworked and reused in widening or raising the embankment to the specified percentage of compaction and in accordance with paragraph 2.6.3.3.

No payment will be made for excavation under this item and it will be deemed to be included in the rates in accordance with Article 2.6.5.

Where the item "embankment fills from roadway excavation" is used and paid for there shall be no separate payment for sub-grade preparation under section 2.7.

(e) Cladding Layer

Where the embankment fill consists of sand it will require a cladding layer of soil having Plasticity Index of 15 to 20. This layer shall cover the embankment slope and the earthen shoulder. After placing the cladding will be compacted in the desired level, trimmed and finished to the desired line, level and grade.

2.6.3.3 Compaction of Embankment

Embankment shall be constructed in not more than 150mm compacted layers. When necessary, each layer, before being compacted, shall be mixed with dry material or otherwise processed to bring the moisture content to within the limits established in Article 2.6.2 above. The material shall be so worked as to have a uniform moisture content through the entire layer (STP Sec. 4).

Each layer of material shall be compacted uniformly by use of adequate and appropriate mechanical compaction equipment. The compaction shall be carried out in a longitudinal direction along the embankment and shall generally begin at the outer edges and progress toward the centre except in the super elevated area in such a manner that each *section receives equal compactive effort*.

Compaction equipment shall be operated over the full width of each layer insofar as practicable.

Samples to determine the compaction shall be taken regularly with a minimum one sample for each full width 100 linear meters of a finished layer or as directed by the Engineer. Such density tests will be carried out according to STP T5.1. The compacted layer shall be approved by the Engineer before the Contractor can commence a new layer. If the test results show that the density is less than the required density the Contractor shall carry out further compaction to obtain at least the required density.

2.6.3.4 Overfilling

To ensure that, the embankment is properly compacted up to the edges of each layer, overfilling and compaction of approx. 300mm horizontally on both sides of the embankment is required, which later on has to be cut and removed. No extra payment will be made for this procedure.

2.6.4 Measurement

Embankment shall be measured in cubic meters based on cross sections compacted and accepted in place. The volume to be measured will be the net volume of required and accepted embankment, actually constructed and completed in accordance with the Specification, to the lines, levels, grades and cross sections required or as directed by the Engineer.

The cross section to be used will be the area bound by the subgrade (below improved subgrade or sub-base) the side slopes or edge limits and the original ground line.

No allowance will be made for material cut in benching operations.

The final volume of embankment fill shall not include the voids for bridges and box culverts. The voids for pipes, manholes, catch basins and the like will not deducted.

2.6.5 Payment

This work measured as provided above shall be paid for at the Contract unit prices per cubic meter. Payment shall be full compensation for performing the work, furnishing the materials and providing all labour, equipment, tools and incidentals necessary to complete the work, including all payments for obtaining, carrying and stockpiling of the embankment fill.

Pay item shall be:

	Unit
Embankment fill from any approved source outside the site	Cubic meter
Embankment fill from roadway excavation	Cubic meter
Providing cladding layer in earthen shoulder and slope with	Cubic meter

suitable material	
Sand backfill to Swamp	Cubic meter

2.7 PREPARATION OF SUBGRADE

2.7.1 Description

This work shall consist of the preparation of subgrade in embankment in cut by scarifying, watering, aserating, compacting and shaping existing or previously placed material in accordance with these specifications and to the lines, levels grades, dimensions, camber and cross sections shown on the Drawings or as instructed by the Engineer.

This item shall only be applicable where the existing embankment level is within 440mm of the designed formation level.

2.7.2 Materials

All subgrade material shall be suitable material in accordance with the requirements of Article 2.6.2.

Any subgrade material in cut or existing old embankment which is found to be unsuitable shall be removed and replaced as directed by the Engineer.

2.7.3 Construction Methods

The subgrade shall be prepared over the full width of the embankment including shoulders. Half width working may be allowed only with the prior written approval of the Engineer.

The subgrade shall be prepared in lengths of not less than 1 00 meters and not more then 500 meters at a time.

Existing subgrade material shall be excavated to a depth of 150mm and stockpiled and a further 150mm should be scarified and compacted. The excavated top layer material shall then be spread and compacted as specified.

When necessary, each layer, before being compacted, shall be allowed to dry or be watered to bring the moisture content with $\pm 5\%$ of optimum to make possible its compaction to the required density. The material shall be so worked as to have a uniform moisture content through the entire layer (STP Section 4 or 5).

The subgrade material shall be compacted uniformly by use of adequate and appropriate mechanical compaction equipment. The compaction shall be done in a longitudinal direction along the embankment and shall generally begin at the outer. edges and progress toward the centre in such a manner that each section receive equal compactive effort.

Samples to determine the compaction shall be taken regularly with at least one. satisfactory sample for each 100 linear meters per finished layer or as directed by the Engineer. Such density tests will be carried out according to STP T5.1. STP T 4.5 (Standard Compaction) the Contractor shall carry out further compaction to obtain at least the required density.

The subgrade material will be tested for CBR in accordance with STP- T6.1. The subgrade material shall be compacted to 95% Maximum dry density as determined by STP T4.5 (Standard Compaction), with at least one satisfactory sample per 100 liner meters per finished layer. Where existing ground or embankment is encountered at sub grade level, then a minimum of one satisfactory CBR test shall be performed per contract or more frequently if the material character changes. If the CBR proves to be unsatisfactory then appropriate steps will be ordered by the Engineer in writing.

2.7.4 Measurement

Subgrade preparation shall be measured in square meters based on the surface area of compacted subgrade, in accordance with the specification, to the lines, levels, grades and cross sections required as directed by the Engineer. No allowance will be made for overlapping of areas due to half width working.

2.7.5 Payment

This work measured as provided above shall be paid for at the contract unit price per square meter. Payment shall be full compensation for performing the work and providing all labour, equipment, tools and incidentals necessary to complete the work.

The rates shall include the cost of furnishing the additional subgrade materials to reach a compacted thickness of 300mm.

Pay item shall be:

	Unit
(a) Preparation of subgrade 300mm compacted depth	Square meters

The surface of the finished subgrade shall be neat and workmanlike and have the required form, super elevation, levels, grades and cross section. The finished surface shall be constructed with a tolerance of 20mm above or below the specified levels at any point. Separate item for this where no subgrade operation required.

2.8 IMPROVED SUBGRADE

2.8.1 Description

This work shall consist of furnishing placing and compacting improved sub-grade material on a prepared and accepted subgrade in accordance with these Specifications and to the lines, levels, grades, dimensions and cross sections shown on the Drawings or as instructed by the Engineer.

2.8.2 Materials

Material shall be of natural sand or soil or mixture of sand and soil, free from vegetable matter, from soft particles and from excess clay. If the material is sand the F.M. shall not be less than 0.8.

- (a) **Plasticity:** The fraction passing the 425 micron sieve shall, have a Plasticity Index not greater than 10 (STP Section 3).
- (b) **CBR:** The material shall have a soaked CBR value not less than 8% when compacted to 98% of maximum dry density as determined by STP T 4.5.
- (c) The material shall be free draining.

2.8.3 Construction Methods

2.8.3.1 Preparation of Subgrade

The subgrade shall be shaped and compacted in conformity with the provisions of Section 2.7 and completed for at least 100 meters ahead of the placing of the improved subgrade material. Notwithstanding any earlier approval of subgrade, any damage to or deterioration of subgrade shall be made good before improved subgrade is laid.

Preparation of the subgrade shall be carried out, unless otherwise agreed by the Engineer, immediately prior to laying the improved subgrade.

2.8.3.2 Spreading

All subgrade drainage shall be completed prior to spreading the improved subgrade material.

Improved subgrade shall be spread in layers, with a compacted thickness up to 150mm subject to the approval of the Engineer, and the layers shall be as nearly equal in thickness as possible.

Prior to spreading the improved subgrade, a partial width of shoulder, not less than 750mm wide, shall be constructed to the elevation of the top of each uncompacted layer being placed and the inside edge made as straight as practicable. After the partial completion of the shoulders, the improved subgrade shall be spread upon the subgrade and against the previously formed shoulders, in layers of uniform thickness, as herein specified, to give the required compacted depth shown on the Drawings.

2.8.3.3 Sprinkling, Rolling and Compacting

Immediately after each layer has been spread and shaped to camber or super elevation satisfactorily, it shall be thoroughly compacted with mechanical compaction equipment approved by the Engineer. Rolling operations shall begin from the outer edge of roadbed toward the centre, gradually in a longitudinal direction, except on super-elevated curves, where rolling shall begin at the low side and progress towards the high side

The moisture content at the time of compaction shall be the optimum moisture content (Standard Compaction) $\pm 3\%$.

Each layer shall be compacted to at least 980/0 of the maximum dry density as determined by STP T 4.5. 3 Nos. in situ density tests in accordance with STP T5.1 or T5.5 shall be taken each 1 00 linear meters of compacted improved sub-grade.

If the density measurement checks fall below the specified density level then recompaction, shall be required, irrespective of the field compaction trial results.

In order to ensure uniform bearing capacity at the finished improved subgrade level CBR measurements shall be made. The CBR shall be such that the Laboratory Value obtained tested in accordance with STP T6.1, at the specified compaction and after 4 days soaking, shall exceed 8 percent. In areas where these requirements are not met, correction shall be made by such measures as the Engineer deems necessary

Improved subgrade material which does not contain sufficient moisture to be compacted in accordance with the requirements of this section shall be reworked and watered as directed by the Engineer. The Contractor shall carry out this work at his own expense.

Improved subgrade material containing excess moisture shall be reworked and dried prior to or during compaction. Drying of wet material shall be performed by methods approved by the Engineer, at the expense of the Contractor.

The finished improved subgrade at any point shall not vary more than 20mm above or below the planned grade or adjusted grade. The thickness of the finished improved subgrade shall be on average not less than the required thickness and not thinner than 20mm less than the required thickness at any point and the average of five thickness measurements in any 100 meters of road shall be not thinner than 15mm less than the required thickness. Improved subgrade which does not conform to the above requirements shall be reworked, watered and thoroughly recompacted to conform.

2.8.4 Measurement

Improved subgrades described in this article shall be measured by the cubic meters of material compacted in place and accepted. Measurement shall be based on the average width and thickness of the improved subgrade shown on the Drawings or instructed by the Engineer and actual length measured horizontally along the centerline of the surface of the road

2.8.5 Payment

This work measured as provided above shall be paid for at the Contract unit rate per cubic meter for improved subgrade as detailed below. The payment shall be full compensation for furnishing all materials, hauling, placing, compacting, sprinkling, finishing and shaping, and for all labour, equipment, tools and other incidentals necessary to complete the work specified.

Pay item shall be:

	Unit
Improved Sub-grade	Cubic meter

2.9 PREPARATION OF IMPROVED SUBGRADE

2.9.1 Description

This item will consist of leveling, dressing, cambering and compacting the existing improved sub-grade surface exposed after removal of the brick flat soling, HBB and the edging to receive new sub-base and base course. Where necessary additional improved sub-grade materials shall be added to make the finished compacted improved subgrade as per drawing

2.9.2 Materials

Materials should meet the requirements of Article 2.8.2

2.9.3 Construction Method

The picking up of the brick pavement shall not done for more than 100m at a time in order to avoid disturbance to traffic and damage to the sub-grade. The salvaged bricks shall be stacked separately from half or broken bricks on such a way that disturbance to traffic is minimized.

Before picking up the brick pavement the contractor must provide sub-base or base materials ready at the site so that this shall be placed and compacted immediately after preparation of the improved subgrade.

The improved subgrade shall be levelled, graded and cambered according to the design and compacted to 98% of MOO (STO) using an appropriate roller. Where necessary additional improved subgrade materials shall be added to make the finished compacted thickness as per drawing.

2.9.4 Measurement

The preparation of improved subgrade shall be measured in square meters.

2.9.5 Payment

The payment will be in full compensation for doing the work according to Specification and drawings including supplying of additional materials, if any, labour, tools and machineries for leveling, dressing, cambering, and compacting the Improved subgrade.

Pay item shall be:

	Unit
Preparation of Improved subgrade	Square meters

2.10 SUBGRADE DRAIN

2.10.1 Description

This work shall consist of excavation, furnishing material, backfilling and finishing drains to the prepared and accepted subgrade in accordance with Specifications and the dimensions and cross sections shown on the Drawings or as instructed by the Engineer.

2.10.2 Materials

The material for backfilling of subgrade drains shall be clean free draining sand and gravel, free from any vegetable matter, soft particles, silt or clay.

The grading of the material shall conform to the grading shown in Table 2.10-1.

Table 2.10-1: Grading requirements of Drain Backfill Material

Sieve Size	% Passing by Weight
10mm	100
4.8mm	80-100
2.4mm	65-95
1.2mm	50-80
600 micron	25-50
300 micron	10-20
150 micron	0-10
75 micron	0-2

2.10.3 Construction Methods

Subgrade drains shall be excavated neatly by hand in the prepared subgrade to dimensions and grades shown on the Drawings or directed by the Engineer.

Drains shall be constructed at the intervals shown on the Drawings and details of it as shown on the drawings. Drains on opposite sides of the road shall be staggered.

The excavation shall be backfilled with material in accordance with Table 2. 10-1.

The backfill shall be compacted by hand ramming and struck off level with, or slightly above, the finished subgrade level.

The finished backfill shall be immediately covered with jute fabric material to act as a filter which shall extend 150mm beyond the edges of the drain on all exposed faces. Any joints in the fabric shall be overlapped by at least 150mm. Jute fabric shall be held in place by suitable means to prevent its movement during construction operations.

Shoulder and pavement materials over the drain and jute fabric shall be placed carefully by hand for a depth of not less than 100mm prior to placing and rolling of the general shoulder and pavement materials.

2.10.4 Measurement

Subgrade drains shall be measured in linear meters of drain completed and accepted.

Drains shall extend from a point vertically below the outer edge of the carriageway surfacing layer to the finished face of the embankment, or side ditch, side slope. In the event that the Contractor constructs the embankment to dimensions in excess of those shown on the plans and sections the Contractor shall extend the subgrade drains to the embankment face at his own expense.

2.10.5 Payment

The work measured as provided above shall be paid at the Contract unit rate per linear metre. Payment shall be full compensation for performing the work and providing all labour, equipment, materials, tools and incidentals necessary to complete the works.

Pay item shall be:

	Unit
Subgrade drains	Linear meter

PART-7: ROADS

3.0 PAVEMENT WORKS

3.1 INTRODUCTION TO PAVEMENT WORKS

3.1.1 General

Section 3 of these Specifications covers all requirements for road pavements that will be incorporated in the works

3.1.2 Preparation and Stockpiling of Materials

Materials to be used in pavement works shall be processed and stockpiled only in areas designated by the Contractor as approved by the Engineer. Preparation and storage of materials along the alignment will not be allowed. The Contractor shall make all arrangements and bear all costs associated with the provision of these storage areas.

The designated areas shall be cleared of all vegetation and topsoil prior to commencing of work and the arrival of any materials.

Bricks of different frog marks, different materials and size fractions shall be kept in separate stockpiles divided as necessary to prevent contamination.

The site of the stockpile shall be cleared of all vegetation and debris, graded and drained and where the Engineer deems it necessary, the areas shall be surfaced with a 100mm layer of approved stone or with brick flat soling.

Each stock pile shall be built with a maximum height of 1.25m or as specified by the Engineer-in-Charge with sufficient space left in between two stacks for easy inspection.

The bottom 50mm layer of aggregate or any contaminated aggregate shall not be used in the work.

3.1.3 Brick Aggregates/Stone Aggregates

Brick aggregates may be replaced by stone aggregates. In case of improved shoulder/sub-base both crushed and uncrushed stone can be used; in case of base course only crushed stone may be used provided that the quality of the stone satisfies the relevant specifications. No extra cost will be paid for replacing the brick aggregates by stone.

3.2 SHOULDERS

3.2.1 Improved Shoulders

3.2.1.1 Description

This work shall consist of providing, laying and compacting Aggregate-Sand-hard shoulder on the prepared and accepted Improved Sub-grade to the lines levels, dimensions, and cross section shown on the Drawings or as directed by the Engineer. The soaked CBR of AS sub-base should be more than 65% when compacted to 100% of MOD. However the proportion would be subjected to refixation at the time of designing if the situation is different. The materials for improved shoulder shall of the quality same as those of Base Coarse.

3.2.1.2 Materials

The material shall consist of a homogeneous mixture of crushed brick aggregate, local sand and soil. The PI value of soil should not be of soil, but of combined material and should not be more than 6 (portion passing # 40 or .425mm sieve).

The aggregate shall be crushed First class and or Picked Jhama Bricks. The crushed bricks shall comply with the following requirements:

- water absorption shall not exceed 18%
- maximum nominal size of aggregate shall be 38mm.
- Aggregate Impact Value of not more than 32 or Los Angeles Abrasion 45 or as directed by the Engineer in the case of reuse of salvaged materials.
- the unit weight shall comply with the minimum values stated in Article 3.3.2a of these Specifications.

The Material shall conform to the grading envelope shown in Table 3.2-1 given below and have a 4 days soaked CBR value not less than 35% when compacted to 100% of maximum dry density as determined by STP T 4.5.

Table 3.2-1: Grading Requirements for Improved Shoulder

Sieve Size	% Passing by Weight
38mm	100
25mm	80-95
10mm	60-80
2mm	40-60
# 200 Sieve	0-15

3.2.1.3 Construction Methods

The Improved Shoulder materials shall be at or near the optimum moisture content (OMC) at the time of placing. The brick aggregate, sand and soil shall be mixed thoroughly to obtain a homogeneous mix complying with the grading requirements of this Section. Water shall be added during mixing to keep the mixed material moist so as to prevent segregation during transportation.

The compacted thickness of improved I shoulder should be minimum 150mm. Prior to laying the Improved shoulder, the existing surface shall be watered. The mixed Improved Shoulder material shall then be spread in equal layers so that the compacted thickness of each layer shall not be more than 150mm. On completion of the spreading and watering, the surface shall be shaped according to the cross-section shown in the drawing and compacted using approved mechanical compaction plant. Compaction shall continue until the material has attained the required density. The Improved Shoulder shall be compacted to have 100% maximum dry density (Standard) and soaked CBR of 35%. The field density shall be checked at least once every 250 linear meters of hard shoulder surface. Moisture content at the time of compaction shall be optimum moisture content $\pm 3\%$.

The finished surface of the base course shall in no place be more than $\pm 10\text{mm}$ from the designed level longitudinally. But in no case the thickness of the hard shoulder shall vary $\pm 5\text{mm}$.

3.2.1.4 Measurement

The Improved Shoulder shall be measured in cubic meters. It shall be based on the average width and thickness of improved shoulder course as shown on the drawings and the actual length measured horizontally along the centerline of the surface of the road.

3.2.1.5 Payment

This work as measured above shall be paid for at the Contract unit price for improved shoulder course. Payment shall be full compensation for performing the work as per specification including furnishing the materials, water, carrying out all placing and compaction etc. all complete is including other incidental charges.

Pay item shall be:

	Unit
Improved Shoulder Course	Cubic meter

3.2.2 Earth Shoulders

3.2.2.1 Description

This work consists of the provision of specified wide strips of shoulders adjacent to the pavement on either side. The shoulders shall be constructed in accordance with the lines, levels, dimensions and cross sections shown on the Drawings and as directed by the Engineer.

3.2.2.2 Materials

The material used shall meet the same requirements as that shown in Sections 2.6.2.

3.2.2.3 Construction Methods

Pre-work measurement should be taken just before commencing the work. The material shall be spread in layers of uniform thickness to achieve 150mm of compacted thickness and sprinkled with water. After approval by the Engineer, compaction shall be carried out on each layer by approved mechanical plant. The material shall be compacted to a density of 95% of the maximum dry density as determined by STP T 4.5. Samples to determine the compaction shall be taken regularly with a minimum one sample for each 100 linear meters per layer of each finished shoulder or as decided by the Engineer. Such density tests will be carried out according to STP T5.1. The compacted layer shall be approved by the Engineer before the Contractor can commence a new layer. If the test results show that the density is less than the required density the Contractor shall carry out further compaction to obtain at least the required density.

3.2.2.4 Measurement

This item of work shall be measured in cubic meters of the completed accepted works on the basis of pre and post work. The volume to be measured will be the net volume of required and accepted shoulder, actually constructed and completed in accordance with the Specification, to the lines, levels, grades and cross sections required or as directed by the Engineer.

3.2.2.5 Payment

Payment will be made as per the requirements of Article 2.6.5

3.3 BRICK ON END ENDING

3.3.1 Description

This work consists of provided and placing brick on end edging along the road adjacent to the side of the pavement of single layer brick flat soling and herringbone bond brick or of water bound macadam and bitumen carpet.

3.3.2 Materials

The materials shall consist of First Class or Picked Jhama Bricks which should meet the requirements given below.

(a) Bricks

First Class Bricks shall be made from good brick earth free from saline deposits, and shall be sand moulded. They shall be thoroughly burnt by coal without being vitrified, of uniform and good colour, shall be regular and uniform in size, shape and texture with sharp square edges and parallel faces. They must be homogeneous in texture and emit a clear metallic ringing sound when struck one against the other. They shall be free from flaws, cracks, chips, stones, modules of lime or canker and other blemishes. A first Class Brick shall not absorb more than 16% of its weight of water after being soaked for one hour, and shall show no sign of efflorescence on drying.

Picked Jhama bricks are those which are so over burnt as to become vitrified. Those bricks may be broken and used for aggregate in road works provided the vitrified mass has not become porous or spongy as a result of over burning and the aggregate satisfies the

requirements of those Specifications.

First Class Bricks should have the following dimensions after burning: 250mm x 120mm x 70mm. Picked Jhama Bricks may have dimensions slightly below those for other brick but not less than 235mm x 110mm x 70mm. The unit weight of First Class Bricks shall not be less than 1100 kg per m³ and the unit weight of picked Jhama Bricks shall not be less than 1200 kg per m³.

The crushing strength of bricks shall be tested in accordance with ST 7.9. The average crushing strength of Bricks shall not be less than 17 N/mm².

3.3.3 Construction Methods

Bricks shall be laid on end edging with their longest side vertical and 75mm/125mm side across the road including necessary excavation filling and ramming to the satisfaction of the Engineer. The completed work shall be true to line and level and grade as indicated on the Drawings. Interstices between brick edging and adjacent paving or soling shall be filled by brushing in sand until voids are filled; the edging shall be sprinkled then with water.

3.3.4 Measurement

This item shall be 'measured in linear meters of completed brick on end edging.

3.3.5 Payment

This work shall be measured as provided above and shall be paid for at the Contract unit price per unit of measurement. The prices and payment shall be full compensation for preparation of the edging including excavation, furnishing and placing of materials, backfilling, ranging including provision of labour, equipment, tools and incidentals necessary to complete the works as specified in this Section.

Pay item shall be:

	Unit
Brick on end edging	Linear meter

3.4 SINGLE LAYER BRICK FLAT SOLING

3.4.1 Description

This item consists of providing single layer brick flat soling on the sub-grade or improved subgrade as directed by the Engineer.

3.4.2 Materials

The materials shall consist of First Class or Picked Jhama Bricks which meet the requirements of Article 3.3.2a of these Specifications.

3.4.3 Construction methods

The bricks shall be laid flat in one layer or as specified on the consolidated and prepared surface. Bricks shall be laid in a regular and uniform manner. Interstices of bricks shall be filled with sand of FM 0.8 and water shall be applied by sprinkling. No bricks shall be laid on a foundation or any surface until the same has been inspected and approved by the Engineer. The gaps between two adjacent bricks should not exceed 10mm. The pattern and placing of the bricks shall be as indicated in the drawings.

3.4.4 Measurement

Brick flat soling shall be measured in square meters for areas covered by the same.

3.4.5 Payment

This item of work shall be measured as provided above and shall be paid at the Contract unit price. The price and payment shall include all costs for completion of the work and supply of all required

materials, including cost of all labour, equipment, tools and incidentals necessary to complete the works' as specified in this section.

Pay item shall be:

	Unit
Single layer brick flat soling	Square meter

3.5 DOUBLE LAYER BRICK FLAT SOLING

3.5.1 Description

This item consists of providing double layer brick flat soling on the sub-grade or improved sub-grade as directed by the Engineer.

3.5.2 Materials

The materials shall consist of First Class or Picked Jhama Bricks which meet the requirements of Article 3.3.2a of these Specifications.

3.5.3 Construction methods

First layer of the bricks shall be laid flat on the consolidated and prepared surface in a regular and uniform manner. Interstices of bricks shall be filled with sand of FM 0.8 and water shall be applied by sprinkling. Then sand cushion of 25mm thickness (minimum) with sand of FM not less than 0.8 should be placed over the first layer. Second layer of the bricks shall be laid flat on the sand cushion in a regular and uniform manner. Interstices of bricks shall be filled with sand of FM 0.8 and sprinkling water as did in case of first layer. No bricks shall be laid on a foundation or any surface until the same has been inspected and approved by the Engineer. The pattern and placing of the bricks shall be as indicated in the drawings.

3.5.4 Measurement

Brick flat soling shall be measured in square meters for areas covered by the same.

3.5.5 Payment

This item of work shall be measured as provided above and shall be paid at the contract unit price. The price and payment shall include all costs for completion of the work and supply of all required materials, including cost of all labour, equipment, tools and incidentals necessary to complete the works as specified in the section.

Pay item shall be:

	Unit
Double layer brick flat soling	Square meter

3.6 HERRINGBONE BOND BRICK PAVEMENT

3.6.1 Description

This work shall consist of a base composed of bricks, laid on edge in a herringbone pattern, placed on a prepared single layer brick flat soling in accordance with these Specifications and to the lines, grades levels, dimensions and cross sections shown in the Drawings and as required by the Engineer.

3.6.2 Materials

The materials shall consist of First Class or Picked Jhama Bricks which meet the requirements of Article 3.3.2a of these specifications.

3.6.3 Construction methods

3.6.3.1 Laying the bricks

A sand cushion of 25mm thickness (minimum) with sand of F.M. not less than 0.8 would be placed over the brick flat soling. The brick then shall be laid on edge with 125mm across the surface in a single layer in a herringbone pattern to the lines, grades, levels, dimensions and cross section shown on the Drawings and as required by the Engineer. The edge of the layer shall be made with cut bricks to produce a line which is compatible with brick edging. The joints shall be filled with sand of FM 0.8 brushed in and the completed layer shall be sprinkled liberally with water.

3.6.3.2 Surface tolerance

In those areas in which pavement are to be placed, any deviation in excess of five millimeters from the specified surface within 3 meter shall be corrected by removal, reshaping and relaying.

3.6.3.3 Measurement

This item shall be measured in square meters of material in place and accepted.

3.6.3.4 Payment

The work measured as provided above shall be paid for at the Contract unit price per square meter. The price and payment shall include all costs for completion of the work including all materials, labour and equipment necessary to complete the work prescribed under this section.

Pay item shall be:

	Unit
Brick pavement (HBB only). excluding soling and edging	Square meter

3.7 SUB-BASE

3.7.1 Description

This work shall consist of providing, laying and compacting sub-base on the finished approved sub-grade or improved sub-grade, to the lines, levels, dimensions and cross section shown on the drawings or as directed by the Engineer.

3.7.2 Aggregate-Sand sub-base

3.7.2.1 Materials

The sub-base should consist of AS (Aggregate & Sand). The sub-base shall consist of a homogeneous mixture of crushed brick aggregate local sand and natural or artificial mixture of sand free from vegetation and excess clay. The FM shall not be less than 0.8.

The aggregate shall be crushed First Class or Picked Jhama Bricks. The crushed bricks shall comply with the following requirements:

- o water absorption shall not exceed 18%
- o maximum size of aggregate shall be 38mm.,
- o Aggregate Impact Value of not more than 30 or LAA-40 or as directed by the Engineer in the case of reuse of salvaged materials.

The resultant mixture shall meet the following requirements:-

- a) **Plasticity:** The fraction passing the 425 micron sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 6. (STP Section 3)
- b) **CBR:** The materials shall have a soaked CBR value not less than 30% when compacted to 98% of maximum dry density (Modified Proctor).

Grading Requirements for sub-base material

Sieve Size	% Passing by Weight
38mm	100
20mm	55-95
10mm	35-75
4.8mm	25-60
2.4 mm	15-50
600 micron	1 0-35
300 micron	1 0-25
75 micron	5-15

3.7.2.2 Construction Method

Sub-base materials shall be at or near the optimum moisture content (OMC) at the time of placing. The brick aggregate and sand shall be mixed thoroughly to obtain a homogeneous mix complying with the grading requirements of this Section before placing it on the sub-grade. The mixed materials shall be spread uniformly upon the prepared and approved sub-grade in such quantities that the thickness of the layer after compaction shall not exceed 150mm. The material shall be mixed or sprinkled with water to bring it to the correct moisture content. Total thickness required shall be in accordance with the drawings. The relationship between the loose thickness and compacted thickness shall be determined from field trials and used in controlling the loose thickness at the time of spreading the mix.

After spreading has been completed and the surface shaped according to the cross sectional requirements, rolling shall commence. Rolling should be done by a power roller weighing 8 to 10 tons or equivalent vibratory roller. Rolling shall begin at the outer edge towards the centre of the road with the rear wheel overlapping the shoulder. When the broken aggregates become firm, the roller will be shifted to the opposite side of the road and the operation will be repeated. After both edges rolled modestly firm, the roller will be gradually moved towards the centre by overlapping 150mm of the rolled width until the mix has attained the required density

The rolled surface shall be checked for correctness of levels and cross-falls and any irregularities therein shall be corrected by loosening the affected areas, adding or removing the necessary quantities of aggregate and re-rolling until the entire surface conforms to the correct levels and cross levels and cross-falls.

The dry density after compaction shall not be less than 98% of the maximum dry density (Modified Proctor). The field density shall be checked at least once in every 100 linear meters of sub-base surface. The prepared sub-base layer shall be protected against damage until covered by the base course. Moisture content at the time of compaction shall be the optimum moisture content: $\pm 3\%$.

The finished surface shall be within a tolerance of $\pm 10\text{mm}$ or of the elevation shown in the drawings and it shall no where vary more than 10mm from the straight edge 3m long applied to the surface parallel to the centre line of the pavement and no more than 12mm from a template conforming to the cross-section.

The depth over each 100m shall be measured in at least 3 places by digging holes. The average depth should be as per drawings but the minimum depth shall not be less than 95% of the specified depth.

3.7.2.3 Measurement

Sub-base shall be measured in cubic meters. It shall be based on the average width and compacted thickness of sub-base as shown on the drawings and the actual length measured horizontally along the centre line of the surface of the road.

3.7.2.4 Payment

The work, measured as provided above, shall be paid for the contract unit price. The price and payment shall be full compensation for performing the work including furnishing and placing the

materials, supplying all labour, equipment, tools and incidentals necessary to complete the work prescribed in the Section. Separate measurements should be taken at the bends if found necessary

Pay item shall be:

	Unit
Sub-base	Cubic Meter (Compacted thickness)

3.8 WET MIX MACADAM (WMM) BASE COURSE

3.8.1 Description

This work shall consist of providing, laying and compacting Graded Aggregate-Sand base course on the prepared and accepted sub-base to the lines, levels, dimensions. and cross sections shown on the Drawings or as directed by the Engineer.

3.8.2 Materials

The base course material shall consist of a homogeneous mixture of crushed brick aggregate and local sand.

The aggregate shall be crushed Picked Jhama or mixed with First class bricks. The crushed bricks shall comply with the following requirements:

- o Water absorption shall not exceed 16%
- o Maximum size of aggregate shall be 38mm
- o Aggregate impact value (AIV) of not more than 30 or Los Angeles Abrasion (LAA) 40.
- o Flakiness index 15%

The F.M. of sand shall not be less than 0.80 and shall be free from deleterious material. Base course material shall conform to the grading envelope shown in the table given below and have a soaked CBR value not less than 80% when compacted 98% of maximum dry density (Modified Proctor).

Grading Requirements for Graded Aggregate-Sand Base course

Sieve Size	% Passing by Weight	
38mm	100	
20mm	60-90	
10mm	40-70	
4.8mm	30-55	
2.4mm	20-45	
600micron	10-30	
300micron	10-25	
75micron	5-15	

In addition the material shall be well graded with the envelope having no excess or deficiency in any size. The fraction passing the 75 micron sieve shall not be more than 75/0 of that passing the 300 micron sieve. The portion of the material passing the 425 micron- sieve shall, if it is plastic, have a liquid limit not more than 25 and a plasticity index not more than 6.

3.8.3 Construction Methods

The base-course materials shall be at the optimum moisture content (OMC) $\pm 3\%$ at the time of placing. The brick aggregate and sand shall be mixed thoroughly to obtain a homogeneous mix complying with the grading requirements of this Section. Water shall be added during mixing to keep the mixed material moist so as to prevent segregation during transportation. Prior to laying the base course, the sub-base shall be watered. The mixed base course material shall then be spread in two equal layers so that the compacted thickness of each layer shall combine to conform to the thickness shown on the Drawings or as directed by the Engineer. On the completion of the spreading and

watering, rolling shall commence.

Rolling should be done by a power roller weighing 8 to 10 tons or equivalent vibratory roller. Rolling shall begin at the outer edge gradually moving towards the centre of the road with the rear wheel overlapping the shoulder. When the broken aggregates become firm, the roller will be shifted to the opposite side of the road and the operation will be repeated. After both edges rolled modestly firm, the roller will be gradually moved towards the centre by overlapping 150mm of the rolled width until mix has attained the required density

The base course shall be compacted to have 98% maximum dry density (Modified Proctor) and soaked CBR as specified in Article 3.8.2. The field density shall be checked at least once in every 100 linear meter of base course surface. Moisture content at the time of compaction shall be the optimum moisture content $\pm 3\%$.

The finished surface of the base course shall in no place be more than ± 10 mm from the designed level and the mean of five measurements of thickness taken in any 200 meters long section shall at least equal to or more than the required base course thickness.

3.8.4 Measurement

Base course shall be measured in cubic meters. It shall be based on the average width and compacted thickness of base course as shown on the Drawings and the actual length measured horizontally along the centre line of the surface of the road.

3.8.5 Payment

The work, measured as provided above, shall be paid at the contract unit price. The price and payment shall be full compensation for performing the work including furnishing and placing the materials, supplying all labour, equipment, tools and incidentals necessary to complete the work prescribed in the section. Separate measurements should be taken at the bends if found necessary.

Pay item shall be:

	Unit
Wet Mix Macadam (WMM) Base Course	Cubic meter (compacted thickness)

3.9 WATER BOUND MACADAM BASE COURSE

3.9.1 Description

This work shall consist of providing, laying, watering and compacting water bound macadam base course on the prepared and accepted sub-base to the lines, levels, dimensions, and cross profiles shown on the Drawings or as directed by the Engineer in charge

3.9.2 Materials

The base course material shall consist of crushed first class brick and/or picked Jhama brick aggregates well graded and of desired strength, mechanically "Keyed" or locked by rolling and cemented or bounded together by the application of sand and water.

The aggregate shall be crushed Picked Jhama or mixed with First class bricks. The crushed bricks shall comply with the following requirements:

- o Water absorption shall not exceed 16%
- o Maximum nominal size of aggregate shall be 38mm according to A8TM-C-131 Los Angeles Abrasion Test (AA8HTO Designation T-96) with a percentage of wear less than 40 at 500 revolutions.
- o Flakiness index as per B8-812-15%
- o Aggregate Impact Value of not more than 32% (According to B8-812).

The F.M. of sand shall not be less than 0.80 and shall be free from deleterious material.

Material shall conform to the grading envelope shown in the Table A and have a soaked CBR value not less than 65% when compacted to 100% of maximum dry density as determined by 8TP T 4.5.

Grading Requirements for Water Bound Macadam Base course

SIEVE SIZE	% PASSING BY WEIGHT
38mm	100
20mm	60-80
10mm	40-60
4.8mm	25-45
2.4mm	15-32
600 micron	10-20
75 micron	0-15

The material shall be well graded with the envelope having no excess or deficiency in any size.

The above grading may be changed by the Engineer-in-charge when the laboratory result of the above proportion does not meet the quality requirements of the specification

3.9.3 Construction methods

Prior to laying of base course the aggregate drainage layer shall be shaped true to cross fall or super elevation and shall be rolled as necessary till the surface is smooth, firm and tight. The prepared aggregate drainage layer shall be protected against damage until covered by the base course.

Mixing of various course aggregates should be carried out in a stockyard to achieve the specified grading. Different kinds of materials shall not be mixed together except that sand or naturally occurring granular materials finer than 5mm size can be mixed with any of these materials to meet the grading requirements. The mixing may be done by mechanical means or a combination of manual labour and machinery. The materials shall be mixed thoroughly and uniformly to have a homogeneous mass also satisfying the grading requirements. During mixing, water is to be added to keep the mixed material moist, so as to prevent segregation during transportation.

The materials shall be spread in layers, the compacted thickness of which shall not exceed 100mm. However the Engineer may allow higher compacted thickness upto 150mm if he is satisfied that the specified degree of compaction can be imparted throughout such greater thickness of layer with the contractor's equipments and methods used by the contractor. The spreading shall be done using methods acceptable to the Engineer. The required amount of water, predetermined from laboratory tests and field trials, shall be added and mixed thoroughly. The moisture content of the material during compaction shall be guided by the optimum moisture content (OMC) as determined from laboratory compaction tests but subject to variations as needed for achieving specified density as decided by the Engineer on the basis of trial compaction.

Rolling should be done by a power roller weighing 8 to 10 tons or equivalent vibratory roller. Rolling shall begin at the outer edge with the rear wheel overlapping the shoulder. When the broken aggregates become firm, the roller will be shifted to the opposite side of the road and the operation will be repeated. After both edges rolled modestly firm, the roller will be gradually moved towards the centre by overlapping 150mm of the rolled width until the entire base course thoroughly compacted.

The base course shall be compacted to have 100% maximum dry density (standard) and soaked CBR as specified in Article 3.9.2. The field density shall be checked at least once every 100 linear meter of base course surface. Moisture content at the time of compaction shall be the optimum moisture content $\pm 3\%$.

The finished surface of the base course shall in no place be more than $\pm 10\text{mm}$ from the designed level and the mean of five measurements of thickness taken in any 200 meters long section shall be equal to or more than the required base course thickness.

3.9.4 Measurement

Base course shall be measured in cubic meters of material complete in place and accepted. It shall be based on the average width and compacted thickness of base course as shown on the Drawings and the actual length measured horizontally along the centre line of the surface of the road.

3.9.5 Payment

The work as measured above shall be paid for at the contract unit prices for each of the items listed below and shown in the Bill of Quantities. Payment shall be for full compensation for performing the work including furnishing the materials, water, carrying out all, placing, compaction, protection work, trials, tests and all other procedures described herein and providing all labour, tools, equipments and incidentals necessary to do the work.

The pay item shall be

	Unit
Water Bound Macadam	Cubic meter (compacted thickness)

3.10 UPGRADING THE OLD EXISTING WATER BOUND MACADAM/GRADED AGGREGATE AND BASE COURSE**3.10.1 Description**

The top 75mm of existing Water Bound Macadam/Graded Aggregate-Sand Base Course shall be loosened, reshaped and compacted, as directed by the Engineer, to the proper grade and camber, supplying additional quantities of base course material if required to bring the grading of the scarified salvaged material to the specification described in Article 3.8.2 & 3.9.2; spreading the properly mixed and graded salvaged and additional materials on top of the prepared and accepted exposed layer of the Base Course, compacting the spreaded materials to the specified grade and camber to make the total thickness as per design to the line, levels, dimensions and cross-section shown on the drawings or as directed by the Engineer.

3.10.2 Materials

The materials required for this item should meet the specifications described for Water Bound Macadam and for Graded Aggregate-Sand Base course.

3.10.3 Construction methods

The top 75mm layer of the existing water bound macadam/graded aggregate-sand base course shall be scarified or loosened by any suitable means.

The grading of the salvaged materials shall be checked and additional base course materials shall be added to bring to the required shape, size and quality as specified and mixed to bring the grading of the mixed base course materials within the grading envelope specified.

The scarified surface of the exposed layer shall be reshaped, watered and compacted to bring it to the proper line, levels, dimensions and cross-section.

Additional materials to the specified grading and quality shall then be spread over the prepared and accepted surface. The base course materials shall be spread in such a way that the compacted thickness of the base course is not less than the design thickness. On the completion of the spreading and watering, the surface shall be shaped according to the cross-section shown in the drawings and compacted using approved mechanical compaction equipment. Compaction shall continue until the material has attained the required density. The base course shall be compacted to have 100% maximum dry density (standard proctor) and a soaked CBR as specified in Article 3.9.2. The in-situ density shall be checked at every 100 linear meters of recompacted surface.

3.10.4 Measurement

The salvaged material and supplying of additional material shall not be measured. Only the accepted base course compacted as specified shall be measured in square meters. It shall be based on the

average width and thickness of base course shown on the drawings and the actual length measured horizontally along the centre line of the surface of the road.

3.10.5 Payment

This work as measured above shall be paid for at the contract unit price for the additional works required to the base course. Payment shall be full compensation for performing the work including but not limited to scarifying and picking up the existing top layer, supplying additional base course materials, mixing to the proper grading spreading the mixed base course materials, watering, compacting to the specified density, grade, cross-section and thickness.

Pay item shall be:

		Unit
Upgrading the old existing Water Bound Macadam/ Graded Aggregate-Sand Base Course		
(i)	Scarifying and loosening the existing surface	Square meter
(ii)	Spreading and supply of additional material	Square meter
(iii)	Compaction	Square meter

3.11 GENERAL REQUIREMENTS FOR BITUMINOUS SURFACING

3.11.1 Description

3.11.1.1 General

This work shall cover the general requirements that are applicable to all types of bituminous bound surfacing irrespective of gradation of mineral aggregate, grade and amount of bituminous materials used. Deviations from these general requirements are indicated in the specific requirements as set forth in the respective sections for each type.

The work shall consist of one or more courses of pre-mixed bituminous mixtures constructed on a prepared and accepted base course or other road bed in accordance with these Specifications and the specific requirements of the type under Contract, and in conformity with the required lines, levels, grades, dimensions and typical cross sections

3.11.1.2 Composition of Mixtures

The bituminous mix shall be composed basically of coarse mineral aggregate, fine mineral aggregate, filler and bituminous binder. The several mineral constituents shall be sized, uniformly graded and combined in such proportions that the resulting blend meets the grading requirements for the specific type under the Contract. To such composite blended aggregate shall be added bitumen within the percentage limits set in the specifications for the specific type.

3.11.2 Construction

3.11.2.1 Weather Limitation

Bituminous mixtures shall be placed only when the surface is dry, when the weather is not rainy and when the prepared road bed is in a satisfactory condition. However, the Engineer may permit, in case of sudden rain, the placing of mixture then in transit if laid at proper temperature and if the road bed is free from pools of water.

Such permission shall in no way relax the requirements for quality and smoothness of surface.

3.11.2.2 Progress of Work

No work shall be performed when there is insufficient hauling, spreading or finishing equipment or labour to ensure progress at a rate consistent with meeting proper temperatures and rates of compaction.

3.11.2.3 Equipment**(a) Equipment for Preparation of Bituminous Binder**

Tanks or kettles for storage of bituminous binder shall be capable of heating the binder under effective control at all times, to a temperature within the range specified. Bitumen shall not be heated in open pans or drums. Suitable means shall be provided for maintaining the specified temperature of the bituminous binder at all times. Generally Tar boilers with thermometer are used to heat the bitumen.

(b) Thermometric Equipment

Armoured thermometers in good condition reading from 50° C to 200° C shall be available at the sites of mixing and laying at all times.

- (c) Equipment for hauling bituminous mixtures shall have tight, clean and smooth metal sides that have been sprayed with soapy water, thinned fuel oil, paraffin oil or lime solution to prevent the mixture from adhering to the beds. The amount of sprayed fluid shall however be kept to the practical minimum. Any equipment causing excessive segregation of material by its suspension or other contributing factors, or that shows oil leaks in detrimental amount or that causes undue delays, shall upon direction of Engineer in charge be removed from the site until such conditions are corrected
- (d) The equipment for spreading and finishing shall be capable of spreading and finishing the mixture true to the lines, grades, levels dimensions and cross sections
- (e) The Contractor shall provide suitable means for keeping all small tools clean and free from accumulation of bituminous material. He shall provide and have ready for use at all times enough tarpaulins or covers, as may be directed by the Engineer, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any material that may have been dumped and not spread.

3.11.2.4 Preparation and Placing**(a) Preparation of Existing Surface.**

Where the existing road bed is broken or shows instability, the unstable material shall be removed and disposed off as directed by the Engineer and be replaced with the same mixture as specified for the next course, compacted to the standard and elevation of the adjacent surface. The surface upon which the mixture is to be placed shall be swept thoroughly and cleaned of all loose dirt and other objectionable material immediately before spreading the bituminous mixture. If directed by the Engineer Tack coat is to be applied before placing the next layer. If this has become necessary due to delays caused by the contractor in starting the next layer this will not be paid.

(b) Preparation of Bituminous Binder

The bituminous binder shall be heated to the specified temperature (140°C-155°C for 60/70 or 80/100 penetration bitumen) in Tar boiler, kettle or tanks so designed as to avoid local overheating and to provide a supply of the bituminous binder at a uniform temperature at all times.

(c) Preparation of Mineral Aggregate

The aggregates produced, whether by machine or by manual methods should be screened into the major component sizes prior to recombining in the correct proportions.

The mineral aggregates for the mixture shall be dried and heated to a temperature of between 150°C - 170°C before mixing. The aggregates shall be heated to the temperature specified in the applicable section.

(d) Preparation of Mixture

The heated mineral aggregate prepared above, shall be combined in the amount of each fraction of aggregate required to meet the mix formula for the particular mixture. The bituminous material shall be measured or gauged and introduced into the mix in the amount determined by the Engineer. Only sufficient heat shall be applied during mixing to maintain the temperature of the mix without increasing the temperature. The proper amount of bituminous material shall be distributed over the mineral aggregate and the whole thoroughly mixed for a period of at least 60 seconds or longer if necessary to produce a homogeneous mixture in which all particles of the mineral aggregate are coated uniformly. Mixing should not be carried out on fire.

(e) Transportation and Delivery of Mixture

The mixture shall be transported from the mixer to the point of use in equipment conforming to the requirements of Article 3.11.2.3. Loading and transporting shall be such that spreading, compaction and finishing shall all be carried out during daylight hours unless satisfactory illumination is provided by the Contractor.

(f) Spreading and Finishing

Upon arrival at the point of use, the mixture shall be spread and struck off to the grade, elevation, and cross-section shape intended, either over the entire width or over such partial width as may be practicable. The mixture shall be laid upon an approved surface and only when weather conditions are considered suitable by the Engineer.

(g) Compaction of Mixture

(i)	General: Immediately after the mixture has been spread and struck off, the surface shall be checked and any inequalities adjusted. The mixture shall then be thoroughly and uniformly compacted by rolling. Each course shall be rolled as soon after being placed as the material will support the roller without undue displacement or cracking.
(ii)	All rollers shall be self propelled, capable for being reversed without backlash. Each roller shall be in good condition and worked by a competent and experienced operator. Generally Tandem roller is suitable for B.C work; in addition Tyre roller is also needed.
(iii)	Rolling shall start longitudinally at the sides and proceed toward the centre of the pavement except that on super-elevated curves rolling shall begin at the low side and progress toward the high side. Successive trips of the roller and alternative trips shall not terminate at the same point.

Rolling shall start with a temperature of at least 120° C and shall be discontinued if temperature falls below 90° C.

The speed of the rollers shall not exceed 4 kilometers per hour for steel wheeled rollers and 6 kilometers per hour for pneumatic tyred rollers and shall at all times be slow enough to avoid displacement of the hot mixture. Any displacements occurring as a result of reversing the direction of the roller or from any other cause shall at once be corrected with rakes and fresh mixture where required. Care shall be exercised in rolling not to displace the line and grade of the edges.

Rolling shall progress continuously as may be necessary to obtain uniform compaction while the mixture is in a workable condition and until all roller marks are eliminated.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excess water will not be permitted.

Heavy equipment or rollers shall not be permitted to stand on the finished surface until it has thoroughly cooled or set.

Any petroleum products dropped or spilled from the vehicles or equipment employed by the Contractor upon any portion of the pavement under construction is caused for the removal

and replacement of the contaminated pavement by the Contractor. The surface of the mixture after compaction shall be smooth and true to the established crown and grade within the tolerance specified. Any mixture that becomes loose and broken, mixed with dirt, or which is defective in any way, shall be removed and replaced with fresh hot mixture, which shall be compacted immediately to conform to the surrounding area. Any areas of one square metre or more showing an excess or deficiency of bituminous material shall be removed and replaced. All high spots, high joints, depressions, and honeycombs shall be adjusted as directed by the Engineer.

(h) Joints

Both longitudinal and transverse joints in successive courses shall be staggered so as not to be one above the other. Longitudinal joints shall be arranged so that the longitudinal joint in the top course shall be at the location of the line dividing the traffic lanes. Lateral joints shall be staggered a minimum of 250 millimeters and shall be straight.

The edges of the pavement shall be straight and true to the required lines. Any excess material shall be cut off after final rolling and disposed off by the Contractor at the end of a day's work.

Just prior to recommencing operations, the sides of all longitudinal and transverse joints shall be painted with hot bitumen to ensure a satisfactory bond between the old and new work.

3.11.3 Measurement

All work prescribed above shall be measured and paid for as provided in the respective sections for each type of pavement. The quantity measured and paid for shall always be the quantity ordered with any permitted excess or the actual quantity used whichever is the less.

3.11.4 Payment

The work shall be paid for as provided in the respective section for each type of bituminous layer.

3.12 PRIME COAT

3.12.1 Description

This work shall consist of the careful cleaning of the surface of the granular base material to be primed and furnishing and applying bituminous material in accordance with these Specifications to the areas shown on the Drawings and as directed by the Engineer.

3.12.2 Materials

3.12.2.1 Bituminous materials

Bituminous prime coat material shall be a cut back bitumen, conforming to the requirements of ASTM/AASHTO.

Cut back bitumen may be prepared by cutting back 60/70 or 80/100 penetration grade straight run bitumen with kerosene/diesel in the ratio of 100 parts by volume of bitumen to 40-60 parts by volume of kerosene depending on the porosity of the surface and will be decided by field trials or as directed by the Engineer. The correct amount is the quantity that is completely absorbed within 24 hours. The spraying temperature of the cutback bitumen shall be 100°C to 120°C.

3.12.2.2 Blotting material

Blotting material shall be clean, dry, free-flowing sand not containing any cohesive materials or organic matter. Not more than 10 percent of the sand shall be finer than the 75 micron sieve.

3.12.3 Construction Methods

3.12.3.1 Weather Limitations

Prime coat work shall not be carried out when the weather conditions are, in the opinion of the Engineer, likely to adversely affect the stability of wet prime coat material. Such conditions may include but shall not necessarily be limited to rain, low temperatures or storms

3.12.3.2 Cleaning Surface

Immediately before applying the prime coat material, all loose stones, dirt and other objectionable materials shall be removed from the surface with a broom or blower as appropriate. When so directed by the Engineer, a light application of water shall be made just before the application of the prime coat.

3.12.3.3 Application of Prime Coat

Prime coat material shall be applied by mechanical distributor or manually at a uniform rate between 1.00 and 1.20 liters/square meter as directed by the Engineer, and at a temperature between 100°C to 120°C. Additional primer shall be applied where surface conditions indicate this to be necessary, if the Engineer so directs. No further coatings shall be applied until the prime coat has been cured.

The contractor may be required to lay a trial section of prime coat for the approval of the Engineer with regard to the method of operations and to establish the optimum spray rate for the prime coat to achieve adequate penetration. Following the approval of the Engineer in writing of such trial section (s), the prime coat works may then be carried out strictly in accordance with the approved method and spray rates and the specification.

The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being splattered or marred. No bituminous material shall be discharged into a borrow pit, gutter or kerb.

3.12.4 Maintenance and opening to Traffic

After application of the prime coat there shall be a curing period of 48 hours or more, when traffic shall not be permitted on the coated surface. In case of any damage caused by traffic, the surface shall be redone at the cost of the contractor. The period of curing shall be extended if necessary till the bituminous material has penetrated and dried and, in the opinion of the Engineer, will not be picked up by traffic. At the end of the curing period, minor areas where prime coat material is still not dry shall be treated by sprinkling, blotting sand as necessary to avoid picking up of prime coat material before allowing traffic to use the coated areas. For existing roads, the work shall be done over half width at a time, the other half being used to carry the traffic.

3.12.5 Measurement

Prime coat shall be measured in square meter. Blotting material shall not be measured for payment and shall be considered to be included in the rate for prime coat

3.12.6 Payment

This work, measured as provided above, shall be paid at the Contract unit price. The price and payment shall be full compensation for preparation of the surface and furnishing and placing the materials including all labour, equipment, tools and incidentals necessary to complete the work prescribed in the Section.

Pay item shall be:

	Unit
Prime Coat	Square meter

3.13 TACK COAT

3.13.1 Description

This work shall consist of the cleaning and preparation of the bituminous surface specified, or otherwise as directed by the Engineer, together with the furnishing and application of the tack coat in

accordance with these Specifications to the areas shown on the Drawings and as directed by the Engineer.

Tack Coat should be applied only in between two bituminous surfaces.

3.13.2 Materials

Bituminous tack coat material shall be 60/70 or 80/100 penetration grade straight run bitumen complying with the requirements of ASTM / AASHTO.

3.13.3 Construction Methods

3.13.3.1 Weather Limitations

Tack coat work shall not be carried out when the weather conditions are, in the opinion of the Engineer, likely to adversely affect the stability of wet tack coat material. Such conditions may include but shall not necessarily be limited to rain, low temperatures or storms:

3.13.3.2 Cleaning Surfaces

Immediately before applying the tack coat all loose stone dirt and other objectionable material shall be removed from the surface with a broom or blower as appropriate.

3.13.3.3 Application of Tack Coat

Tack coat material shall be applied by mechanical distributor or manually at a rate of 0.5 liter S/m² and at a temperature between 135°C and 155°C. Additional tack coat shall be applied where surface conditions indicate this to be necessary, if the Engineer so directs.

The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being splattered or marred. No bituminous material shall be discharged into a borrow pit, gutter or kerb.

3.13.4 Measurement

Tack coat shall be measured in square meter as shown on the Drawings or ordered by the Engineer, complete, in place and accepted.

3.13.5 Payment

This work, measured as provided above, shall be paid for at the contract unit price per unit of measurement stated below. The price and payment shall be full compensation for preparation of the surface and furnishing and placing the materials including supply of all materials, labour, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Pay item shall be:

	Unit
Tack coat	Square meter

3.14 PREMIX BITUMINOUS CARPETING

3.14.1 Description

This work shall consist of supply and laying of a premix bituminous carpet on a previously prepared and primed granular base course in accordance with these Specifications and to the lines, levels, grades and cross-sections shown on the Drawings. The bituminous carpeting shall consist of a compacted single layer of surfacing which, except when otherwise stated on the Drawings shall be of 25mm thickness.

3.14.2 Materials

3.14.2.1 General

The bituminous carpet material shall be a mix of bitumen, coarse aggregate and fine aggregate.

The bitumen shall be stored and handled in such a manner that risks of fire and other hazards, and of pollution, are eliminated. Sufficient storage shall be provided to contain at least 7 days supply of bitumen to meet the programmed rate of construction.

The coarse and fine aggregate shall be stockpiled separately.

3.14.2.2 Bitumen

Bitumen shall be of penetration grade 80/100 conforming to the requirements of AASHTO/ASTM. The Contractor shall provide a supplier's test certificate that the material conforms to Specification.

3.14.2.3 Coarse Aggregate

Coarse aggregate shall be the material component fully retained on 4.8mm sieve and shall consist of clean, naturally occurring or mechanically crushed stone or gravel or blended combinations of both, free from decomposed stone, organic matter, shale, clay and any other substances which, in the opinion of the Engineer, may be deleterious to the mixture. Coarse aggregate shall satisfy the following physical characteristics:

- Bulk Specific Gravity shall be not less than 2.50
- Aggregate Impact value shall not exceed 30 (BS 812)
- Water Absorption shall not exceed 2%
- Flakiness Index shall not exceed 35.

Not less than 75% by weight of the particles of coarse aggregate shall have at least two fractured faces.

3.14.2.4 Fine Aggregate

The portion of the aggregate passing a 4.8mm sieve shall be known as fine aggregate and shall consist of natural sand, stone screenings or a combination of both. Fine aggregate shall be non-plastic, clean, hard durable particles, rough surfaced and angular and free from any substances which, in the opinion of the Engineer, may be deleterious to the mixture.

Fine aggregate passing a 425-micron sieve shall have a Plasticity Index of not more than 4 (STP T3.2).

3.14.2.5 Combined Mineral Aggregate

The combined mineral aggregates shall conform to the following grading limits for 25mm thickness bituminous carpeting:

Sieve Size	Percent by Weight Passing
16mm	100
12.5mm	75-100
10mm	60-80
6.3mm	45-65
4.8mm	35-55
2.4mm	20-35
600micron	10-20
75micron	2-8
Bitumen Content by weight of total mix %	5.20% to 5.80%
Thickness (mm)	25

Other parameters shall be as defined in Clause No. 2.13.4.

3.14.3 Construction Methods**3.14.3.1 Weather Limitations**

Bitumen carpeting shall be placed only when the atmospheric temperature in the shade is above 16°C, and in dry weather except that in the case of sudden rain the Engineer may permit the placing of mixture then in transit if the surface is free from pools of water.

3.14.3.2 Aggregate Grading and Mixing

The aggregate shall be screened in the major component sizes and then shall be thoroughly mixed together in the correct proportions to give a stockpile of mixed aggregate of the required grading and in sufficient quantity for at least one day's carpeting work.

3.14.3.3 Preparation of Surface

The surface on which the bituminous carpeting is to be laid shall be swept thoroughly and cleaned of all loose dirt and other objectionable material immediately before spreading the carpet.

3.14.3.4 Heating and Mixing of Materials

The bitumen and the aggregates shall be separately heated in the mixing plant to a temperature between 135°C to 155°C before mixing.

The proportion of bitumen in the mix shall be as determined by the trial mix (see 2.13.4). The heated bitumen shall be distributed over the aggregate and the whole thoroughly mixed for at least one minute to produce a homogeneous mix in which all aggregate particles are evenly coated.

The temperature of the mixed materials shall be maintained at between 135°C and 155°C and laid at this temperature. Bitumen, or bitumen aggregate mixture, which has been overheated by more than 10°C at any time, shall be rejected.

3.14.3.5 Spreading and Compacting

The mixed materials shall be laid to a uniform thickness. The thickness and camber shall be maintained by the use of steel angle screeds at least 25% deeper than the compacted thickness of the bituminous carpeting.

After lying, the materials shall immediately be compacted using an approved roller. The initial pass of the roller on the bituminous premix shall be at the temperature specified above and shall be carried out with the steel angle screeds in position. A minimum of five passes of the roller shall be made.

When the temperature of the bituminous premix falls below 90°C no further compaction may be permitted. Material that falls below 90°C before it has been compacted as described may be rejected, and shall be replaced by new material to the required Specification by the Contractor at his own expense.

The bituminous carpeting shall be fully compacted maintaining the proper grade and camber. The compacted thickness as shown in the Drawing shall be uniformly maintained all along the road surface. The resultant density of the compacted bituminous carpeting shall be between 2250 and 2350 kg/m³.

3.14.3.6 Protection of Newly-Laid Carpeting

Rollers and other mechanical plant shall not be allowed to stand on newly laid material. Sections of newly finished work shall be protected from traffic of any kind until the mixture has cooled to ambient air temperature. Traffic shall not be permitted on the newly laid surface until at least 6 hours after completion of the layer.

3.14.4 Quality Control of Material and Work

Prior to starting work the Contractor shall prepare a trial mix in the laboratory and lay a trial section of bituminous carpeting. Following approval by the Engineer work shall proceed using the same mix

formula as in the trial mix. If a change in material source or character is encountered, the trial mix procedure shall be repeated. Marshall stability and flow test procedures for the trial mix to be conducted in accordance with Section 9.4 of S.T.P.

The Engineer shall exercise control over quality of the materials incorporated and works performed through quality control tests carried out to the frequencies indicated herein under. The frequencies are the minimum, and the Engineer shall have the authority to have these tests at more frequent intervals where quality of a material or work is in doubt.

3.14.4.1 Materials

Material	Type of Test	Frequency
Bitumen	Conformity to Specification	As deemed necessary
Coarse Aggregate	Aggregate Impact Value	One test per 500m (more frequently one if material character changes)
	Flakiness Index	-do-
	Water Absorption	-do-
Mixed Aggregate	Grading	Twice a day
Bitumen	Temperature	At the time of heating
Bituminous Carpet	Temperature	At the time of laying and during rolling

3.14.4.2 Field Compaction

After final rolling cored samples with a minimum diameter of 100mm shall be obtained at a frequency of one sample for 100m lengths. The results shall be tested for thickness and density. The results shall be examined in a lot of 10 samples. The average thickness of the layer shall not be less than that specified, and no sample shall have a thickness more than 5mm less than the specified thickness.

The finished surface when tested under a 3m long straight edge shall not show any undulation greater than 8mm in the longitudinal direction and 4mm in the transverse direction.

3.14.5 Measurement

This work shall be measured as the area in square metres of bituminous carpeting of the specified thickness completed and accepted.

3.14.6 Payment

The payment shall be full compensation for supply, mixing, placing and compacting all materials, for carrying out all trials and tests necessary for the work and for all labour, equipment, tools and incidentals necessary to complete the work.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
2.13	25mm Thick Premix Bituminous Carpeting	Square metre

3.15 PREMIX BITUMINOUS SEAL COAT 7MM THICK

3.15.1 Description

This work shall consist of premix bituminous seal coat applied to a prepared and primed granular base course or over the bituminous surfacing in accordance with these Specifications or as directed by the Engineer. The thickness of premix bituminous seal coat shall be 7mm.

3.15.2 Materials

3.15.2.2 Bituminous material

Bituminous material shall be of 60/70 or 80/100 penetration grade straight run bitumen complying with the requirements of ASTM AASHTO.

3.15.2.3 Aggregate

The aggregates shall consist of 6.3mm down graded stone or gravel free from any organic matter, clay and any other objectionable matter.

Where required to achieve the specified grading the aggregate shall be mixed with natural sand. Sand shall be non-plastic, clean and free from any deleterious substances. The minimum F.M. of sand for the sealing premix shall be between 2.00 to 2.50 and that of sand to be spread over the seal coat as blotting material shall be between 0.80 to 1.00.

3.15.2.3 Overall aggregate grading

The mix of the aggregates and sand combined shall comply with the following grading given in Table 3.15.1

Table 3.15.1 Grading Requirements for 7mm Premix Bituminous Seal Coat

Sieve Six	% by Weight Passing Sieve
6.3mm	100
4.75mm	80-100
2.4mm	70-95
600 micron	20-50
75 micron	5-15

3.15.3 Construction Methods

Bitumen and aggregates shall be heated separately at the following temperatures:

Only Bitumen	between 140°C to 155°C (Max)
Only Aggregate	between 150°C to 170°C
Mix of Bitumen & Aggregate	between 140°C to 160°C

Material that has been over-heated at any time shall be rejected. No mixing of preheated bitumen and aggregate should be done on fire. 0.01 M1J of aggregate will be mixed with 1 liter of bitumen and shall be laid on 1 (one) square meter of road surface.

The aggregate mixed with bitumen shall be laid over the bituminous carpeting or over the primed granular base to a uniform thickness which shall be at least 25% greater than the compacted thickness and immediately compacted fully with a power driven road roller to the satisfaction of the Engineer. Temperature of bitumen and aggregate mix at the time of starting of rolling should not be less than 130°C.

3.15.4 Measurement

Premix bituminous seal coat shall be measured in square meters completed and accepted by the Engineer. Measurement shall be based upon the nominal width of seal coat at its top surface as shown on the Drawings or as directed by the Engineer. The measurement will be exclusive of prime coat. Mean of the three measurements of thickness taken in any 100 meter long section shall at least equal to or more than the required thickness.

3.15.5 Payment

The quantities measured as provided above shall be paid for at the contract unit shown below. The price and payment shall be full compensation for supplying, placing and compacting all materials, for all labour, equipment, tools and incidentals necessary to complete the work.

Pay item shall be:

	Unit
7mm premix bituminous seal coat	Square meter

3.16 PREMIX BITUMINOUS SEAL COAT 12MM THICK

3.16.1 Description

The work shall consist of a premix bituminous seal coat applied to a prepared and primed granular base course or over bituminous surfacing in accordance with these Specifications or as directed by the Engineer. The thickness of the premix bituminous seal coat shall be 12mm.

3.16.2 Materials

3.16.2.1 Bituminous material

Bituminous material shall be of 60/70 or 80/100 penetration grade straight run bitumen complying with the requirements of ASTM/AASHTO.

3.16.2.2 Aggregate

The course aggregates shall consist of 10mm down graded stone or gravel free from any organic matter, clay and any other objectionable matter.

Where required to achieve the specified grading the aggregate shall be mixed with natural sand. Sand shall be non-plastic, clean and free from any deleterious substances. The F.M of sand for the sealing premix shall be between 2.00 and 2.50. The F.M of sand to be spread over the seal coat as blotting material shall be between 0.80 and 1.00.

3.16.2.3 Overall Aggregate Grading

The mix of the aggregates and sand combined shall comply with the following grading given in Table 3.16.1

Table 3.16.1 Grading Requirements for 12mm Premix Bituminous Seal Coat

Sieve Size	Percentage by Weight Passina Sieve
10mm	100
6.3mm	80-100
4.75mm	70-95
2.4mm	20-50
600 micron	5-15
75 micron	2-10

3.16.3 Construction methods

Prior to heating the aggregate and sand shall be mixed together to give a stockpile of mixed aggregate of the required grading in sufficient quantity for at least one day's surfacing work.

Bitumen and aggregates shall be heated separately at the following temperatures:

Only Bitumen	between 140°C to 155°C (Max)
Only Aggregate	between 150°C to 170°C
Mix of Bitumen & Aggregate	between 140°C to 160°C

Material that has been over-heated at any time shall be rejected. No mixing of preheated bitumen and aggregate should be done on fire. 0.016M:3 of pea gravel will be mixed with 1.40 liter of bitumen and shall be laid on 1 (one) square meter of road surface.

The mixture shall be laid to a uniform thickness which shall be at least 250/0 greater than the compacted thickness and immediately compacted fully with a power driven road roller to the satisfaction of the Engineer.

3.16.4 Measurement

The premix bituminous seal coat shall be measured in square meters completed and accepted by the Engineer. Measurement shall be based upon the nominal width of seal coat at its top surface as shown on the drawings or as directed by the Engineer. The measurement will be exclusive of prime coat.

3.16.5 Payment

The quantities measured, as provided above, shall be paid for at the contract unit shown below. The price and payment shall be full compensation for supplying, placing and compacting all materials, for all labour, equipment, tools and incidentals necessary to complete the work.

Pay item shall be:

	Unit
12mm premix bituminous seal coat	Square meter

3.17 BITUMINOUS SURFACE TREATMENT**3.17.1 Description**

This work shall consist of application of bituminous binder material and cover aggregates over primed aggregate base course or over cleaned, prepared and accepted bituminous or concrete surface in accordance with these specifications and the lines, dimensions and cross-section shown on the drawing or as required by the Engineer. Specifications for application of bituminous surface treatment may be divided into the following categories:

1. Single Bituminous Surface Treatment (SBST)
2. Double Bituminous Surface Treatment (DBST)
3. Single Otta Seal. (SOS)
4. Double Otta Seal (DOS)

3.17.2 Single Bituminous Surface Treatment**3.17.2.1 Materials****3.17.2.1.1 Bituminous Materials**

The binder material shall be of 60/70 or 80/100 penetration grade straight run bitumen complying with the requirements of ASTM / AASHTO.

3.17.2.1.2 Aggregate

Aggregate shall consist of clean, hard, dry, tough, sound, crushed stone or crushed gravel of uniform quality free from dust, clay, dirt and other deleterious matter and from excess of flat or laminated pieces. Crushed stone shall comply with BS 63 and gravel shall comply with BS: 1984.

Aggregate shall be of such a nature that, when thoroughly coated with the bituminous material proposed for the work, the coating will not be removed upon contact with water.

The aggregate, when tested shall have an Aggregate Impact Value not more than 30 and Los Angeles Abrasion 40 and water absorption of not more than 2%. The flakiness index, as determined in accordance with BS: 812, shall not exceed 35%.

The size of stone chippings shall be in accordance with Table 3.17 (1)

Table 3.17 (1) Size Requirements of Stone Chippings for SBST

SL. No.	Type of Construction	Nominal size of Stone Chippings	Specifications
1.	Single bituminous surface treatment	14mm	100 percent passing through 16 mm sieve and retained on 10 mm sieve

3.17.2.1.3 Quantities of Materials

The quantities of materials used for this work, shall in general, be within the range specified in Table 3.17 (2)

Table 3.17 (2): Quantities of Materials required for one Square Meter of Single Bituminous Surface Treatment

SL. No.	Type of Construction	Stone Chippings		Bitumen
		Nominal Size	Quantity	
1.	Single bituminous surface treatment	14mm	0.015m ³	1.2 to 1.4 Kg

The actual quantity of stone chips and bitumen will be decided on the basis of field trials.

3.17.2.1.4 Stockpiling of Aggregates

Stockpiling of aggregates will be permitted only where agreed by the Engineer. A separate stockpile shall be made for each nominal size of aggregate at each location.

The site of the stockpile shall be cleared of all vegetation and debris, graded and drained, and where the Engineer deems it necessary, the area shall be surfaced with an approved separation layer to keep the aggregate clear and clean without any contamination.

The bottom 5 centimeter layer of aggregate, or any contaminated aggregate, shall not be used in the work.

3.17.2.2 Construction Methods

3.17.2.2.1 Weather and Seasonal Limitations

The surface treatment work shall be carried out only when the atmospheric temperature in the shade is above 10°C. No bituminous material shall normally be applied when the material of the surface to be covered is damp, when the weather is foggy or rainy, or during dust storms.

3.17.2.2.2 Preparation of Base

The base on which surface dressing is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross-sections in accordance with the drawings and as directed by the Engineer. Where the existing surface shows signs of fatting up, this shall be rectified.

The surface shall be thoroughly swept and scraped clean of dust and any other extraneous matter before the spraying of the binder. As necessary, the cleaning shall be done first with hard brushes, then with softer brushes and finally by blowing with a blower or wiping with clean sacks or gunny bags.

3.17.2.2.3 Application of Bituminous Material

Bitumen shall be heated between 140°C to 155°C and the specified quantity shall be sprayed on to the dry surface in a uniform manner preferably with the help of mechanical sprayers if available. In absence of mechanical sprayers, hand sprayers may also be used.

Excessive deposits of binder caused by stopping or starting spraying operations or through leakage or for any other reason shall be rectified before the stone chippings are spread.

3.17.2.2.4 Application of Stone Chippings

Immediately after the application of binder, stone chippings in a dry and clean state, shall be spread uniformly in the surface, preferably by means of a mechanical gritter or approved aggregate spreader, or otherwise manually so as to cover the surface completely. If necessary, the surface shall be broomed to ensure the uniform spread of chippings. The stone chippings shall be spread over the binder coat and initial rolling not later than 3 (three) minutes after application of the binder coat.

3.17.2.2.5 Rolling

Immediately after the application of the stone chippings, the entire surface shall be rolled with an approved smooth wheeled steel roller or with a pneumatic tyred roller having sufficient weight to embed the stone chippings into the bituminous binder layers. Rolling shall commence at the edges and progress towards the centre except in super-elevated portions where it shall proceed from the lowest level to the highest level. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up irregularities.

Rolling shall continue until all aggregate particles are firmly bedded in the binder and present a uniform closed surface. In case of steel roller, it shall not be too heavy so that the aggregates are not crushed during rolling.

3.17.2.2.6 Opening to Traffic

Traffic shall not be permitted to run on any newly surface dressed area until the following day. In special circumstances, however, the Engineer may open the road to traffic immediately after rolling, but in such cases speed shall be limited to 16 km, per hour until the following day (by speed breaker as an example or any other method approved by the Engineer).

3.17.2.3 Measurement

Single bituminous surface treatments shall be measured in square meters of materials of the specified quantities provided, placed and accepted. Measurements shall be based upon the nominal width of the surface course at its top surface as shown in drawings and measured at site and the actual length measured horizontally along centerline of the surface of the road.

Priming on the aggregate base course shall be measured and paid separately.

3.17.2.4 Payment

The quantities measured for surface treatment shall be paid for at the contract unit price for the item listed below and as shown in the Bill of Quantities. The prices and payment shall be full compensation for furnishing and placing all materials, including all labour, equipment, tools and incidentals necessary to complete the works.

Where defective work is corrected, or additives are used which have not been specified or ordered by the Engineer, no payments shall be made in respect of the extra work or materials used in excess of the quantities specified or ordered.

Pay item shall be:

	Unit
Single Bituminous Surface Treatment (SBST)	Square meter

3.17.3 Double Bituminous Surface Treatment**3.17.3.1 Materials****3.17.3.1.1 Bituminous Materials**

The binder material shall be of 60/70 or 80/100 penetration grade straight run bitumen complying with the requirements of ASTM / AASHTO.

3.17.3.1.2 Aggregate

Aggregate shall consist of clean, hard, dry, tough, sound, crushed stone or crushed gravel of uniform quality free from dust, clay, dirt and other deleterious matter and from excess of flat or laminated pieces. Crushed stone shall comply with BS 63 and gravel shall comply with BS: 1984.

Aggregate shall be of such a nature that, when thoroughly coated with the bituminous material proposed for the work, the coating will not be removed upon contact with water.

The aggregate, when tested shall have an Aggregate Impact Value not more than 30 and Los Angeles Abrasion 40 and water absorption of not more than 2%. The flakiness index, as determined in accordance with BS: 812, shall not exceed 35%.

The size of stone chippings shall be in accordance with Table 3.17 (3)

Table 3.17 (3): Size Requirements of Stone Chippings for DBST

SL. No.	Type of Construction	Nominal size of Stone Chippings	Specifications
1.	First coat of double bituminous surface treatment	14mm	100 percent passing through 16 mm sieve and retained on 10 mm sieve
2.	Second coat of double bituminous surface treatment	7mm	100 percent passing through 10.00 mm sieve and retained on 5.00 mm sieve

3.17.3.1.3 Quantities of Materials

The quantities of materials used for this work, shall in general, be within the range specified in Table 3.17 (4)

Table 3.17 (4): Quantities of Materials required for one Square Meter of Double Bituminous Surface Treatment

SL. No.	Type of Construction	Stone Chippings		Bitumen
		Nominal Size	Quantity	
1.	First coat of double bituminous surface treatment	14mm	0.015 m ³	1 .2 to 1 .4 Kg
2.	Second coat of double bituminous surface treatment	7mm	0.008 m ³	0.8 to 1.0 kg

The actual quantity of stone chips and bitumen will be decided on the basis of field trials.

3.17.3.1.4 Stockpiling of Aggregates

Stockpiling of aggregates will be permitted only where agreed by the Engineer. A separate stockpile shall be made for each nominal size of aggregate at each location.

The site of the stockpile shall be cleared of all vegetation and debris, graded and drained, and where the Engineer deems it necessary, the area shall be surfaced with an approved separation layer to keep the aggregate clear and clean without any contamination.

The bottom 5 centimeter layer of aggregate, or any contaminated aggregate, shall not be used in the work.

3.17.3.2 Construction Methods**3.17.3.2.1 Weather and Seasonal Limitations**

The surface treatment work shall be carried out only when the atmospheric temperature in the shade is above 10°C. No bituminous material shall normally be applied when the material of the surface to

be covered is damp, when the weather is foggy or rainy, or during dust storms.

3.17.3.2.2 Preparation of Base

The base on which surface dressing is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross-sections in accordance with the drawings and as directed by the Engineer. Where the existing surface shows signs of fatting up, this shall be rectified.

The surface shall be thoroughly swept and scraped clean of dust and any other extraneous matter before the spraying of the binder. As necessary, the cleaning shall be done first with hard brushes, then with softer brushes and finally by blowing with a blower or wiping with clean sacks or gunny bags.

3.17.3.2.3 Application of Bituminous Material

Bitumen shall be heated between 140°C to 155°C and the specified quantity shall be sprayed on to the dry surface in a uniform manner preferably with the help of mechanical sprayers if available. In absence of a mechanical sprayers hand sprayers may also be used. Excessive deposits of binder caused by stopping or starting spraying operations or through leakage or for any other reason shall be rectified before the stone chippings are spread.

3.17.3.2.4 Application of Stone Chippings for the first Coat

Immediately after the application of binder, stone chippings in a dry and clean state, shall be spread uniformly in the surface, preferably by means of a mechanical gritter or approved aggregate spreader, or otherwise manually so as to cover the surface completely. If necessary, the surface shall be broomed to ensure the uniform spread of chippings. The stone chippings shall be spread over the binder coat and initial rolling not later than 3 (three) minutes of after application of the binder coat.

3.17.3.2.5 Rolling

Immediately after the application of the stone chippings, the entire surface shall be rolled with an approved smooth wheeled steel roller or with a pneumatic tyred rollers having sufficient weight to embed the stone chippings into the bituminous binder layers. Rolling shall commence at the edges and progress towards the centre except in super-elevated portions where it shall proceed from the lowest level to the highest level. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly bedded in the binder and present a uniform closed surface. In case of steel roller, it should not be too heavy so that the aggregates are not crushed during rolling.

3.17.3.2.6 Application of the Second Coat of Surface Dressing

The second coat shall be applied immediately or within 15 days of laying the first coat as decided by the Engineer on the basis of field condition, and volume and type of traffic. The construction operations for the second coat shall be the same as described in clauses 3.17.3.2.3 up to 3.17.3.2.5.

3.17.3.2.7 Opening to traffic

Traffic shall not be permitted to run on any newly surface dressed area until the following day. In special circumstances, however, the Engineer may open the road to traffic immediately after rolling, but in such cases speed shall be limited to 16 km per hour until the following day (by speed breaker as an example or any other method approved by the Engineer).

3.17.3.3 Measurement

Double bituminous surface treatments shall be measured in square meters of materials of the specified quantities provided, placed and accepted. Measurements shall be based upon the nominal width of the surface course at its top surface as shown in drawings and measured at site and the actual length measured horizontally along centerline of the surface of the road.

Priming on the aggregate base course shall be measured and paid separately.

3.17.3.3 Payment

The quantities measured for surface treatment shall be paid for at the contract unit price for the item listed below and as shown in the Bill of Quantities. The prices and payment shall be full compensation for furnishing and placing all materials, including all labour, equipment, tools and incidentals necessary to complete the first coat and the second coat of the double bituminous surface treatment.

Where defective work is corrected, or additives are used which have not been specified or ordered by the Engineer, no payments shall be made in respect of the extra work or materials used in excess of the quantities specified or ordered.

Pay item shall be:

	Unit
Double bituminous Surface Treatment (DBST)	Square meter

3.17.2 Otta seal**3.17.4.1 Description**

Otta Seal, named after the name of Otta valley in Norway where it was first introduced is basically one of the methods of surface dressing. This work consists of one or two careful applications of bituminous material and covered with aggregate on prepared bituminous, concrete and aggregate base course surface in accordance with the specifications, lines, dimensions and cross-sections as shown on the drawings or as directed by the Engineer. When one application placed, the term "Single Otta Seal" shall apply; when two applications are placed the term "Double Otta Seal shall apply.

3.17.4.2 Single Otta Seal**3.17.4.2.1 Bituminous Material**

Bituminous material shall be of 80/100 penetration grade bitumen complying with the requirements of ASTM/ AASHTO. The binder has to be cut back by using the cutters, power paraffin and engine oil (SAE 30 grade) blended by the proportions of 10% and 8% respectively as percentage of total volume at blending temperature of the bitumen (maximum 140°C). If directed by the Engineer, trial should be carried out before application

3.17.4.2.2 Aggregate

Both natural gravel and crushed gravel or a mixture of both may be used. The maximum size of stone shall be 16 mm. Screening of aggregate shall be required to remove over size stones as well as excess of fines. The gradation of aggregate is given below.

Sieve (mm)	Dense % Passing	Coarse % Passing
19.0	100	100
16.0	79-1 00	77 -1 00
12.5	61-100	59-1 00
9.5	42.100	40.85
4.750	19-68	17 -46
2.360	8-51	1-20
1.180	6-40	0.10
0.600	3.30	0.3
0.300	2.21	0.2
0.150	1-16	0-1
75 micron	0-10	0-1

For light traffic (Less than 100 vehicles per day) gradation should be in the coarser side and at finer side for more than 100 vehicles per day. For roads carrying more than 200 vehicles per day, a blend of crushed and uncrushed aggregate at a ratio of 30/70 is preferable. The aggregate strength shall have a minimum dry 10% FACT strength value (ref. BSI 812) 70 kN or an ACV value (aggregate

crushing value. ref. BSI 812) not more than 30. If crushed aggregate is used, the weighted Flakiness index shall be determined using 13.2 mm and 6.7 mm sieves and shall not exceed 30%.

3.17.4.2.3 Preparation of binder

The emptying of the 80/100 pen. bitumen from drums and into bitumen boilers shall be carried out under strict control. Any opened drum must be checked if water is present, and water removed before placed onto the bitumen boiler. Water in contact with hot bitumen will cause boil over and foaming, which may lead to a fire or an explosion. The bitumen boiler shall be equipped with a thermometer and gas or paraffin/diesel burners to control overheating of the bitumen.

Maximum heating temperature in bitumen boilers shall not exceed 130°C.

Required quantity of bitumen from the boiler should be loaded into the distributor by using the equipment designed for that purpose (filling hose and the filling valve). It is important to ensure that the bitumen level in the distributor is minimum 150 mm above the heating flue before the burner is operated.

The adding of cutter (power paraffin) and flux oil (engine oil) at the correct quantity shall follow the same procedure as for the bitumen and be added using the designed hose and valve and NOT through the manhole. The cutter shall be added first and followed by adding the flux oil.

The maximum temperature of the bitumen (80/100 pen) during the blending process shall NOT exceed 140°C.

To ensure a homogeneous mix of the components the blend shall be circulated for minimum ONE HOUR after all three components are filled into the distributor. The last 15 minutes before spraying the blend shall also be circulated through the spray bar. During the circulation time the binder is heated up to the required spray temperature of minimum 150°C and maximum 155°C. In general, blends should not be held at temperatures within the spraying range for periods exceeding 10 hours

3.17.4.3 Construction Method

3.17.4.3.1 Preparation of the Road Base

The preparation of the road base to be surfaced shall be in such a condition that a good bond between the base and the surfacing is achieved. The base shall be broomed free of sand, mud, excess dust or any other foreign matter. Places where lamination can be seen in the top base shall be removed and repaired. The brooming work shall preferably be carried out manually.

Water should be sprayed to dampen the entire road surface, but not cause the moisture content in the base to rise significantly or allow water to pond within the area to be sealed. If voids near the surface are filled with water, the surface shall be allowed to dry out by evaporation to a slightly damp condition.

Traffic can be allowed to pass during the preparation phase, but excessive speeding shall be avoided.

3.17.4.3.2 Spraying of Binder

Area to be sprayed shall be set out with a string line and shall be 20cm off verge of the spray. Prior to spraying, all the necessary arrangement for sealing shall be ensured. Three trays at staggered position shall be used to check the application rate. No priming is needed for Otta Seals. The application rate of binder shall be 2.1 to 2.5 liter/sq.m. which shall be decided by trial. A light spray of water in some cases may be required to develop a good bond between the base and the seal.

3.17.4.3.3 Spreading of aggregate

The spreading of aggregate does not require any mechanical equipment, manually spreading of aggregate can be considered as appropriate. Aggregate shall - be stockpiled with sufficient quantity at staggered intervals (left and right hand side of the road) of 10 metres or as seems to be appropriate. The spreading of aggregate shall commence immediately after spraying of binder has started. The binder shall be covered with aggregate as quickly as possible. The spreading should be done in such a way that there are no areas left out with too little aggregate or no aggregate at all. Any such spots shall be covered with aggregate immediately.

A spray length of 100 meter at full sealing width shall be taken in one lift so that an immediate cover with aggregate and rolling operation can be started within 10 minutes after bituminous binder applied. The contractor shall arrange the following equipment required to carry out the sealing operation.

1.	Bitumen distributor or a suitable hand spray machine with an arrangement of heating and mixing the cut back bitumen to the desired temperature.
2.	Brush, broom/powerbroom and drag-broom capable of distributing the unevenly sprayed aggregate without disturbing the particles freshly bedded in the bitumen binder.
3.	Pneumatic (5 Ton) Tyre Roller and steel roller. In the absence of pneumatictyred roller two half loaded trucks can be arranged.

If any initial occurrence of fatty spots, shall be blinded off with more aggregate and rolled. During spreading of aggregate care shall be exercised to apply the cover material a bit excessive in order to ensure proper covering. If the application is far in excess shall be broomed off about a week after since completion. All of the loose aggregate shall not be broomed off as the remaining aggregate plays an important role in forming the final surfacing.

3.17.4.3.4 Rolling

Immediately following the spreading of aggregate to the satisfaction of the Engineer, rolling shall commence (preferable within 10- minutes after spraying of binder) with preferably a pneumatic tyred roller or a steel roller followed by half to embed the chips in the bituminous binder. Before traffic is allowed to pass, the entire surfaced area shall be rolled minimum three times by the pneumatic roller. As the centre of the road has less exposure to traffic loading compared to the wheel path, the centre section of the surfacing shall be rolled more heavily during the initial rolling. Care shall be taken not to destroy the camber.

Rolling shall generally begin at the outer edge of surfacing and progress uniformly toward the centre

except on super elevated curves where rolling shall begin at the lower edge and progress uniformly towards the higher edge. Consecutive roller passes shall generally overlap by about one third of the roller's width.

After day's production is completed, rolling shall commence for the entire sprayed area with all rolling equipment available until sunset. The following day from noon time rolling shall be commenced again and be continued for the rest period of the day.

Excess of aggregates shall be broomed off not before one week since completion. The brooming of material shall be carried out in the morning. It is important not to broom off all aggregate as the remaining aggregate plays an important role in forming the final surfacing.

3.17.4.4 Open to Traffic

When the initial rolling is completed, commercial traffic could be allowed in the surfaced area. The speed of traffic shall be temporarily reduced to avoid the damage to the aggregate cover materials. Maximum speed limit of 30-40 km/hour shall, therefore, be enforced during the first month after construction (by speed breaker as an example or any other method approved by the Engineer.)

3.17.4.5 Measurement

Otta seal surface shall be measured in square meter for the surface completed and accepted by the Engineer. Measurement shall be based upon the nominal width at its top surface as shown on the drawings or as directed by the Engineer.

3.17.4.6 Payment

Payment for the measured and accepted Otta Seal surface shall be at the contract price for the item listed below and as shown in the Bill of Quantities. Payment shall be the full compensation for the provision of all materials, labour, equipment and all other incidental including trial sections required to complete the work as specified or as directed by the Engineer.

Pay item shall be:

	Unit
Single Otta Seal coat	Square meter

3.17.5 Double Otta Seal

3.17.5.1 General

The second seal should be applied after about one year or at least one rainy season of application of the first seal.

By delaying the second seal until after the first rainy season, any occurring failures or defects of the surfacing or pavement caused by the rain can be repaired before the second seal is applied. This will ensure a better short and long term performance of the surfacing.

The preparatory work before the sealing operation commences and the way it is constructed is similar to what is required for the first seal. The surface to be sealed has to be clean from any foreign matter, including droppings from animals, which will reduce the adhesion between the old and the new surfacing

3.17.5.2 Bituminous Binder

Bituminous binder shall be of 80/100 penetration grade bitumen complying with the requirements o. ASTM/ AASHTO. The binder has to be cut back by using, the cutters, power paraffin and engine oil (SAE 30 grade) blended by the proportions of 10% and 8% respectively as percentage of total volume at blending temperature of the bitumen (maximum 140°C).

3.17.5.3 Aggregate

Both natural gravel and crushed gravel or a mixture of both may be used. The maximum size of stone

shall be 16 MM. Screening of aggregate shall be required to remove over size stones as well as excess of fines. The gradation of aggregate is given below.

	Sieve (mm)		Dense % Passing		Coarse % Passing	
	19.0		100		100	
	16.0		79-1 00		77 -1 00	
	12.5		61-1 00		59-1 00	
	9.5		42.100		40.85	
	4.750		19-68		17 -46	
	2.360		8-51		1-20	
	1.180		6-40		0.10	
	0.600		3.30		0.3	
	0.300		2.21		0.2	
	0.150		1-16		0-1	
	75 micron		0-10		0-1	

For light traffic (Less than 100 vehicles per day) gradation should be in the courser side and at finer side for more than 100 vehicles per day. For roads carrying more than 200 vehicles per day, a blend of crushed and uncrushed aggregate at a ratio of 30/70 is preferable. The aggregate strength shall have a minimum dry 10% FACT strength value (ref. BSI 812) 70 kN or an ACV value (aggregate crushing value, ref. BS[812) not more than 30. If crushed aggregate is used, the weighted Flakiness index shall be determined using 13.2 mm and 6.7 mm sieves and shall not exceed 30%

3.17.5.4 Preparation of Binder

The emptying of the 80/100 pen. bitumen from drums and into bitumen boilers shall be carried out under strict control. Any opened drum must be checked if water is present, and water removed before placed onto the bitumen boiler. Water in contact with hot bitumen will cause boil over and foaming, which may lead to a fire or an explosion. The bitumen boiler shall be equipped with a thermometer and gas or paraffin/diesel burners to control overheating of the bitumen.

Maximum heating temperature in bitumen boilers shall not exceed 130°C.

Required quantity of bitumen from the boiler should be loaded into the distributor by using the equipment designed for that purpose (filling hose and the filling valve). It is important to ensure that the bitumen level in the distributor is minimum 150 mm above the heating flue before the burner is operated.

The adding of cutter (power paraffin) and flux oil (engine oil) at the correct quantity shall follow the same procedure as for the bitumen and be added using the designed hose and valve and NOT through the manhole. The cutter shall be added first and followed by adding the flux oil.

The maximum temperature of the bitumen (80/100 pen) during the blending process shall NOT exceed 140°C.

To ensure a homogeneous mix of the components the blend shall be circulated for minimum ONE HOUR after all three components are filled into the distributor. The last 15 minutes before spraying the blend shall also be circulated through the spray bar. During the circulation time the binder is heated up to the required spray temperature of minimum 150°C and maximum 155°C. In general, blends should not be held at temperatures within the spraying range for periods exceeding 10 hours.

3.17.5.5 Construction Method

3.17.5.5.1 Preparation of the Road Base

The preparation of the road base to be surfaced shall be in such a condition that a good bond between the base and the surfacing is achieved. The base shall be broomed free of sand, mud excess dust or any other foreign matter. Places where lamination can be seen in the top base shall be removed and repaired. The brooming work shall preferably be carried out manually.

Water should be sprayed to dampen the entire road surface, but not cause the moisture content in the

base to rise significantly, or allow water to pond within the area to be sealed. If voids near the surface are filled with water, the surface shall be allowed to dry out by evaporation to a slightly damp condition.

Traffic shall be allowed to pass during the preparation phase, but excessive speeding shall be avoided.

3.17.5.5.2 Spraying of Binder

Area to be sprayed shall be set out with a string line and shall be 20cm off verge of the spray. Prior to spraying, all the necessary arrangement for sealing shall be ensured. Three trays at staggered position shall be used. to check the application rate. No priming is needed for Otta Seals. The application rate of binder shall be 2.1 to 2.5 liter/sqm for the 1st layer.

For the 2nd layer application rate of binder shall be 1.8 to 2.2 liter/sq.m. Both the spray rates shall be decided by trials.

3.17.5.5.3 Spreading of Aggregate

The spreading of aggregate does not require any mechanical equipment, manually spreading of aggregate can be considered as appropriate. Aggregate shall be stockpiled with sufficient quantity at staggered intervals (left and right hand side of the road) of 10 meters or as seems to be appropriate. The spreading of aggregate shall commence immediately after spraying of binder has started. The binder shall be covered with aggregate as quickly as possible. The spreading should be done in such a way that there are no areas left out with too little aggregate or no aggregate at all. Any such spots shall be covered with aggregate immediately.

A spray length of 100 meter at full sealing width shall be taken in one lift so that an immediate cover with aggregate and rolling operation can be started within 10 minutes after bituminous binder applied. The contractor shall arrange the following equipment required to carry out the sealing operation.

- (1) Bitumen distributor or a suitable hand spray machine with an arrangement of heating and mixing the cut back bitumen to the desired temperature.
- (2) Brush, broom/powerbroom and drag-broom capable of distributing the unevenly sprayed aggregate without disturbing the particles freshly bedded in the bitumen binder.
- (3) Pneumatic 5 ton Tyre Roller and steel roller. In the absence of pneumatic-tyred roller two half loaded trucks can be arranged.

If any initial occurrence of fatty spots, shall be blinded off with more aggregate and rolled. During spreading of aggregate care shall be exercised to apply the cover material a bit excessive in order to ensure proper covering. If the application is far in excess shall be broomed off about a week after since completion. All of the loose aggregate shall not be broomed off as the remaining aggregate plays an important role in forming the final surfacing.

3.17.5.5.4 Rolling

Immediately following the spreading of aggregate to the satisfaction of the Engineer, rolling shall commence (preferable within 10 minutes after spraying of binder) with preferably a pneumatic tyred roller or a steel roller followed by half loaded 5-ton trucks to embed the chips in the bituminous binder. Before traffic is allowed to pass, the entire surfaced area shall be rolled minimum three times by the pneumatic roller. As the centre of the road has less exposure to traffic loading compared to the wheel path, the centre section of the surfacing shall be rolled more heavily during the initial rolling. Care shall be taken not to destroy the camber.

Rolling shall generally begin at the outer edge of surfacing and progress uniformly toward the centre except on super elevated curves where rolling shall begin at the lower edge and progress uniformly towards the higher edge. Consecutive roller passes shall generally overlap by about one third of the roller's width.

After days production is completed, rolling shall commence for the entire sprayed area with all rolling equipment available until sunset. The following day from noon time rolling shall be commenced again and be continued for the rest period of the day.

Excess of aggregates shall be broomed off not before one week since completion. The brooming of material shall be carried out in the morning. It is important not to broom off all aggregate as the remaining aggregate plays an important role in forming the final surfacing.

3.17.5.6 Open to traffic

When the initial rolling with the pneumatic roller is completed, commercial traffic could be allowed in the surfaced area. The speed of traffic shall be temporarily reduced to avoid the damage to the aggregate cover materials. Maximum speed limit of 30-40 km/hour shall, therefore, be enforced during the first month after construction (by speed breaker as an example or any other method approved by the Engineer.)

3.17.5.7 Measurement

Otta seal surface shall be measured in square meter for the surface completed and accepted by the Engineer. Measurement shall be based upon the nominal width at its top surface as shown on the drawings or as directed by the Engineer.

3.17.5.8 Payment

Payment for the measured and accepted Otta Seal surface shall be at the contract price for the item listed below and as shown in the Bill of Quantities. Payment shall be the full compensation for the provision of all materials, labour, equipment and all other incidental including trial sections required to complete the work as specified or as directed by the Engineer.

Pay item shall be:

	Unit
Double Otta Seal coat	Square meter

3.18 RIGID PAVEMENT

3.18.1 Description

This work, construction of rigid pavement shall consist of supplying, bending placing of reinforcement, concreting providing shutters/form work as necessary, curing the concrete pavement for 28 days with sprinkling water. The work may be necessary where the road pavement is submerged with flood water or with normal monsoon water logging and the road surface remains under water for couple of weeks and the alternate alignment is neither suitable nor economically and socially possible or feasible. The work shall be undertaken as per drawing, design, keeping the line, length, thickness, strength and level as indicated in the drawing or as per direction of the Engineer.

The concrete shall consist of a mixture of Portland cement, coarse, fine aggregates and water (free from salinity).

3.18.2 Materials

3.18.2.1 Cement

As of the clause 3.3.2.1 of this specification

3.18.2.2 Coarse Aggregate

As of the clause 3.3.2.2 of this specification

3.18.2.3 Fine Aggregate

As of the clause 3.3.2.3 of this specification

3.18.2.4 Water

As of the clause 3.3.2.4 of this specification

3.18.2.5 Reinforcing Bar

As of the Clause 3.4 of this specification

3.18.2.6 Storage of Material

As of the clause 3.3.2.5 of this specification

3.18.3 Testing of Materials

3.18.3.1 Cement

As of the clause 3.3.3.1 of this specification

3.18.3.2 Aggregate

As of the clause 3.3.3.2 of this specification

3.18.3.3 Steel

The tensile strength of the reinforcing bars shall be tested in the Laboratory collecting samples from the works site. Unspecified materials shall be rejected.

3.18.4 Composition and strength of concrete

3.18.4.1 Concrete Specifications

As detailed in specification for Bridges section or as directed by the Engineer-in-Charge.

3.18.4.2 Trial Mixes

As detailed in specification for Bridges section or as directed by the Engineer-in-Charge.

3.18.5 Testing of Concrete

3.18.5.1 Compressive Strength

As detailed in specification for Bridges section or as directed by the Engineer-in-Charge.

3.18.5.2 Slump

As detailed in specification for Bridges section or as directed by the Engineer-in-Charge.

3.18.6 Construction Methods

3.18.6.1 Form Work

Formwork shall be of Marine Plywood of adequate thickness or of steel shall be built mortar tight and rigid enough to keep the concrete in position during placing, compacting, setting and hardening.

The form work shall be rigidly constructed, supported on a firm-bearing base, and braced so as to retain its shape and position and shall be set to the specified lines and levels. Formwork shall be constructed so that loose material can be removed from inside without disturbing the Formwork.

Metal ties or anchorages within the form shall be constructed to permit their removal to a depth of 50mm from the face without disturbing the concrete, and shall be of such design that the size of the cavity left is minimized.

Timber Formwork shall be of dressed timber, smoothed on the concrete face side or with a form liner of approved type, to impart a "fair faced" finish to the concrete.

Steel Formwork shall be rigid with no surface blemish that will impair the quality of finish of the concrete surface.

Forms shall be sufficiently tight to prevent loss of mortar from concrete.

Molding strips shall be placed in the corners of forms to produce edges on permanently exposed concrete surfaces as shown on the drawings.

Except where otherwise directed, all forms be coated with oil on the concrete face side. The oil used must be non-staining and have no adverse effect on paint or any other finish.

All Formwork shall be approved by the Engineer before placing of concrete commences.

3.18.6.2 Construction Joints

As of the clause 4.18 of the specification for Bridges

3.18.6.3 Expansion Joints

As of the clause 4.18 of the specification for Bridges

3.18.6.4 Mixing of Concrete

As of the clause 4.16.8 of the specification for Bridges

3.18.6.5 Handling and placing of concrete

As of the clause 4.16.8 of the specification for Bridges

For concrete slab pavement construction the sub-base layer of the road shall be moistened sprinkling water before placing concrete for pavement. Concrete shall be placed in full depth at a time as specified and designed. Immediately after placing the reinforcement mesh, dowel bar for joints and shall be placed before the concreting starts keeping the clearance of reinforcement as per design concrete shall be compacted to achieve the specified thickness as per design drawing. Concreting of slabs shall be done for staggered bays and the expansion and contraction joints shall be kept with separation planks of thickness 13mm, which shall be taken out after initial setting of concrete.

3.18.6.6 Compaction

For concrete slab pavement construction the compaction shall be done with a mechanical vibrator and finally with a wooden tamping beam of about 3m long and of compacting face width 100mm and to shape conforming to the camber or lateral slope as specified in the design and to yield a rough surface to form skid resistance of the pavement to traffic.

3.18.6.7 Curing

Should be done as per specification or as directed by the Engineer-in-Charge.

3.18.6.8 Protection of Concrete Work

Should be done as per specification or as directed by the Engineer-in-Charge.

3.18.6.9 Removal of form work

Should be done as per specification or as directed by the Engineer-in-Charge.

3.18.6.10 Measurement

The work shall be measured in volume of concrete in cubic meter completed, cured and accepted.

The reinforcement of all sizes steel bar used and accepted shall be measured in kilogram.

3.18.6.11 Joint Filler

The expansion joints & contraction joints shall be filled with the mixture of hot bitumen and sand as per direction of the Engineer.

3.18.6.12 Dowel Bar at Construction Joints

The dowel bar of specified diameter shall be plain mild steel bar.

3.18.6.13 Placing of Dowel Bar

The Dowel bar of specified size shall be placed at specified spacing as mentioned in the design at the middle of the slab thickness. One half of the dowel bar shall be embedded in concrete of one panel and the other half of the bar shall be wrapped with thin sheet (2mm thick) of sponge of length 20mm more than that of the one half of the Dowel bar, so as to form a small gap between the concrete of the adjacent panel (in the longitudinal direction) and the dowel bar for free movement and expansion.

3.18.6.14 Payment

The accepted work measured shall be paid for at the contract unit prices per cubic meter of concrete as shown in the BOQ. The payment shall be full compensation for construction of the rigid pavement including charges for all equipment, construction and removal shutters/form works, material used and all labour, tools and incidentals necessary to complete the work.

Pay items shall be:

Clause	Description	Unit of Measurement
2.18	Preparation of bed, casting concrete, curing the same, protecting the work and removal of shutters.	Cubic meter
2.18	Supply, bending, binding and placing the reinforcement.	Kilogram

3.19 TOPSOIL

3.19.1 Description

This work shall consist of furnishing topsoil removed from approved sources and transporting, spreading and compacting it on prepared surfaces in accordance with these Specifications and the Drawings.

3.19.2 Materials

Topsoil furnished by the Contractor shall consist of a natural friable surface soil without admixture of undesirable soil, refuse or foreign materials. It shall be reasonably free from roots, hard clay, coarse gravel, stones larger than 50 mm in any dimension, noxious weeds, tall grass, brush, sticks, stubble or other litter and shall have indicated by a healthy growth of crops, grasses, trees or other vegetation that it is free-draining and non-toxic

3.19.3 Construction Methods

The Contractor shall notify the Engineer at least 5 days before he intends to start topsoil stripping operations. After inspection and approval by the Engineer, and prior to stripping the topsoil, the Contractor shall remove noxious weeds and tall grass, brush, large stones and roots.

The topsoil shall be evenly spread on the designated areas to a depth which, after settlement and compaction, shall be that shown on the Drawings. Spreading shall not be done when the ground or topsoil is excessively wet or otherwise in a condition detrimental to the work. The roadway surfaces shall be kept clean during hauling and spreading operations.

After spreading has been completed, any large clods, large stones, roots, stump and litter shall be raked up and removed.

To reduce erosion as much as possible, the placing of topsoil and the subsequent grassing shall be done simultaneously with or immediately after the placing and compacting of the individual layers of fill.

3.19.4 Measurement

The quantity measured for payment shall be the number of cubic meters of required topsoil of the designated thickness complete and accepted in place. If side slopes of embankments or excavation requiring top soil are of greater area than required due to earthworks not conforming to the required dimension, the area measured shall be the required area as if the earthwork had conformed to the required dimension.

This work measured as provided above, shall be paid for at the Contract unit price per cubic meter. The price shall be full compensation for furnishing and placing all material, including all labour, equipment, tools and incidentals necessary to complete the work.

No payment will be made for topsoil until it has been grassed according to Section 2.16.

Pay item shall be:

	Unit
Topsoil	Cubic meter

3.20 GRASSING/TURFING

3.20.1 Description

This work shall consist of supplying turf and sods as required and planting them to give a healthy, stable covering of grass over all embankment slopes and earth shoulders which will maintain its growth in any weather and prevent erosion of the material in which it is planted.

3.20.2 Materials

Grass shall be of species native to Bangladesh, harmless and inoffensive to persons and animals and not of a kind recognized as a nuisance to agriculture. It shall be free of disease and noxious weeds, deep-rooted and sufficiently rapid growing and spreading to give complete cover over the planted area within the Defects Liability Period.

The term "grass" embraces turf and sods and, if the Engineer permits, may include plants of other types capable of giving effective protection.

Fertilizer shall be approved cow dung or mixtures of plant nutrients or both.

3.20.3 Construction Method

Grassing/turfing shall be done by planting sods or turf to give continuous cover over the whole area. They shall be planted with their root system substantially undamaged, well buried in firm material, and packed around with moist earth in which they have grown.

Grass shall be planted as soon as possible to protect completed embankment works. The work shall be done at such a time, and in such a way that areas to be grassed are substantially covered with healthy, well established, firmly rooted grass and the planted area is free from erosion channels, prior to issue of the Certificate of Completion.

The surface to be planted shall be trimmed in such a way that the ground surface after planting shall be as shown on the Drawings.

Fertilizer shall be added at the time of planting if necessary to ensure good ground cover within the required time.

3.20.4 Measurement

This work shall be measured for payment as the area in square meters of turfed or sodded surface whether horizontal or sloping, of required and accepted grassing well established in place.

3.20.5 Payment

The work measured shall be paid for at the Contract unit price per square meter. The payment will be full compensation for supplying all materials including fertilizer, labour, equipment, tools and incidentals necessary to complete the work.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT
3.20	Grass Turfing	Square Meter
3.20	Grass Sodding	Square Meter

3.21 REPAIR WORKS (Introduction)

3.21.1 General

These general requirements shall apply to all pavement repair works undertaken to bring existing pavements to lines, levels, profile and conditions prior to application of a bituminous overlay or strengthening/protection layer. The repair works of the designated type shall be taken up at locations and extent (length, width and depth) as shown on the Drawings or as directed by the Engineer.

- Where damaged seal coat is only by minor cracks or patches, the surface of the damaged areas shall be prepared as directed by Engineer and brought up to existing level with suitable material.
- In addition, in heavily trafficated areas, and as decided by the Engineer in such areas, 25mm Premix Bituminous Carpeting shall also be added, as specified in Sections 2.13 and 2.24.
- Where existing seal coat or other surface material is damaged excessively, all unacceptable material shall be removed throughout. These areas shall thereafter be cleared to existing base course level, properly cleaned and prepared prior to addition 25mm bitumen carpeting throughout as specified in Section 2.24.

3.21.2 Types of Repair Works

The repair works which will depend on the extent of damage or distress to the existing pavement just prior to their start shall be classified under the following categories.

- Ravel Repair**: Raveling is characterized by stripping or separation of the aggregates from the bituminous binder and is manifested in the form of pockmarks or eroded surface.

Repair of the resulting depression to an average depth not exceeding 15mm shall be classified as Ravel Repair, described in Clause 2.18 hereinafter.

- Depression Patching**: Rutting of pavement under the vehicular wheel paths and settlement of one or more of the pavement layers are manifested in the form of isolated or continuous pavement depressions accompanied with or without loss of the existing bituminous surfacing.

For the purpose of these specifications, the depression patching shall be classified under the following three types:

- Type A** : Average depth of depression to be patched varying between 15 and 30 mm;
- Type B** : Average depth of depression to be patched in excess of 30 mm but not more than 50 mm, and
- Type C** : Average depth of depression in excess of 50 mm and the extent of depression exceeding 10 sqm in a single location.

Depression having average depths in excess of 50 mm and area less than 10sqm in a single location shall be classified as potholes described in Sub-Clause (3) below.

- Pothole Repair**: Repair of local areas affected by disintegration and loss of existing pavement materials and showing up in the form of localized depressions or holes in the pavement with average depth exceeding 50 mm and area in a single location less than 10sqm shall be classified as Pothole Repair.

- 4) **Edge Repair:** Repair of pavement edges broken down in chunks or frayed pavement edges arising mainly out of poor compaction or lack of lateral support shall be classified as Edge Repair.

3.21.3 General Requirements of Repair Works

Unless otherwise directed by the Engineers, in all pavement repair works, the Contractor shall observe and satisfy the requirements spelt out below:

- 1) Prior to application of any improvement treatment or overlay to an existing pavement, it shall be jointly inspected by the representatives of the Engineer and the Contractor to identify the location, extent and type of pavement repair. Based on this, the Contractor shall prepare a kilometer-wise list of all the repair works by type, location and extent, and get this approved by the Engineer.
- 2) All the pavement areas to be repaired shall be marked in regular geometrical shapes in advance of starting the works by the Contractor using paint marks on pavement and pegs on earth shoulders, and got approved by the Engineer.

The boundary lines for repair shall be off-set by about 200 mm outside the affected areas.

- 3) Classification of the repair works by type shall be as described in Clause 2.17.2, and any decision of the Engineer in this regard shall be binding on the Contractor.
- 4) The repair shall start and proceed in a systematic manner from one end or other predetermined points as approved by the Engineer. For this purpose, the Contractor shall prepare a work programme which shall be got approved by the Engineer in advance.
- 5) In all cases of pavement repair, the existing pavement surface shall be thoroughly cleaned of mud, loose particles, organic material and other deleterious matter using brooms, compressed air, water jets or a combination of these as required. In all cases, the surface cleaning shall be approved by the Engineer prior to application of any new bituminous or other pavement material for repair purposes.
- 6) Surface of any patchwork or repair work shall be finished slightly proud (not exceeding 5 mm) of the connecting pavement portions and provide an even appearance. No part of the repair work shall present an undulation in excess of 10 mm when tested with a 2-m long straight edge.
- 7) Unless the bituminous binder in an emulsion, no repair work involving the use of bitumen shall be done when it is raining or when the base is wet.
- 8) During all times of the repair work, it shall be the responsibility of the Contractor to forewarn the public about the repair works and take all the necessary measures including posting of advance warning signs, flagmen, etc. for safe passage of public traffic.
- 9) All surplus excavated material shall be transported by the Contractor to the spoil tips and the pavement area kept clean and tidy on completion of the repair works.
- 10) All equipment brought to site shall be of the type appropriate to the type of repair work and their selection is left to the responsibility of the Contractor. The Contractor shall demonstrate the capability for repair works of each equipment brought to site, and any equipment considered unsatisfactory by the Engineer shall be promptly replaced by the Contractor.

Equipment normally found suitable for repair works are listed below as a guide to the Contractor in the selection of the equipment but the Employer does not guarantee that these will invariably be approved by the Engineer.

Application of Tack/Prime Coats	- 4000 lit capacity bitumen pressure distributor with arrangement for part closure of spray bar; - Plate compactors - Hand operated pressure spray attached to a mobile bitumen boiler.
Compaction of brick aggregate and premix bituminous patching	- Double steel drum vibratory roller of 2.5T minimum weight; - Tampers for compacting small areas.

3.21.4 Measurement and Payment

Compliance with the requirements set out in this Clause shall not be measured separately and shall be considered incidental to the related pay items.

3.22 RAVEL REPAIR

3.22.1 Description

The work shall be consist of patching existing pavement areas affected by raveling by premixed bituminous material to an average depth not exceeding 15 mm. The work shall be performed at designated locations and to lines and levels directed by the Engineer. In the construction process the Contractor shall ensure that all the general requirements of repair works, as set out in Clause 2.17.3 are complied with.

3.22.2 Materials

The materials required for ravel repair are:

- liquid bituminous binder for tack coat in accordance with Clause 2.12 and
- bituminous premix material for patching in accordance with Clause 2.14A.

3.22.3 Construction Methods

The area to be treated shall first be paint marked at site in regular geometrical shapes (diamond-shaped/rectangles or a combination thereof) to the approval of the Engineer. It shall then be cleaned of all loose particles and deleterious matter and thoroughly dried.

On the prepared surface, tack coat (to Clause 2.12) shall be applied at the specified rate by means of hand-pressure spray devices attached to a mobile bitumen boiler. For small areas and narrow strips, the Engineer may permit the use of hand pouring cans provided the Contractor demonstrates that uniformity in application rate and temperature can be ensured. The tack coat shall be applied in a day only to such areas as can be covered over by the premix patch the same day. Also no traffic shall be permitted on the tack coat till the patch has been placed and compacted in position.

After application of the tack coat, premixed bituminous material prepared in accordance with Clause 2.13 shall be spread and leveled. Manual method shall be permitted and the Contractor shall employ sufficient labour with rakes and other hand tools to ensure uniform spreading of the mix to the required levels. Soon after spreading, the material shall be compacted with small vibratory roller not less than 2.5T in weight till a closed compact surface is obtained and all roller marks are removed. Any area found to be inadequately compacted should be recompacted to the satisfaction of the Engineer.

3.22.4 Opening to Traffic

The ravel-patched areas can be opened to traffic after the bituminous mix has cooled down to the ambient temperature.

3.22.5 Quality Control

The engineer shall exercise control over quality of the materials incorporated and work performed on the following lines:

Cleanliness and dryness of repair surface	-	by visual observation
Tack Coat	-	in accordance with Clause 2.12
Compaction	-	based on trial compaction using the compaction plant, the Engineer shall determine the minimum number of passes and control the compaction process. The number of passes shall be subject to a minimum of 4.

3.22.6 Measurement

Ravel Repair shall be measured in square meter of existing pavement area over which the repair has been done and accepted. Tack coat shall be considered incidental to the work and shall not be measured separately.

3.22.7 Payment

Payment for Ravel Repair shall be at the contract unit price entered in Bill of Quantities. The payment shall be in full compensation for the necessary marking, cleaning of the surface, tack coat and furnishing and placing of the premixed bituminous materials including all labour, equipment, tools and incidentals required to complete the work to the specification.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT
2.18	Ravel Repair to existing pavement surface	Square meter

3.23 DEPRESSION PATCHING

3.23.1 Description

The work shall consist of patching depressions in the existing pavement caused by rutting or settlement of one or more pavement layers by premixed bituminous material or a combination of brick aggregate and premixed bituminous material. Depression patching shall be classified under the following three types:

- Type A** : Average depth of depression varying between 15 and 30mm. Premixed bituminous material to be used for patching;
- Type B** : Average depth of depression in excess of 30mm but not more than 50mm. Premixed bituminous material to be used for patching; and
- Type C** : Average depth of depression in excess of 50mm and the extent of depression exceeding 10sqm in a single location. A combination of brick aggregate and premixed bituminous material is used for patching.

In all cases, the work shall be carried out at designated locations and to lines and levels directed by the Engineer. Further, the Contractor shall ensure that all the general requirements of repair works as set out in Clause 2.17 are complied with.

3.23.2 Materials

- Brick Aggregate** : Brick aggregates shall be derived by breaking over burnt-bricks and shall satisfy the requirements of sub-base course brick aggregates conforming to Clause 2.9.
- Prime Coat** : Liquid bituminous binder for prime coat conforming to the requirements of Clause 2.11.

Tack Coat : Liquid bituminous binder for tack coat conforming to the requirements of Clause 2.12.

Bituminous premix material : The material shall conform to the requirements of Clause 2.13.

3.23.3 Construction Methods

3.23.3.1 Patching Types A and B

The area to be treated shall first be paint marked at site in regular geometrical shapes to the approval of the Engineer. It shall then be cleaned of all loose particles and deleterious matter, and thoroughly dried.

On the prepared dry surface, tack coat shall be applied at the specified rate by means of hand pressure spray devices attached to a mobile bitumen boiler. For small areas the Engineer may permit the use of hand pouring cans provided the Contractor demonstrates that uniformity in application rate and temperature can be ensured. The tack coat shall be applied in a day only to such areas as can be covered over by the patching material. Also, no traffic shall be permitted on the tack coat till the patch has been placed and compacted in position.

After application of tack coat, premixed bituminous material prepared in accordance with Clause 2.15 shall be spread, leveled and compacted as described for ravel patch in Clause 2.18. The compacted surface shall be well closed and free of roller marks and other blemishes.

3.23.3.2 Patching Type C

For this type of patching for depressions in excess of 50mm, the existing pavement shall be cut along the demarcated lines to vertical faces. The bitumen bound pavement material within the included area shall then be removed and disposed off to spoil tips. After this, the excavation shall be extended to a uniform depth till a firm pavement layer is reached. The bricks, brickbats and stone/brick aggregates removed by the excavation shall be salvaged and suitably stacked for re-use in the pavement repair works.

The cut area shall be carefully cleaned of dust and loose particles and dried of standing water before filling. Filling the excavated hole/trench shall first be filled with brick aggregate up to a depth 25mm below the general pavement level. The aggregate shall be compacted by small vibratory roller of not less than 2.5T in weight or plate compactor till a density not less than 98 percent of MDD (STP T6.1) is achieved. For assuring effective compaction at the trench edges, compaction shall begin at the middle and proceed towards the edges accompanied by addition/removal of aggregates to maintain the desired levels.

After drying the brick aggregate patch, prime coat to the requirements of Clause 2.11 shall be applied and cured.

After a minimum curing period of 48 hours, premixed bituminous materials prepared in accordance with Clause 2.15 shall be spread, leveled and compacted to the levels slightly proud of the adjoining pavement levels, following the procedure described in Clause 2.18.3.3.

3.23.4 Opening to Traffic

The depression-patched areas can be opened to traffic after the premixed bituminous material in the patch has cooled down to the ambient temperature.

3.23.5 Quality Control

The Engineer shall exercise control over quality of the materials incorporated and work performed on the following lines:

Brick aggregate filling for patch	-	in accordance with Clause 2.9
Tack coat	-	in accordance with Clause 2.12

- Bituminous premixed material - in accordance with Clause 2.13
- Compaction of bituminous premix - based on trial compaction using the compaction plant, the Engineer shall determine the minimum number of passes and control the compaction process. The number of passes shall be a minimum of 4.

3.23.6 Measurement

Depression patching shall be measured as area in sq. meter over which the work has been done and accepted for each type of patching. Reusable pavement material like bricks, brick bats and stone/brick aggregate excavated from the repair areas (applicable to Type C depression patching) shall be measured in their stacked position in cubic meter.

Brick aggregate used for filling the lower portion of Type C patch shall be measured in compacted position in cubic meter. For the quantity calculations, depth of the filling at a number of points in each location shall be measured to determine the average depth which shall be multiplied by the width and length of the patch to arrive at the quantity.

Excavation of the existing pavement for Type C patch including salvaging reusable material shall be measured as in-situ volume of the excavated pavement material in cubic meter.

Prime coat, tack coat and the bituminous premix for patching shall be deemed to parts of the patchwork pay item and shall not be measured separately.

3.23.7 Payment

Payment for the various types of depression patching and the other measured attendant items of work shall be at the Contract unit prices entered in the bill of quantities. The payment shall be in full compensation for the necessary marking, cleaning the surface, and furnishing, placing and finishing the patch materials including all labour, equipment, tools and incidentals required to complete the work to the specification.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
2.17	Excavation of existing pavement including salvaging reusable pavement material	Cubic meter
2.19	Depression patching Type A	Square meter
2.19	Depression patching Type B	Square meter
2.19	Depression patching Type C	Square meter
2.19.2	Brick aggregate for patch filling	Cubic meter
2.19.2	Rebate to be given by Contractor for reusable excavated pavement material	Cubic meter

3.24 POTHOLE REPAIR

3.24.1 Description

The work shall consist of excavating the existing pavement in localized areas subject to serious distress in the form of potholes, "alligator or map cracking" with loss of pavement materials, settlements in excess of 50mm at individual spots less than 10sqm in area in a single location, and in all other localized areas where the Engineer consider that the existing pavement has failed and has to be replaced prior to application of any improvement treatment and filling up the excavated area with compacted brick aggregate and finally with bituminous premix material over a prime coat. The work shall be performed at designated locations and to lines and levels directed by the Engineer. Further, in the construction process the Contractor shall ensure that all the general requirements of repair works as set out in Clause 2.17.3 are complied with.

3.24.2 Materials

- Brick aggregate : Brick aggregates satisfying the requirements of sub-base course brick aggregates conforming to Clause 2.9.
- Prime coat : Liquid bituminous binder for prime coat conforming to the requirements of Clause 2.11.
- Bituminous premix material : The material shall conform to the requirements of Clause 2.13.

3.24.3 Construction Methods

The construction, which comprises:

- demarcating the pothole area to be treated;
- excavation of the area down to firm level;
- filling and compacting the hole with brick aggregate upto 25mm below the general pavement level;
- application of prime coat; and
- filling and compacting the remaining 25mm depth with premixed bituminous material shall be carried out on the same lines as specified for patching Type C in Clause 2.19.3.2. The only difference is that while treated areas less than 10sqm shall be classified as pothole patching, those with areas larger than 10sqm shall be categorized under patching Type C.

3.24.4 Opening to Traffic

Patched pothole areas shall be opened to traffic after the bituminous premix patch has cooled down to the ambient temperature.

3.24.5 Quality Control

The control over the quality of the materials incorporated and work performed to be exercised by the Engineer shall be on the same lines as stipulated for depression patching in Clause 2.19.5.

3.24.6 Measurement

Pothole repair shall be measured as area in sq. meter over which the work has been done and accepted.

Brick aggregate used for filling part of the pothole shall be measured in compacted position in cubic meter.

Excavation of the existing pavement including salvaging if re-usable material shall be measured as in-situ volume of the excavated pavement material in cubic meter.

Prime coat and bituminous premix material for patching shall be deemed to be parts of the pothole repair work and shall not be measured separately.

3.24.7 Payment

Payment for pothole patching and other measured attendant items of work shall be at the Contract unit prices entered in the Bill of Quantities. The payment shall be in full compensation for the necessary marking, cleaning the surface, and furnishing, placing and finishing the patch materials including all labour, equipment, tools and incidentals required to complete the work to the specification.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
2.17	Excavation of existing pavement including	Cubic meter

	salvaging reusable pavement material	
2.20	Pothole repair	Square meter
2.20	Brick aggregate for patching	Cubic meter
2.20	Rebate to be given by Contractor for reusable excavated pavement material	Cubic meter

3.25 EDGE REPAIR

3.25.1 Description

The work shall consist of repairing and reinstating broken pavement edges by means of a combination of brick aggregate and premixed bituminous material patching at designated locations to the lines, dimensions and levels shown on the Drawings or directed by the Engineer. The work shall comprise excavation of the broken pavement edges to regular lines and down to firm pavement layer; providing lateral support along the pavement edge by means of brick-on-end lining; filling the hole in the included area first by brick aggregate to a depth 25mm below the pavement surface and then last 25mm by premixed bituminous material over a prime coat; and recompacting the disturbed shoulders including finishing and clean-up of the affected area. In the construction process the Contractor shall ensure that all the general requirements of repair works as set out in Clause 2.17.3 are complied with.

3.25.2 Materials

Brick aggregate	:	Brick aggregates satisfying the requirements of sub-base course brick aggregates conforming to Clause 2.9.
Bricks on edge for lateral support	:	The bricks shall be burnt clay bricks of first class or picked jhama type. These shall produce a clean metallic sound when struck and shall be of uniform colour and size. Whole bricks salvaged from pavement excavation for the repair works shall be permitted to be used for the purpose.
Prime Coat	:	Liquid bituminous binder for prime coat conforming to the requirements of Clause 2.11.
Bituminous premixed material:		The material shall conform to the requirements of Clause 2.13.

3.25.3 Construction Methods

The area at each location to be repaired shall first be paint marked at site in rectangular shape with the inner line parallel to the pavement edge. The outer line of the repair area shall be the nominal pavement edge, which shall be demarcated by means of a taut string line tied at the pavement edge level.

After demarcation, the pavement in the included area shall be excavated to vertical edges and to depths till a firm pavement layer is reached. On the shoulder side, a narrow trench about 100mm in width shall be excavated just outside the sting line can be fixed with the top of the bricks at the level of the pavement edge.

The area between the brick-on-end line and the excavated pavement line shall be cleared of all mud and loose particles and gradually filled in layers not exceeding 75mm in thickness and compacted till a level 25mm short at the pavement level is reached. Filling of the top 25mm depth shall be by compacted premixed bituminous material to Clause 2.15 on prime coat applied and cured in accordance with Clause 2.11 side by side, the disturbed shoulder outside the brick line shall be filled up and compacted to the top of the bricks. In the construction process, care shall be taken to ensure that the bricks are not disturbed by placing uniform lifts of material on either side of the brick line.

Compaction shall be by plate compactors and the compaction shall continue till the surface is well closed and free of protruding surfaces.

3.25.4 Opening to Traffic

The edge repair areas can be opened to traffic after the premixed bituminous material in the patch has cooled down to the ambient temperature and the adjoining shoulder is reinstated.

3.25.5 Quality Control

The Engineer shall exercise control over quality of the materials incorporated and work performed on the following lines:

Brick aggregate filling for patch	:	in accordance with Clause 2.9
Bituminous premixed material	:	in accordance with Clause 2.15
Bricks for Brick-on-end lateral support	:	Checking conformity with the specification through visual assessment.
Compaction of patch material in narrow trench	:	Control on layer thickness for brick aggregate and conforming to the minimum compaction effort using the equipment at site as determined by the Engineer based on field trials.

3.25.6 Measurement

Edge repair shall be measured as area in sq. meter over which the work has been performed and accepted by the Engineer.

Brick aggregate used for filling part of the edge trench/hole shall be measured in compacted position in cubic meter.

Excavation of the existing pavement including salvaging of reusable material shall be measured as in-situ volume of the pavement material in cubic meter.

Prime coat, bituminous premix patch material, and provision and installation of brick-on-end lateral support shall be deemed to be parts of the edge repair work and shall not be measured separately.

Lifting up of the existing depressed or eroded shoulder where required to be performed shall be measured in accordance with Clause 2.22.

3.25.7 Payment

Payment for edge repair and other measured attendant items of work shall be at the contract unit prices entered in the Bill of Quantities. The payment shall be in full compensation for the necessary marking, cleaning of the surface, and furnishing, placing and finishing the patch materials including all labour, equipment, tools and incidentals required to complete the work to the specification.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
2.17	Excavation of existing pavement including salvaging reusable pavement material	Cubic meter
2.21	Edge repair	Square meter
2.21	Brick aggregate for pothole patching	Cubic meter
2.21	Rebate to be given by Contractor for reusable excavated pavement material	Cubic meter

3.26 SHOULDER REPAIR

3.26.1 Description

The work shall consist of repairing shoulders of existing pavements and bringing these to the specified lines, levels and cross-fall by way of:

- a) lifting up eroded and depressed shoulders as described in Clause 2.22.2 or
- b) grading high shoulders by cutting excess materials as described in Clause 2.22.3.

For both the above cases, after completion of the work, the repaired shoulder surface shall be provided with turfing in accordance with Clause 2.16.

3.26.2 Lifting up Eroded and Depressed Shoulders**3.26.2.1 Materials**

The material for lifting low shoulders shall be soil of medium to low plasticity with plasticity Index not exceeding 25 and having a CBR of not less than 6 when tested on specimens compacted to 90% of MDD (STP T6.1) and soaked in water for 4 days. The Contractor shall select the borrow areas outside the right of way for extracting the required quantities of the soil and submit samples of the material along with results of tests carried out thereon to the Engineer for his examination/testing as he deems appropriate.

3.26.2.2 Construction Methods

The shoulder repair area shall first be demarcated at site and got approved by the Engineer. The demarcated area shall be slightly loosened followed by addition of fresh soil in required quantities, leveling by suitable mechanical or manual means and compacted to a density not less than 90% of MDD (STP T6.1).

The shoulder surface shall be finished to the specified cross-fall subject to a minimum at 4% and to levels 20-30 mm below the pavement edge to allow for turfing to be performed in accordance with Clause 2.16.

The finished shoulder shall not show ponding of water at any point, and the Contractor shall promptly rectify any defect in this regard.

The work of repairing depressed shoulders in any area shall be taken up side by side with the pavement edge repair works in that area.

Once completed, it shall be the responsibility of the Contractor to maintain the repaired shoulders until the completion certificate is issued for the particular section of the road.

3.26.3 Grading High Shoulders

At the designated locations marked at site, the high shoulders shall be trimmed by balding or other mechanical means or by labour to the specified cross-fall (not less than 4%) and to levels 20-30mm below the pavement surface to allow for turfing. The surface shall then be compacted to density not less than 90% of MDD (STP T6.1).

The corrected surface shall then be turfed in accordance with Clause 2.16.

The finished shoulder shall not show ponding of water at any point, and the Contractor shall promptly repair any defect in this regard.

The work of repairing high shoulders may be done along with other shoulder works or on completion of the pavement works. In either case, the Contractor shall be responsible for maintaining the repaired shoulders until completion certificate is issued for the particular section of the road.

3.26.4 Quality Control

The Engineer shall exercise control over quality of the materials incorporated and work performed on the following lines:

Soil for lifting depressed shoulders	:	P.I. - one test per day
	:	C.B.R - one test for each borrow area
Compaction	:	Field density - one for each 200 sqm.
Surface levels	:	Checks with straight edge and wedge at random locations.

3.26.5 Measurement

Lifting up at eroded and depressed shoulder shall be measured in square meter irrespective of the height of lifting at individual locations.

Grading of high shoulders shall be measured in square meter irrespective of the height of cut at individual locations.

Turfing shall be measured separately in accordance with Clause 2.16.

3.26.6 Payment

Payment for the shoulder repair works shall be at the Contract unit prices entered in the Bill of Quantities. The payment shall be in full compensation for the necessary marking, furnishing and pacing the required material, compaction and finishing including all labour, equipments, tools and incidentals required to complete the work to the specifications.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
2.22	Lifting up eroded and depressed shoulders	Square meter
2.22	Grading high shoulders	Square meter

3.27 DRAINAGE REPAIR

3.27.1 Description

The work shall consist of carrying out necessary repairs to existing drains and drainage structures at locations and to the direction given by the Engineer. The repairs may include deepening and reshaping of drainage channels; repairs to parts of cross-drainage structures like parapets, head walls, wing walls, abutment walls, apron etc.; or repairs to any other roadside structures affecting proper drainage of the road.

3.27.2 Materials

Materials for repairing structures shall be cement, sand, bricks, stones, aggregates etc. as required at individual locations.

3.27.3 Construction Methods

3.27.3.1 Deepening and reshaping of drains shall be carried out at locations and to lines, levels and cross-sections indicated by the Engineer. The bed of drains shall be prepared to uniform slope to avoid water ponding.

3.27.3.2 Repair to structures shall be to the instructions of the Engineer. Filling of cracks in masonry shall be by cement filling in structural concrete shall in general be in epoxy resin or epoxy resin mortar to the directions of the Engineer.

3.27.4 Measurement and Payment

Deepening and reshaping of drains shall be measured and paid for as common excavation in cubic meter in accordance with Clause 2.4.

Repair to members of cross-drainage structures shall be paid for on Day Work basis.

3.28 GENERAL SURFACE REPAIR

3.28.1 Description

This work shall consist of removing existing damaged road surface material and make good where the surfacing has reached a point of deterioration, excessive cracking or otherwise damaged.

These works defined as "General Surface Repairs" applies where the Engineer in Charge decides that other than more superficial repair methods per Section 2 is needed.

3.28.1.1 Works

Existing damaged and/or unacceptable surface material shall be removed and disposed of as directed by the Engineer in Charge.

The existing granular base shall be scarified, and required additional quality material shall be imported, mixed and compacted to an accepted level and density. The preparation of the road base shall be followed by a layer of prime coat, which shall be applied to the approved surface, in accordance with Section 2.11.

After specified curing, a final layer of 25mm premixed bituminous carpet shall be applied throughout the prepared surface, in accordance with Section 2.13.

3.28.2 Measurement and Payment

This work shall be measured as the area in square meters of surface from which damaged material was removed, followed by scarification, import of material, compaction, application of prime coat and Premixed Bituminous Carpeting and relevant quality controls, all inclusive.

The work measured shall be paid for at the Contract Unit Prices and as shown in the Bill of Quantities. The payment shall be full compensation for supply and placing of all materials, including all labour, equipment, tools and incidentals necessary to complete the works.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
2.24	General Surface Repairs	Square meter

PART-8: BRIDGE & CULVERT WORKS

1. GENERAL SPECIFICATION

1.1 Introduction

These Specifications shall apply to all such works to be executed involving construction of a Bridge and its allied works under the Contract or otherwise directed by the Engineer. In every case, the work shall be carried out to the satisfaction of the Engineer and conform to the location, lines, dimensions, grades and cross-sections shown on the Drawings or in the BOQ or as indicated by the Engineer. The quality of materials, processing of materials as may be needed at the site, salient features of the construction work and quality of finished works shall comply with the requirements set forth in the succeeding Sections and Sub-sections. Where the Drawings and Specifications describe a portion of the work in only general terms and not in complete detail, it shall be understood that only the best general practice is to prevail, materials and workmanship of the best quality are to be employed and instructions of the Engineer are to be fully complied with.

Words importing the singular also mean the plural and vice versa where the context so demands. Similarly, words importing the male also mean female or neuter and vice versa where the context so requires. Words have their normal meaning under the English language unless specifically defined.

1.2 Scope of Work

The Work to be carried out under the Contract shall consist of the various items as generally described in the Tender Documents as well as in the BOQ furnished in the Tender Documents.

The Work to be performed shall also include all general works preparatory to the construction of a bridge, erosion protection work, drainage and all other related works. The Work shall include work of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the intent and meaning of the Drawings, BOQ and these Specifications and further Drawings and orders as may be issued by the Engineer from time to time. Whether specifically mentioned or not in the various Sections of this Specification, the Scope of Work shall include compliance by the Contractor with all conditions of the Contract, all materials, apparatus, plant, equipment, tools, fuel, water strutting, timbering, transport, offices, stores, workshop, staff, labour and the provision for proper and sufficient protective works, diversions, temporary fencing and lighting. It shall also include safety of workers, first-aid equipment, suitable accommodation for the staff and workmen with adequate sanitary arrangements, the effecting and maintenance of all insurances, the payment of all wages, salaries, fees, royalties, duties or other charges arising from the erection of works and the regular clearance of rubbish, reinstating and clearing the site as may be required on completion of the Work, safety of the public and protection of the Work and the adjoining land.

The Contractor shall ensure that all actions are taken to have a built-in quality assurance in the planning and execution of the Work. The quality assurance shall cover all stages of work such as setting out, selection of materials, selection of construction methods, selection of equipment and plant, deployment of personnel and supervisory staff, quality control testing, etc. The work of built-in quality assurance shall be deemed to be covered in the Scope of Work.

1.3 Submittal

The submittal by the Contractor shall include construction programme, all Shop Drawings, reports, samples, test results etc. to conform with all applicable provisions of the General Conditions of the Contract and as required under the various Sections of these Specifications. The purpose of the submittal required herein is to assure that items furnished and installed are in all matters of consequence equivalent to the specified items and that proper records are maintained of the changes made in the Specifications, Drawings or in materials used or any deviations made in the construction process.

The Contractor shall forward all submittal to the Engineer under a cover letter stating that the submittal have been carefully reviewed by the Contractor and that on-site conditions or dimensions where necessary and correctness have been verified and checked.

The submittal shall be reviewed by the Engineer to verify that the Contractor's obligations are fulfilled as per the turn intention of the Contract. In checking and approving submittal the Employer does not relieve the Contractor from responsibilities for construction errors or omissions which may occur, even though executed in accordance with the approved Shop Drawings. Any such errors or omissions as is discovered later on should be corrected by the Contractor irrespective of any approval by the Employer at no additional cost to the Employer. This does not apply to modifications approved as specified herein.

The Contractor shall make submittal of construction requirements at least 10 days prior to actual construction of the component to allow time for checking and re-checking, if necessary. Any work fabricated or installed by the Contractor prior to approval of the Shop Drawings or other required submittal shall be done at his own risk.

Construction programme

Within 10 days of the Formal Work Order being issued, the Contractor shall submit to the Engineer for his approval a Bar Chart/Gantt Chart showing the programme sequence in which works have been proposed to be carried out including the procurement and delivery of equipment and materials.

The Contractor shall, whenever required by the Engineer, also provide in writing a general description of the arrangements and methods which would be adopted for the execution of the Work.

If at any time it would appear to the Engineer that the actual progress of work does not conform to the approved programme, the Contractor shall be obliged to produce for the approval of the Engineer the reasons for any changes with a revised programme showing the modifications to the previously approved programme necessary to complete the Work on schedule. Submission to and approval by the Engineer of such programmes or furnishing of such particulars shall neither relieve the Contractor from any of his duties and responsibilities under the Contract nor it shall prejudice the 'Liquidated Damages' Clause of the Contract.

Notice of operation

The Contractor shall give full and complete written notice of all the important operations, including setting out, to the Engineer sufficiently in advance (not less than 10 days) to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purposes. The Contractor shall not start any important operation without the written approval of the Engineer.

As-built drawings

Before the expiry of the period of maintenance, the Contractor shall submit the full sets of As-Built Drawings of the completed works to the Employer. The sets shall comprise the negatives of Drawings prepared with high quality reproducible polyester transparent "Mylar" film (or similar material) from which clear copy can be re-produced, three clearly printed Drawings and a CD.

The As-Built Drawing shall clearly show the lines and dimensions of the permanent construction actually made based on the changes to the original design from time to time as ordered by the Engineer or proposed by the Contractor and approved by the Engineer.

The original transparent negatives of the Tender Drawings and the Design Drawings will be lent free of charge to the Contractor on request free of charge for his making further prints or reproducing additional number of negatives of Drawings.

Shop drawings

The Contractor shall prepare at his own costs Shop Drawings clearly showing all elements of construction those are required to assure proper shop fabrication or job installation of items requiring Shop Drawings shall be clearly shown. All material quality, finishes, construction details as specifically related to the project must be shown on the Shop Drawings.

1.4 Taking Over Possession Of Site

The Contractor shall upon receiving the Work Order, immediately take possession of the site and move his men and materials to prepare the site in order to create conditions for starting the Work as per terms of the Contract, Drawings and Specifications.

1.5 Mobilization

The work of mobilization shall consist of carrying out the following listed actions together with all other requirements of the Contract with regard to commencing the execution of the Work by the Contractor at his own cost.

- (a) Procurement, assembly, repair and make to running condition of all the contractor-owned constructional plant and equipment by the Contractor convenient to him at any site other than the actual place of construction.
- (b) Transportation of Contractor-owned constructional plant, equipment and materials from the storage site as mentioned above in (a) to the place of construction.
- (c) Assembling and installation of all items of constructional plants, equipment, etc. required for the execution of the Work.
- (d) Receiving all constructional plants, equipment and materials to be furnished by the Employer, if any, and collect and transport those to the Work site. All materials shall be properly stored, inventoried and protected until used in to the Work and all plants and equipment shall be tested and made ready for use.
- (e) Construction of a suitable site office building or shed for storage of materials and equipment, workshop, other operational buildings and First-Aid Center attended by the competent Medical Assistants.
- (f) Maintenance of all temporary roads, fences and sanitary facilities, keep all areas used by the Contractor clean, neat, well-kept and in good repair and provide proper drainage to protect the area from surface run-off and flooding.
- (g) Provide all the required electric power, water supply and other utility connections to temporary installations at the site as may be necessary for the execution of the Work.
- (h) Obtain all insurance policies, performance bond and payment guarantees as required under this Contract.
- (i) Payment of all fees, permits, licenses, etc. as may be required covering the execution of the Contract.

1.6 Monitoring Progress

Monthly reports

The Contractor shall furnish the Engineer, without cost to the Employer, at regular monthly interval and in a form and number of copies determined by the Engineer, with the following:

- a) Physical progress for the month under report and the estimated progress for the following month.
- b) Completion schedules (target and actual) based on the approved construction programme.
- c) A tabulation of construction equipment listing the major items and pieces of equipment comprising the construction plants those were utilized for performance of the Work during the month under report.
- d) A tabulation of employees countersigned by the Engineer's representative, showing the supervisory staff and the numbers of the several classes of labour employed by the Contractor in the month under report.

- e) Any report which may be specifically requested by the Employer and/or by the Engineer.

Attendance at site meetings

The Contractor shall attend punctually the progress and other on-site meetings as would be requested by the Engineer and receive the Employer's authorized visitors.

Receiving visitors

The Contractor shall receive all authorized visitors of the Employer and allow them to visit the Work in the manner as would be requested by the Employer.

1.7 Contractor's Site Facilities

The Contractor shall, at his own expenses, be responsible for the provision, maintenance, operation and subsequent removal of the following and all other necessary temporary facilities and services on site those are required to accomplish the Work in a safe and orderly manner as per provisions of the Contract:

- a) Temporary stores (including warehouses for cement and other perishable materials), warehouse and workshop.
- b) Temporary buildings for office accommodation for the Contractor's staff.
- c) Living accommodation for staff.
- d) Adequate number of toilets necessary for all persons engaged for the Work with separate arrangements for women. All sewage from toilets shall be disposed off by means of septic tank and soak pit or by some other acceptable disposal system.
- e) To keep all sanitary facilities clean and their frequent disinfecting.
- f) Fencing, lighting and security.
- g) Cranes or other appropriate ways and means for off-loading plant and equipment, placing in temporary storage and moving from storage to equipment locations.
- h) Site transport for the staff.
- i) Electric power for temporary buildings and tools.
- j) Provisions for adequate supply of water of acceptable quality at the Site for use in the Work.
- k) Raw water from Site Tube-wells and provisions for adequate potable water.

In addition to above, the Contractor shall also make available all other necessary temporary facilities and services on site those are required to accomplish the Work in a safe and orderly manner as per provisions of the Contract.

The Contractor shall submit for the approval of the Engineer detailed Plans and/or construction Drawings of the temporary buildings, warehouses, workshops and labour camps that he propose to construct or arrange on lease/rent including the proposals for water and power supply and sewerage facilities. These requirements shall be fulfilled by the Contractor within 10 (ten) days from receipt of the Formal Work Order to commence work (Date of Commencement of Work). All buildings and facilities shall be of standard acceptable to the Engineer.

The labour camps shall be at a location approved by the Engineer and conform to all requirements of the local law. It shall be laid and constructed in accordance with a Drawing prepared by the Contractor and approved by the Engineer.

The Contractor shall be responsible for acquiring the land deemed necessary for the Work beyond the Employer's land and for his temporary buildings, warehouses, workshops, staff quarters, labour camps and any temporary access road. The Contractor shall maintain the site and all working areas in a safe and hygienic condition and in all matters of health and sanitation shall comply with the requirements of the local Medical Officer of Health or other competent Authority.

1.8 Materials, Plant, Equipment and Tools

Products

The Contractor at his own expenses shall provide the materials, products plant and equipment as shown on the Drawings or as specified in the Contract. Necessary haulage and safe storage of materials, supervision of works etc. shall be provided by the Contractor.

Equal products and equivalents

Except as specifically required otherwise, the mention of any proprietary materials by trade name is intended to establish a standard of quality, appearance, size and durability. The products of other manufacturers may be used subject to the conditions as stated below.

Additional costs related to substitutions

Any additional costs, or any losses or damages, arising from the substitution of any materials or methods from those originally specified shall be borne by the Contractor, unless such substitution was made at the written request or direction of the Employer.

Failure of equal products

Where products are accepted, based on representation of the Contractor, as approved equals, those shall be used subject to the same installation and performance standards as required by the original specification. Approval of a request for substitution shall not modify the Contract requirements except as specifically noted. Subsequent failure of "approved equals" shall be considered first. For any evidence of improper installation or product inequality, the installation shall be repaired or corrected as directed by the Engineer at the full costs of the Contractor.

Plant, equipment and tools

The Contractor shall furnish all constructional plant, equipment and tools for the proper execution of the Work at his own expenses and keep those in proper working condition. The Contractor shall supply the Employer a list of major items of the constructional equipment and tools that he propose to use in execution of the Work.

1.9 Sufficiency of Means Employed

The Contractor shall take upon himself the full and entire responsibilities for the sufficiency of his supervisory and other personnel, machinery, plant or equipment or tools, scaffolding, timbering and generally for all means used for the fulfillment of the Contract. In the event of any of these means proving insufficient, the Contractor shall remain fully and entirely responsible for the sufficiency of these means notwithstanding any previous approval or recommendation that might have been given by the Engineer.

1.10 Care of Works

Movement of transport and plant

The Contractor shall exercise diligence and care in the movement of all transports and plants within the Work area so as not to cause injury or damage to life or property. The Contractor shall be responsible for restoring any roadway, bridge, culvert etc. damaged by his transport and plants to the satisfaction of the Engineer or the appropriate Authority.

Keeping works free from atmospheric condition

The Contractor shall construct all temporary works and other works and supply and operate pumping plant and ensures all measures as may be found necessary for the construction of the Work under proper atmospheric condition.

Notwithstanding any approval by the Engineer of the arrangements made, the Contractor shall remain responsible for the sufficiency thereof and shall be liable for keeping the works safe at all time regardless of the climatic condition at his own expenses. Any loss of production, additional overheads or additional costs of any kind that may result from inclement climatic conditions shall be at the Contractor's risk.

Materials on and under the site

All soil, turf, gravel, stone, timber, or other materials obtained in the excavations, clearing of the Site of the Work and soil stripping, shall belong to the Employer and must not be removed from the Work site without the written permission of the Engineer. The Contractor, however, may use for the construction of the Work timber felled on the site and any of the materials excavated under the Contract which the Engineer may determine to be fit for such use and shall use such materials, if directed by the Engineer.

1.11 Survey Works

Permanent Bench Mark

Before commencing the work the Contractor shall establish at least 2 (two) numbers permanent Bench Mark (B.M) with pucca pillars at suitable positions as per direction of the Engineer at his own cost. These B.Ms. shall be incorporated in the Drawings and used for controlling all levels of construction works.

Reference line pillars

The Contractor shall establish pucca Reference Line Pillars (axis pillars, centre line pillars, etc.) at his own cost for all structures before starting of excavation of foundation pits/trenches as per standard practice and or as per direction of the Engineer.

The Contractor shall remain responsible for safeguarding all Survey Monuments, Bench Marks, Beacons, etc. The Contractor, at his own expenses, shall make necessary arrangements to protect the B.M pillars against any disturbances, damages, including their maintenance.

The Engineer will provide the Contractor with the data necessary for the setting out of the center line. All dimensions and levels shown on the Drawings or mentioned in the Documents forming part of or issued under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Engineer of any apparent error or discrepancy, if found by him in such dimensions or levels. The Contractor shall, after or in connection with these staking out of the center line, survey the terrain and shall submit to the Engineer for his approval, a profile as required by the Engineer.

Instruments and equipment for surveys shall be subject to rigorous inspection by both the Contractor and the Engineer and any items found to be defective in the opinion of the Engineer, shall be promptly replaced, repaired or adjusted as per direction. A qualified Surveyor or Engineer shall supervise all survey works.

The checking of the setting-out of works by the Engineer's staff shall not relieve the Contractor of any of his liabilities or responsibilities under the Contract.

1.12 Fabricated Items Incorporated in Works

Whenever required by the Specifications to fabricate or manufacture and furnish equipment for incorporation in the permanent works, the Contractor shall submit to the Engineer for his approval the names of the manufacturers or fabricators the Contractor proposes to engage and also his detailed

Shop Drawings for approval before proceeding with the Work. All such Drawings shall be adequately and properly checked before being submitted to the Engineer for approval and shall be so designated.

Any fabricating or manufacturing undertaken during or before the approval of the Drawings will be at the Contractor's risk. The Engineer shall have the rights reserved to ask the Contractor to make any change in the Design, which may be found necessary, in the opinion of the Engineer, for the equipment or component materials to fully meet the requirements and intent of these Specifications without causing any additional costs to the Employer.

Approval of the Contractor's Drawings shall not relieve the Contractor of any part of his obligation to meet all requirements of these Specifications or of the responsibilities for the correctness of his Drawings. At the time of delivery of the equipment, the Contractor, if requested to do so, shall furnish the Engineer two complete sets of negatives of the final approved Drawings.

1.13 Inspection/Tests at Fabricator's Workshop

All equipment furnished under these Specifications and all works performed thereon will be subject to inspection by the Engineer or his authorized representative. Inspection at the manufacturer's plant, when located only in Bangladesh, may be made with the intention to determine the meeting of requirements of the Specifications in respect of use of equipment and materials.

The Contractor shall notify the Engineer a minimum of 15 (fifteen) days in advance of the date and place of equipment/materials to be available for inspection. No equipment or material shall arrive at the work site until the Engineer's inspection at the manufacturer's plant or contractor's storage site outside the actual work site has been made, the Engineer's approval has been given, final Drawings have been furnished by the Contractor and the Contractor's responsibility for furnishing equipment and materials meeting the requirements of the Contract Document are fully complied with. All costs of the Engineer's inspection shall be borne by the Contractor.

Tests and inspection record

The record shall identify the Contractor and the Supervision Consultant staff (when applicable) involved, the place, the date and time when the inspection is completed, the section of the works and the materials tested or inspected and its state of completion. Reference shall be made to the relevant Working Drawings and the specific aspects or properties, which were checked or measured shall be recorded.

One copy of each record of inspection shall be submitted to the Engineer and one copy of each record of inspection shall be submitted to the Supervision Consultant (when involved). The Contractor shall maintain records of inspections and tests in an orderly fashion at the site until the issuance of the Defects Liability Certificate for the whole of the Work, or such earlier time as the Engineer may instruct. The Engineer shall have the rights of access to them at all times.

After the issuance of the Defects Liability Certificate for the whole of the works, or such earlier time as the Engineer may instruct, the Contractor shall, as instructed by the Engineer, either dispose of the records or deliver them as directed.

Notice of works off site

The Contractor shall give adequate written notices to the Engineer on the preparation or manufacture at a place not within the site of any pre-fabricated units or parts of units or materials to be used in the Work. Such notice shall state the place and time of the preparation or manufacture, quarrying or extraction. The notice be given sufficiently in advance as to enable the Engineer to make arrangements which he may deem necessary for inspection before the start and at any stage of the Work and not only at the time when the units or parts are completed. Off-site works shall not commence without the prior approval of the Engineer.

Any unit or parts, prepared or manufactured without giving such prior notice to the Engineer, may be rejected if the Engineer considers that his inspection was necessary during the time of preparation or manufacture. No inspection by the Engineer shall relieve the Contractor of any of his responsibilities, duties and liabilities under the Contract.

Standards

Except where otherwise specified or authorized by the Engineer, all materials and workmanship shall conform to the latest edition of the relevant Standard Specifications of the AASHTO or ASTM or BS or BDS.

Materials meeting other internationally accepted equivalent or higher Standards may be accepted subject to review by the Engineer. The Contractor shall submit in English language any such alternative Standard proposed by him, for approval by the Engineer.

The Contractor shall provide to the Engineer 3 (three) sets of each of the Standards, Codes and References to be used in the Contract within 45 (forty-five) days of the Date of Commencement of the Work. In addition, he shall supply 3 (three) copies of any other Standard or Code subsequently specified or alternatively proposed to be used by the Engineer, the Supervision Consultant (when involved) and the Site Laboratory. All Standards shall be in English. On completion of the Contract, all copies of Standards, Codes and References, so provided, shall become the properties of the Employer.

Proprietary products

Where a proprietary or brand name or the name of a supplier or manufacturer is indicated on the Drawings or in the Specifications, this would be in respect of items, which have not otherwise been adequately described by AASHTO, ASTM or equivalent recognized Standards. Alternative items based on recognized national Standards of the country of origin may be accepted provided that documented proof in the English language is submitted to the Engineer for his approval sufficiently in advance and showing that the alternative proposal is equal or higher in quality and performance than the specified item.

Materials to be new

All materials used in the permanent works shall be new. No material, incorporated in the permanent works, shall have previously been used in the temporary works.

Orders for materials

Before orders are placed for any material of any description to be used in the permanent works, the Contractor shall submit to the Engineer the names and addresses of the manufacturers or suppliers proposed. Following approval by the Engineer, the Contractor shall submit to him copies of all orders placed for such materials.

Samples

In accordance with the provisions of the Contract, the Contractor shall, in the way as directed by the Engineer, supply samples of materials to be incorporated in the Work. The Contractor shall submit the samples required for approval in labeled boxes suitable for storage and with sufficient time for testing. Due allowance shall be kept for the fact that if samples are rejected, further samples and testing will be required. The Engineer shall keep the approved samples with him and will compare the supply with the sample before acceptance. He shall reject any materials not conforming to the character and quality of the approved samples.

Certificates

All manufacturer's certificates of tests, proof sheets, mill sheets etc., showing that the materials have been tested in accordance with the requirements of the relevant AASHTO, ASTM, or other approved Standard or this Specification, shall be supplied in English language by the Contractor to the Engineer free of charge.

1.14 Tolerances

Unless it has been specified in the different Sections otherwise, all works shall be constructed within the tolerances shown in the Table given below.

Type of Structure	Item	Tolerance
1	2	3
Concrete Structures	Tolerances from specified position (Structure) Maximum departure of plan position structure or element	25mm
	Tolerances from specified dimensions (Structure) Maximum departure in thickness or cross sectional dimensions of columns, beams, buttresses, piers, wall footings etc., like up to and including 500mm thick (except tunnel and shaft linings)	+6mm -3mm
	Ditto – 500mm to 1000mm thickness	+10mm - 5mm
	Ditto – 1000mm to 4000mm thickness	+10mm -8mm
	Ditto – Over 4000mm thickness	+25mm -10mm
	Tolerances from specified position (Surface) Maximum departure of vertical, sloping or curved surfaces including joint surfaces	25mm
	Maximum departure of horizontal or near-horizontal surfaces including joint surfaces	20mm
	- Tolerance on Straightness or Departure from Specified Curve (Surface) General Surface Maximum deviation in horizontal or vertical directions – gradual	12mm in 2m
	- Maximum deviation in horizontal or vertical directions – abrupt	6mm
	- Surface in Contact with Low Velocity flowing Water - Maximum deviation in direction of flow or normal to flow – gradual	6mm in 2m
	- Maximum deviation in direction of flow or normal to flow – abrupt	4mm
	- Surface in Contact with High Velocity Flowing Water - Maximum deviation in direction of flow or normal to flow – gradual	3mm in 2m
	- Maximum deviation in direction of flow or normal to flow – abrupt	0 (Grind to 1 in 50 level)
	- Sectional dimension - Plumb - Levels (before any deflections has been taken place)	+5mm +1 in 1000 of height +3mm
	Length of splice	-25mm
Reinforcement	Variation of protective cover	+5mm
	Variation in indicated position or reinforcement:	
	▪ Starter bars	One bar diameter
	▪ Slabs and Wall	0.25 times the indicated spacing
	▪ Beams and columns	+5mm
	Dimension of bent bars: ▪ Stirrups and ties	+5mm

Type of Structure	Item	Tolerance
1	2	3
	▪ Other bars	+10mm
Slope protection	Stone Work	+50mm over 3m
	Pitching and Masonry	
	Thickness of tipped rock or filter	+50mm -000
	Block Work/Brick Work	+3mm in 1m
	Verticality	
	Line	+ 5mm in 3m
	Finished level	+10mm
Piles	1. Pre-cast driven pile:	
	a) Verticality for vertical pile	1 in 50
	b) Verticality for raker pile	1 in 25
	c) Deviation from position shown on the Plan for vertical and raker piles after driving	$\frac{1}{4}$ th of least dimension or 75mm whichever is greater
	Concrete piles casting tolerances:	
	a) Maximum departure in thickness or cross sectional dimensions	+6mm - 0.00
	b) Deviation of pile face	6mm in 3m
	c) Deviation of cross-section centroid from straight line connecting the centroid of the end faces of the pile	10mm
	2. Bored and Cast-in-situ pile:	
	a) Verticality for vertical pile	1 in 75
	b) Verticality for raker pile	1 in 25
	c) Deviation from position shown on the plan for vertical and raker pile shaft	Maximum 75mm in any direction
Elastomeric bearing	Level of the top surface	3mm
	Point on either surface in contact with the bearing from the plane of that surface	1mm
	Slope of each face	5mm per m
	Horizontal position of any point from the location	10mm

* In addition to above, other tolerances have also been specified in the different Sections and Sub-sections in the relevant portions.

1.15 Recording of Measurement

Conditions of the Contract, Technical Specifications and Contract Drawings are to be read in conjunction with the BOQ.

General directions and descriptions of works and materials are not necessarily be repeated nor summarized in the BOQ. References to the relevant Sections of the Contract documents shall be made before entering the Tender's rate.

The quantities given in the BOQ are only approximate and provisional and are given to provide a common basis for Tendering. It does neither expressly nor by implication prescribed that the actual volume of work to be performed will exactly correspond therewith.

Any clarification regarding Bill of Quantities and Method of Measurement shall be judged by the Engineer in accordance with this Standard Specification, its Sub-sections, BOQ and other Tender Documents.

The works, executed fully complying Drawings and Instructions of the Engineer, will be measured for payment in accordance with the method adopted in the BOQ and the item therein set forth, notwithstanding any custom to the contrary. The net quantity of the finished works in place will always be taken except where otherwise specified.

No allowance shall be made for waste, laps, cuttings, etc. and no deduction will be made for grout nicks, joggle holes or rounded arises and sinkage or for fitting iron works, etc.

1.16 Payment

Full account shall be taken of all information contained in the Tender Documents and made available during the tender period as affects, inter alia, working methods, haulage requirements and sequence of operations. Full allowance shall be made for all these provisions in the rates and sums entered against the various items in the BOQ of the Contract.

The specified payment Sections/Sub-sections of the Contract shall apply to any additional or varied work, which may be required to be executed under the Contract except where specifically varied therein.

The basis of payment will be the actual quantities of works ordered and carried out, as measured by the Engineer (based on the As-built Drawing, BOQ or as otherwise directed by the Engineer) and valued at the rates and prices of the Tender, where applicable, or otherwise at such rates and prices as (in case of non-tendered items) the Engineer may fix within the Terms of the Contract.

No payment will be made on account of the anticipated profit for work covered by the Contract, which is not performed. No adjustment will also be made in the unit rates set out in the Bill of Quantities because of an increase or decrease in the actual quantities from the estimated quantities indicated therein, unless otherwise stated in the Conditions of Contract.

Notwithstanding any limit which may be implied by the wording of the individual item and or the explanations in this Section, it is to be clearly understood that the Tender price is for the works finished and completed in every respect, full account of all requirements and obligations have to be taken, whether expressed or implied covered by all parts of the Contract. The Tender price shall, therefore, include all incidental and contingent expenses (including all taxes and VATs) and risks of every kind necessary to construct, complete and maintain the whole of the Work in accordance with the Contract. Full allowance is to be made in the Tender price for all costs involved in the following, inter alia, which are referred to and/or specified herein:

- All setting out and survey works.
- Temporary access unless separately billed, fencing, guarding, lighting, and all temporary works including their removal on completion.
- Paying fees and giving notices to the Authorities.
- Reinstatement of the site.
- Safety precautions and all measures to prevent and suppress fire and other hazards.
- Interference to the works by persons or vehicles being legitimate users of the facilities on or in the vicinity of the site.
- Protection and safety of adjacent structures so far as they may be affected by the works or temporary works.
- Supplying, maintaining and removing the Contractor's own housing for staff and labour, offices, workshop, plant yard, transport, welfare, services in connection therewith and other facilities required by the Contractor on completion of work unless separately billed.
- Working in the dry condition except where otherwise permitted by the Specification.
- Supplying, inspection and testing of materials intended for use in the works including the provision and use of equipment.

- Maintaining public roads and footpaths.
- Opening quarries and borrow pits including all surveys, site investigations, removal and disposal of overburden, trimming of quarry or borrow pit faces and floors and all measures necessary to render quarries or pits safe and free for draining on completion.
- Providing and transporting to site all plants and equipment necessary for the execution of the Work, setting to works, operating (including all fuel and consumable stores), removal from the site all construction plants and equipment upon completion of the Work, costs of all tests and other requirements in respect of such plants and equipment.
- The requirements and all incidental costs and expenses involved to provide all necessary skilled and unskilled labours and supervision.
- Protection of all completed works following operations making good damages to any completed works due to any cause whatsoever, clearing all rubbish as they accumulate and leaving the site in a tidy condition.
- All costs associated with the provision and submission of Progress Reports, Record Photographs, preparation of the necessary Shop and Working Drawings etc. except those provided in the Bill of Quantities.
- Workmen's compensation and Owner's liability insurance.

Payments under the item for hire charges (if there be any) for land in addition to the Employer's land for temporary works shall be made in accordance with the receipts obtained from the land owners within the limitation of quoted rate only if such provisions are made in the BOQ of the Contract.

Payment of royalties for fill materials obtained from privately owned land/carried earth shall remain included within the rates of the relevant items of the Contract. The volume of borrow material shall be calculated on the basis of pre-work and post-work measurements. Finished sections as per Drawings will be the basis for post-work measurement while the work is complete as per Specifications.

Payment shall mean gross payable amount on the rates of the BOQ including the Performance Security.

With regard to the Sub-section on 'Contractor's Site Facilities', payment will be made for hiring land for the Contractor's temporary works outside the Employer's property, only if such provisions are kept in the BOQ of the Contract.

The cost of keeping the works free from water will only be paid for, if referred to in the BOQ of the Contract Documents.

No payment shall be made for any test required under the Specification unless specifically referred to in the BOQ. If the Engineer requires any test outside the BOQ, the costs of such tests shall be agreed with the Engineer before execution and paid for as a supplementary item.

No direct payment shall be made for works required under other Sub-sections. The costs for such works shall be deemed included in the related items of the BOQ.

2. CONSTRUCTION MATERIALS

2.1 Bricks

General

Bricks shall be manufactured from clay or shale or a combination of these materials and shall be uniformly burnt throughout. They shall be hard and sound and give a clear metallic ring when struck with a small hammer or another brick and should not break when dropped to the earth from a height of 1.5m with one brick above another in the formation of a 'T'. The surface should be too hard to be scratched with the fingernail.

Bricks shall be stacked on dry firm ground in regular tiers. Each stack shall comprise 50 bricks in length and 10 bricks in height, the bricks being placed on edge. The width of each stack shall be formed with two bricks. Clear distance between adjacent stacks shall be not less than 800mm.

Bricks shall be loaded or un-loaded with care, and shall not be thrown or dumped. They shall be carried from the stack to the Site of placement in small batches as and when necessary.

First class bricks

First Class Bricks shall comply with the following requirements:

Appearance Sound, hard and well burnt, uniform in size, shape and colour, homogeneous in texture and shall have plane rectangular faces with parallel sides and sharp straight right-angled edges. This shall be of uniform colour (generally deep red or copper), homogeneous in texture and free from cracks, flaws and nodules of free lime. A fractured surface shall show a uniform compact structure free from holes, lumps or grits. Shall emit clear metallic sound when struck. When scratched by steel or nails there should be no permanent mark on the surface.

Unit Weight Unit-weight to be determined by breaking bricks to the following sizes.

Sieve Sizes (mm)		Percentage of sample	Min. weight in gm.
Passing	Retained		
38	25	25	750
25	19	25	750
19	12.5	25	750
12.5	9.5	25	750

Crushing strength	170 kg/cm ² (average) but not less than 140 kg/cm ² in any individual bricks.
Maximum water absorption capacity	20% of dry weight
Efflorescence	Nil
Dimensions (+3mm)	240mm x 115mm x 70mm

Picked jhama bricks

Picked Jhama Bricks shall be over-brunt first Class Bricks, uniformly vitrified throughout with good shape, hard, slightly black in colour and without cracks or spongy areas.

Picked Jhama Bricks may have dimensions slightly below those for first class bricks but not less than 235mm x 110mm x 70mm.

Water absorption, as a percentage of the dry weight, shall not exceed 15%.

Crushing strength should be on average 210 kg/cm², but not less than 170 kg/cm² in any individual bricks

All other requirements for First class bricks shall also apply to Picked Jhama Bricks.

2.2 Aggregates

General

Aggregates shall be hard, strong, durable, dense and free from injurious amount of adherent coatings, clay, lumps, dust, soft or flaky particles, shell, mica, alkali, organic matter and other deleterious substances. The various sizes of particles of which an aggregate is composed of shall be uniformly distributed throughout the mass.

Testing of aggregates shall be in accordance with BS 812 or ASTM C-136.

Approval of a source of aggregate by the Engineer shall not be construed as constituting the approval of all materials to be taken from that source and the Contractor shall be responsible for the specified quantity and quality of all such materials used in the Work. Aggregates shall not be obtained from sources, which have not been approved by the Engineer.

The Contractor shall provide means of storing the aggregates at each point where concrete is made such that

- aggregates shall be stored on a hard and dry patch of ground covered with a 50mm thick layer of lean concrete
- each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times
- contamination of the aggregates by the ground or other foreign materials shall be effectively prevented at all times
- each heap of aggregate shall be capable of draining freely
- the aggregates shall be handled so as to avoid segregation

The Contractor shall make available to the Engineer such samples of the aggregate as he may require. Such samples shall be collected at the point of discharge of aggregate to the batching plant/mixer machine. If any such sample does not conform to the Specifications, the aggregate shall promptly be removed from the site and the Contractor shall carry out such modifications to the supply and storage arrangements as may be necessary to secure compliance with the Specifications.

Coarse aggregate

General

Coarse aggregate shall be obtained from breaking hard durable rock or gravel or Picked Jhama Bricks, which conform to the requirements of AASTHO Standard Specifications M-80. Coarse aggregate shall be clean, free from dust and other deleterious materials. The grading of the coarse aggregate shall be such that when combined with the approved fine aggregate and cement, it shall produce a workable concrete of maximum density.

Aggregate pieces shall be angular in shape and have granular or crystalline or smooth, but not glossy non-powdery surfaces.

Maximum allowable limits of deleterious substances that shall not be exceeded for coarse aggregate have been shown in the following table:

Material	Mass Percent
Soft fragments	2.00
Clay lumps	0.25
Material passing the 0.075mm sieve	0.50 for clay, 1.50 for fracture dust
Thin or elongated pieces: Flakiness index (STP T7.13) less than	30.00

The Aggregate Crushing Value (STP T7.7) shall be less than 30% and the ten percent fine value (STP T7.8) shall be greater than 150 kn.

Grading for nominal size coarse aggregate shall comply with the following ASTM C-33 standard gradations:

20mm nominal size Coarse Aggregate

Sieve Size (mm)	% Passing by Weight
25	100
19	90-100
12.50	20-55
9.50	0-15
4.75	0-5

40mm nominal size Coarse Aggregate

Sieve Size (mm)	% Passing by Weight
50	100
37.5	95-100
19	35-70
9.5	10-30
4.75	0-5

Coarse aggregate subject to five cycles of the Soundness Test, specified in ASTM C88, shall not show a loss exceeding 10% when magnesium sulphate solution is used except where otherwise approved.

The flakiness and elongation indices of the predominant size fractions in each single sized coarse aggregate, determined in accordance with BS 812, shall not exceed 20% and 35% by weight respectively.

Aggregate for use in concrete which is subject to abrasion and impact shall comply with the Test requirements of BS 812 and the Specification of BS 63 Part 1 and BS 63 Part 2 and BS 882 respectively.

Coarse aggregate shall be tested for drying shrinkage characteristics in accordance with BRS Digest No.35.

Coarse aggregate shall be stored at site in such a manner that it is not contaminated by fine aggregate, earth or other foreign matter. Adequate precautions shall be taken to prevent segregation of the coarse aggregate while it is being transported and stacked.

Stone aggregate

The boulders to be used as coarse aggregate in concrete shall be composed of limestone, sandstone, granite, trap rock or rock of similar nature and shall have the following properties:

Compressive strength (minimum)	490 kg/cm ²
Specific gravity	2.4 – 2.7
Unit-weight	2245 – 2566 kg/cum
Porosity	2% – 6%
Water absorption	1.5% – 5% by weight

The boulder shall be of uniform light colour as approved and shall be free from thin lamination, adherent coatings and deleterious substances. The wear loss of coarse aggregate of all types shall not exceed 35% by weight when tested by the Los Angeles Abrasion Test.

The boulders shall be supplied in sizes that can be handled manually by one person. Stock piling shall be such as to permit ready identification of the materials and shall be approved by the Engineer. Site for stockpiles shall be clean prior to storing materials. The stockpiles shall be built up in layers not to exceed 1.22m. In height and each layer shall be inspected before the next layer is started. The crushed boulder chips shall be stacked in accordance with the specified sizes in different stacks as directed by the Engineer. Height of each stack should not exceed 33% of the minimum base dimension of the stack.

Brick aggregate

Brick aggregate shall be as far practically as possible of uniform specific gravity. Blown bricks or unevenly burnt bricks shall not be crushed for purposes of providing aggregates. Best possible first class picked jhama bricks of selected quality only shall be allowed to be crushed.

Brick aggregate shall consist of first class Picked Jhama Brick chips graded as stated above under the Sub-section 'General'. All brick aggregates shall be screened and washed at Contractor's own costs and shall consist of clean, well shaped cubical particles, free from splintered or flaky particles, soil, organic matter or any deleterious material.

Storage of coarse aggregate

Aggregate of different sizes or grades and from different sources of supply shall not be mixed. All aggregate shall be stored separately free from contact with earth and other deleterious matter. The coarse aggregate should be stockpiled in different stacks, according to the sieve sizes.

All precautions shall be taken during transport and stockpiling of coarse aggregate to prevent segregation. Segregated aggregate shall not be used until they have been thoroughly re-mixed and the resulting stack is of uniform and acceptable gradation.

Aggregate shall be stock-piled at least 7 (seven) days prior to their anticipated use to permit the Engineer to sample each stock-pile to determine the acceptability of the material for the intended use.

Fine aggregate**General**

Fine aggregate for use in the concrete and masonry work shall be non-saline clean natural sand and have a Specific Gravity not less than 2.6 and conform to the requirements of AASHTO Standard Specification M-6 and ASTM C 144. It shall be angular (gritty to touch), hard and durable, free from clay, mica and soft flaky pieces. All sands must be well washed and clean before use.

A well graded sand should be used for cement work as it adds to the density of the mortars and concretes. Sand required for brick work needs to be finer than that for stone work.

Sand which contains 90% of particles of size greater than 0.06mm and less than 0.2mm is fine sand. On the other hand, sand which contains 90% of particles of size greater than 0.6mm and less than 2mm is coarse sand.

Supply methods and stock piling of sand shall be such as to permit ready identification of the materials delivered and shall be approved by the Engineer.

Impurities

Sand shall be clean and free from injurious amount of organic impurities. Deleterious substances shall not exceed the following percentage by weight.

Material passing No. 200 sieve	2.0
Shale, coat, soft or flaky fragments	1.0
Sulphur compounds	0.3
Clay Lumps (wet, on No. 4 sieve)	0.00

Fine aggregate subject to five cycles of the soundness test, specified in ASTM C88 shall not show a loss exceeding 10 mass percent when magnesium sulphate solution is used except where otherwise approved.

Grading

Sand shall be well graded from coarse to fine within the limits given below or shall conform to the specified Fineness Modulus.

Fine aggregate for concrete

Sieve No.	% Passing by Weight
9.5mm	100
4	95-100
16	45-80
50	10-30
100	2-10

Fine aggregate for masonry

Sieve No.	% Passing by Weight
4	100
8	95-100
16	70-100
30	40-75
50	10-35
100	2-15

Sand fill

Sand for sand fill shall consist of hard, dense, durable materials free from injurious amounts of clay lumps, light weight materials or other deleterious substances.

Unless otherwise specified on the Drawings, sand fill with gunny bags shall have Fineness Modulus not less than 0.8.

Sand fill for the Geo-textile bags shall, unless otherwise approved by the Engineer, comply with the following grading:

	mm
d ₉₀	0.60 to 0.30
d ₈₆	0.50 to 0.25
d ₆₀	0.40 to 0.20
d ₅₀	0.35 to 0.20
d ₁₀	0.20 to 0.05

2.3 Cement

Cement used in the works shall be obtained from manufacturers, approved in writing by the Engineer and shall be Ordinary Portland Cement complying with the requirements of ASTM C150 Type 1 or BS 12 or BDS 232 or equivalent standard. Special cements shall conform to the requirements provided in writing by the Engineer.

Each consignment of cement delivered to the site must be accompanied by a certificate showing the place of manufacture and the results of standard tests carried out on the bulk supply from which the cement was extracted.

The Engineer may make any test, which he considers advisable or necessary to ascertain, if the cement has deteriorated in any manner during transit or storage. Any cement which, in the opinion of the Engineer, is of doubtful quality shall not be used in the Work until it has been re-tested and test result sheets, showing that it complies in all respects with the relevant standard, have been delivered to and accepted by the Engineer.

Cement that becomes lumpy or otherwise deteriorated in transit or storage shall not be used for brick masonry or concrete works. All cement unfit for use shall be removed from the site immediately.

The Engineer shall ask to carry out sampling, inspection and testing of all cement as may consider be necessary. Samples shall be taken as instructed from the site store, or from elsewhere on the Work or from any places where cement is used for incorporation in the work. The compressive strength and tensile strength of standard cubes and briquettes respectively shall be not less than as follows:

Days	Compressive Strength (N/mm ²)	Tensile Strength (N/mm ²)
3	12.4	1.0
7	19.3	1.9
28	27.6	2.4

Initial setting time shall be not less than 45 minutes and the final setting time shall be not more than 375 minutes. Cement, when tested for fineness, shall have a specific surface of not less than 160m²/kg. Cement when tested for soundness shall not have an expansion of more than 10 mm. The unit weight of cement shall be 14.16 KN/m³.

Rejection of cement

The Engineer may reject any cement as the result of any tests thereof notwithstanding the manufacturer's certificate. The Engineer may also reject cement, which has deteriorated owing to inadequate protection or from other causes where the cement is not to his satisfaction. The Contractor shall remove at his costs all rejected cement from the site without delay.

Storage of cement

Cement shall be delivered to the Work site in sound and properly sealed jute/paper bags, each plainly marked with manufacturer's name or registered mark. Cement shall be well protected from weather by tarpaulins or other approved cover during transit. Weight of individual bag containing cement shall be 50 kg and weight of all bags shall be uniform. Weight of cement shall be legibly marked on each bag. Bags in broken or damaged condition shall be rejected.

The Contractor shall provide waterproof and well-ventilated godowns at the specified or approved location at the site having a floor of wood or concrete raised platform at minimum 450mm above the ground so as to protect the cement against moisture from air or from any other source. Sheds shall be large enough to allow a minimum 300mm gap between the stacked cement and the godown walls to store cement in sufficient quantity to ensure continuity of work and to permit each consignment to be stacked separately therein to permit easy access for inspection. All storage facilities shall be subject to approval by the Engineer.

Immediately upon arrival at the site, cement shall be stored in the godowns with adequate provisions to prevent absorption of moisture. The Contractor shall use the consignments in the order in which they are received. Cement delivered to the site in drums or bags provided by the supplier or manufacturer, shall be stored in the drums or bags until used in the Work. Any cement in drums or bags which has been opened shall be used immediately on opening. Cement shall not be stored in a godown for more than 3 (three) months if bagged or 6 (six) months, if in bulk or a lesser period as directed by the Engineer. After this period is over, any unused cement shall be removed from the site.

2.4 Admixture

Admixture shall be used to provide excellent acceleration of gaining strength at early age and major increase in strength at all ages by significantly reducing water demand in a concrete mix, specially suitable for pre-cast concrete and other high early strength requirements. Admixture shall conform to BS 5075 Part 3 and ASTM C 494. Contractor may use Conplast SP-430, SP-211, which is a product of FORSOC or any other product approved by the Engineer.

2.5 Reinforcement

Mild steel bar

This is a type of bar plain and round or deformed in shape of a structural or intermediate grade conforming to ASTM Specification A 510 or A 615 with a yield strength of not less than 280 MPa (N/mm²) i.e. 40 grade.

High strength deformed rod

Reinforcing steel under this type comprises Grade-60 Deformed re-bars. The steel shall conform to ASTM Specification A-617M or A-615M with an yield strength of not less than 420 MPa (N/mm²). The structural grade shall be made from billets. The ends of the bar shall be machine sheared perpendicular to the axis of the bar. The bars shall be free from injurious defects and shall have a workman like finish.

Cleaning and storage

Steel reinforcement bars and structural steel shall be stored in a way to prevent distortion, corrosion, scaling and rusting. Reinforcement bars and structural steel sections shall be coated with cement wash before stacking, specially in humid areas. In case of long time storage or storage in coastal areas, reinforcement bars and steel sections shall be stacked at least 200mm above the ground level.

Steel sections shall be stacked upon platforms, skids or any other suitable supports. Bars of different sizes and lengths and structural sections shall be stored separately to facilitate issues in required sizes and lengths without cutting from standard lengths. Ends of bars and sections of each type shall be painted with separate designated colours.

Tag line shall be used to control the load in handling reinforcing bars or structural steel when a crane is used. Heavy steel sections and bundles of reinforcing bars shall be lifted and carried with the help of slings and tackles.

All bars, prior to its use, shall be cleaned with wire brush to make them free from nail scale, loose rust, dirt, paint, oil, grease or other foreign substances.

Bars of reduced sectional area to excessive rust shall be rejected.

All reinforcing steel shall be stored properly under shed not to be contaminated by oil, grease, dirt or mud.

All stacking and storing of bars shall be the Contractor's responsibility and contingent upon his Tenders.

2.6 Wire Mesh for Brick Mattress

The wire mesh to be used for anchoring and encasing the brick mattress shall be made of 12 BWG Galvanized Iron wire twisted to form hexagonal openings of uniform size. The mesh opening shall not have more than 112mm in linear dimension with maximum opening area of 51centimeter square. The wire netting roll shall be as large as possible.

2.7 Water

Water shall be clean, fresh and free from organic or inorganic matter in solution or suspension in such amount that may impair the strength or durability of the concrete. Water shall be obtained from a supply where possible, and shall be taken from any other source only, if approved. No water from excavation shall be used. Only water of approved quality shall be used for washing shuttering, curing of concrete and similar other purposes.

Water to be used in construction shall be stored in tanks, bottom and the sides of which shall be constructed with brick or concrete. Contact with any organic impurities shall be prevented.

The tank shall be so located as to facilitate easy storage and filling in, and supply for construction works and other purposes.

2.8 Fill

Materials for filling shall be uniform in character throughout and free from substances that by decay or otherwise may cause the formation of hollows or cavities or otherwise affect the stability of the filling.

Earth filling shall be of selected materials obtained from the excavation or carted fine sand as approved by the Engineer. No soft chalk or clay or earth with a predominating clay content shall be used. Hard core shall be selected hard clean gravel, broken brick, broken concrete, broken or crushed stone, quarry waste or similar approved material. Concrete for filling shall be to the proportions specified.

2.9 Timber

General

All timber for temporary or permanent works shall be of best quality, sound, straight, well seasoned, free from sap, defects, radial cracks, cup-shakes, large/loose/dead knots, or other imperfections and shall show a clean surface with cut.

Timber shall be stored in stacks on well treated and even surfaced beams, sleepers or brick pillars so as to be at least 200mm above the ground level. Members shall be stored separately in layers according to the lengths.

A space of 25mm shall be kept between the members. The longer pieces shall be placed in the bottom layers and at the shorter pieces in the top layers. At least one end of the stack shall be in true vertical alignment.

The recommended width and height of a stack are 1.5m and 2.0m respectively. Minimum distance between two stacks shall be 800mm.

The stacks of the timbers shall be protected from hot dry wind, direct sun and rain. Weights may be placed on top of the stacks to prevent wrapping of timber. Nails, metal straps, etc. attached to used timber shall be removed before stacking.

Inspection

All timbers shall be subject to inspection at site piece by piece and shall be to the approval of the Engineer who may reject such timber as is considered by him to be under-specified. In the case of timber specified to be creosoted, the Engineer may reject such timber before or after creosoting, if specifications are not correctly followed. The Contractor shall provide all necessary labour for handling the timber during inspection free of charge.

Wrought Faces and Allowances on Joiner's Work

All joiner's work shall be wrought and finished with a clean, even and smooth face, the thickness given to include 2mm for each wrought face in soft wood and 1.5mm for hard wood.

Timber Piles

Timber piles shall be made of Sal, Sundari, Gajari or any other approved hard wood. They shall be matured, straight and free from large or loose knots, cracks and other defects.

Piles shall have a minimum diameter of 100mm measured at one third point from the thickest end (butt) without bark. Piles should be straight and a straight line drawn from the centre of the butt to the centre of the tip shall be contained entirely within the pile.

Timber piles exposed permanently above water shall be treated with a water repellent preservative such as creosote for a minimum period of 24 hours in accordance with BS 5268, Para 5, 1977.

2.10 M.S. Pipe

M.S. Pipe shall be made from low carbon steel conforming to the requirements of ASTM A 53 and physical requirements as specified therein.

PVC Pipe

PVC pipe shall be of unplasticized polyring/chloride and shall conform to BS 3500: 1968/3506: 1969 or equivalent. The pipes shall be laid and jointed in accordance with the manufacturer's instructions and to the Engineer's satisfaction.

Storage and handling of pipe

Pipes shall be stored in stacks with stoppers provided at the bottom layer to keep the pipe stack stable. The stack, particularly of smaller diameter pipes, shall be in pyramid shape. Pipes shall not be stacked more than 1.5m in height.

Each stack shall have pipes of the same type and size only. Removal of pipes shall start from the top layer and by pulling from one end. A pipe shall not be stored inside another pipe. The pipes may also be placed alternately length and crosswise.

PVC pipes shall be stored in a shaded area. The ends of pipe, particularly those specially prepared for jointing, shall be protected from abrasion. Damaged portion of a pipe shall be cut out completely.

Pipes of conducting materials shall be stacked on solid level sills and contained in a manner to prevent spreading or rolling of the pipe. For storage in large quantity, suitable packing shall be placed between the layers. During transportation, the pipes shall be so secured as to prevent displacement/rolling.

2.11 Gunny Bags

The gunny bags used in the permanent works shall be new, 50/75 kg capacity bags similar to those normally used. The Contractor shall submit sample bags to the Engineer for his approval.

2.12 Geo-textile

General

All Geo-textiles shall be manufactured and supplied by a firm or firms of reputable geo-textile manufacturers. The Engineer shall approve the quality of geo-textile and the manufacturer as well.

Before placing an order for any quantity of geo-textile, the Contractor shall submit samples and test reports to the Engineer for approval for each type of geo-textile from an independent testing laboratory approved by the Engineer.

The geo-textiles to be incorporated within the works shall comply with the appropriate Codes and Standards including the following:

ASTM D4491	Standard test methods for water permeability of geo-textile by permittivity.
DIN 53936 (pt1)	Determination of the water permeability coefficient k_{v1} normal to the geo-textile plane with constant head.
ISO 9073-1	Determination of mass per unit area for non-woven textiles.
ISO 9073-2	Determination of thickness of non-woven textiles.
ISO 9073-3	Determination of tensile strength and elongation of non-woven textiles.

The filter effective opening size, O_{90} , defined as being the grain size of a standard sand corresponding to 90% retention by weight on a sample of the geo-textile in a vibrating sieve apparatus, shall be measured in a wet apparatus using the BAW (Bundesanstalt fur Wasserbau – German Federal Institute for Waterways Engineering) method.

All geo-textiles shall be clearly and uniformly marked on the upper face. The marking shall take the form of an indelible repeat roll imprint at the edge of each geo-textile roll recurring at least every 1.5m.

Geo-textile filter

Geo-textile fabric used for the filter layer below the slope protection shall be a non-woven needle punched of different grades with a specifications mentioned below:

Grade-1

Mass (minimum)	170 gm/m ²
Thickness under pressure 2 kpa (minimum)	1.55mm
Strip Tensile Strength (minimum)	12.0 kn/m
Elongation (minimum)	35%
Grab Tensile Strength (minimum)	700 N
CBR Puncture Resistance (minimum)	2000 N
Effective Opening Size (maximum)	0.10mm
Permeability vertical under 2 kpa pressure h is 100mm (minimum)	0.003 m/s
Permeability horizontal under 2 kpa pressure (minimum)	0.004 m/s

Grade-II

Mass (minimum)	190 gm/m ²
Thickness under pressure 2 kpa (minimum)	1.8mm
Strip Tensile Strength (minimum)	14.0 kn/m
Elongation (minimum)	35%
Grab Tensile Strength (minimum)	750 N
CBR Puncture Resistance (minimum)	2200 N
Effective Opening Size (maximum)	0.10mm
Permeability vertical under 2 kpa pressure h is 100mm (minimum)	0.003 m/s
Permeability horizontal under 2 kpa pressure (minimum)	0.004 m/s

Grade-III

Mass (minimum)	240 gm/m ²
Thickness under pressure 2 kpa (minimum)	2.0mm
Strip Tensile Strength (minimum)	18.0 kn/m
Elongation (minimum)	35%
Grab Tensile Strength (minimum)	1000 N
CBR Puncture Resistance (minimum)	2700 N
Effective Opening Size (maximum)	0.09mm
Permeability vertical under 2 kpa pressure h is 100mm (minimum)	0.003 m/s
Permeability horizontal under 2 kpa pressure (minimum)	0.004 m/s

Grade-IV

Mass (minimum)	310 gm/m ²
Thickness under pressure 2 kpa (minimum)	2.6mm
Strip Tensile Strength (minimum)	22.0 kn/m
Elongation (minimum)	40%
Grab Tensile Strength (minimum)	1300 N
CBR Puncture Resistance (minimum)	3700 N
Effective Opening Size (maximum)	0.09mm
Permeability vertical under 2 kpa pressure h is 100mm (minimum)	0.003 m/s
Permeability horizontal under 2 kpa pressure (minimum)	0.004 m/s

Grade-V

Mass (minimum)	365 gm/m ²
Thickness under pressure 2 kpa (minimum)	3.0mm
Strip Tensile Strength (minimum)	25.0 kn/m
Elongation (minimum)	40%
Grab Tensile Strength (minimum)	1500 N
CBR Puncture Resistance (minimum)	4000 N
Effective Opening Size (maximum)	0.08mm
Permeability vertical under 2 kpa pressure h is 100mm (minimum)	0.003 m/s
Permeability horizontal under 2 kpa pressure (minimum)	0.004 m/s

The Contractor shall undertake the necessary grading and permeability tests of the embankment soils to determine the required filter cloth characteristics.

Geo-textile bags

Geo-textile bags shall be manufactured from short staple non-woven geo-textile weighing not less than 0.8 kg/m², and with O₉₀ not greater than 0.07mm or similar material approved by the Engineer.

Geo-textile bags shall be manufactured to the dimensions and capacity specified on the Drawings and filled with sand which complies with the requirements stated in the preceding Sub-section.

Each bag shall be double stitched along all edges except for the opening at the top of each bag, which shall be wide enough to allow the filling of the bag. The minimum tensile strength of the seam shall be not less than 90% of the tensile strength of the geo-textile. The top of each bag shall have a flap, which shall be closed tightly after filling and then double stitched.

The bags shall be stored under cover, well covered from direct sunlight and to prevent the ingress of dust or mud. They shall be protected from damage by insects or rodents.

2.13 Elastomeric bearings

The raw elastomer to be used for bearings shall be made either from virgin Neoprene (polychloroprene) or virgin natural rubber (polyisoprene) chloroprene rubber only satisfying to the requirements of these specifications. However, unless specifically mentioned in plans or directed by the Engineer in writing, only virgin Neoprene (polychloroprene) shall be used in the manufacture of bearings.

Grades of raw elastomer of proven use in elastomer bearings with low crystallization rates and adequate shelf life shall be used. No reclaimed elastomer or vulcanized wastes shall be used. The raw elastomer content of the compound shall not be lower than 60% and the ash content shall not exceed 5%. Elastomer shall have high environmental resistance compatible with conditions of use. The elastomer compound shall meet the minimum requirement of the following Table.

Properties of Polychloroprene				
Physical Properties				
D 2240	Hardness (Shore A Drometer)	50±5	60±5	70±5
D 412	Tensile Strength, Minimum psi	2250	2250	2250
	Ultimate Elongation, Minimum%	400	350	300
Heat Resistance				
D 573 70 Hours at 100° C	Change in Durometer hardness, Maximum Points	15	15	15
	Change in Tensile Strength Maximum%	-15	-15	-15
	Change in Ultimate Elongation, Maximum %	-40	-40	-40
Compression Set				
D 395 Method B	22 Hours @100° C, Maximum %	35	35	35

If the material is specified by its shear modulus, its measured shear modulus shall lie within 15% of the specified value. A consistent value of hardness shall also be supplied for the purpose of defining limits for the tests mentioned in the above Table. If the hardness is specified, the measured shear modulus must fall within the range of the Table below:

Shear Modulus				
D 4014 23+ 2°C	Hardness (Shore "A")	50	60	70
	Shear Modulus (G) at 23+ 2°C (MPa)	0.68-0.93	0.093-1.43	1.43-2.14

Steel Laminates:

Steel laminates used for reinforcement shall be made from rolled mild steel conforming to ASTM A 36, A-570, or equivalent unless otherwise specified by the Engineer. The laminates shall have a minimum nominal thickness of 16 gauges. Holes in plates for manufacturing purposes will not be permitted unless they have been accounted for in the design, as shown on the plans.

Steel laminated bearings shall develop minimum peel strength of 7 KN/m. ASTM D 429, Method B, shall perform Peel strength tests.

3. MATERIAL TESTING

3.1 General

Notwithstanding the requirements stated in the detailed specifications for individual items, the following minimum tests shall be carried out in the LGED specific laboratories and in the field. In the cases the testing facilities are not available in the LGED laboratory, the tests shall be performed elsewhere as directed by the Engineer.

Contractor's Materials Engineer will be responsible for liaison and coordination with the site laboratory, the Engineer, field sampling/testing staff and off-site laboratories to ensure that all sampling, specified tests and inspections are carried out in a timely manner.

No inspection or approval by the Engineer shall relieve the Contractor of any of his duties and obligations under the Contract.

All test types and quantities described in the following Sub-sections are considered "Normal Testing" and anything beyond that in type and quantity is considered as "Special Testing". The Engineer may increase the frequency of testing as per requirement.

3.2 Tests

Bricks

For each consignment not exceeding 100,000 bricks, minimum 6 (six) bricks shall be tested to ascertain:

- Dimensions and unit weight
- Compressive strength
- Water absorption

Coarse aggregate

The tests mentioned below shall be carried out for each day's casting or per 15 cubic meter of concrete whichever provides the greater number of tests.

- Gradation
- Unit weight
- Water absorption
- Specific gravity
- Abrasion loss

Fine aggregate

The tests mentioned below shall be carried out for each day's casting or per 15 cubic meter of concrete whichever provides the greater number of tests.

- Gradation
- Fineness Modulus (F.M.).
- Specific Gravity and Absorption.

Cement

For each consignment of a particular brand not exceeding 25 tons, at least 3 (three) samples collected random shall be tested prior to the cement be incorporated in to the works to ascertain:

- Setting time
- Compressive strength

Reinforcement

For each consignment not exceeding 10 (ten) tons or as directed, 3 (three) representative samples of each size of M.S. bar shall be tested for:

- Cross sectional area
- Unit weight
- Yield strength
- Elongation
- Bending
- Tensile strength
- Measurement of deformation

Only Test Certificates issued by BUET or the concerned regional University of Engineering and Technology shall be accepted by the Engineer when the requisite test facilities are not available with the LGED Laboratory.

Strength Test for Concrete

Six Cylinders would form a set of sample for strength determination. Three Cylinders shall be tested at seven days and three cylinders shall be tested at twenty-eight days. Each and every twenty-eight days Cylinders shall attain the minimum specified compressive strength. The Contractor shall perform trial mix of his own to determine the characteristic strength or mean strength that has to be attained.

The twenty-eight days strength tests shall be used as a basis for acceptance of the concrete. Seven days tests are made to obtain advance information on the adequacy of strength development. Age-strength relationships shall be pre-established for the materials and proportion used.

Elastomeric bearings

No bearing shall be installed unless an approved laboratory on sampled bearings has completed tests in accordance with AASHTO M251-92 and the Engineer has approved the bearings, having achieved all requirements.

The Contractor shall supply all the requisite number of bearings required for a bridge to the respective Office of the Executive Engineer. Samples for inspection and testing shall be selected from within the lot at random. A minimum of 1 (one) bearing shall be taken from the lot when the requirement of bearings remains within 12 (twelve), 2 (two) bearings shall be taken for testing when the number of required bearings is more than 12 (twelve) but not exceeding 30 (thirty). When it exceeds 30 (thirty), then additional testing requirement shall be 1 (one) for each additional 30 (thirty), or part thereof. The selected samples shall be sent to the authorized laboratory (preferably BUET) in sealed condition.

The test shall be conducted to verify the results in accordance with the requirements specified in the Table given under 'Elastomeric Bearings' in the Sub-section of 'Construction Materials' of this Specification.

Geo-textiles

Tests of mass per unit area, thickness and tensile strength in accordance with the Standards listed under the Section on 'Construction Materials' shall be carried out by an approved testing laboratory on samples taken from each quantity of 10,000 m² of geo-textile fabric supplied. The k and O_{90} values shall be tested on samples taken from every 50,000 m² of geo-textile fabric supplied. Seams shall be tested for tensile strength every 10,000 m of seam.

The geo-technical test results of the underlying embankment soil together with the manufacturer's specification and installation instructions for the proposed cloth, including permeability and porosity (with methods of testing) and a sample of the cloth shall be submitted for the approval of the Engineer.

The sample size for the fabric shall be 2 square meter and shall be marked to indicate its upper side, longitudinal and transverse directions, type of geo-textile and the date that the sample was taken. Seam samples shall be at least 1m in length and the ends of the threads are to be firmly tied off by the Contractor or Supplier at the time the samples are taken. Each test shall be carried out on at least five samples.

The Contractor shall bear the expenses of all routine tests. Notwithstanding the submission of reports to the effect that the geo-textile conforms to the Specification, the Engineer shall at all times be entitled to have additional samples of geo-textile tested, if he is of the opinion that the geo-textile does not conform to the Specification. The Engineer shall only select samples from ends of geo-textile rolls or geo-textile, which has been cut already.

A geo-textile will be regarded as defective, if any of the specified values are not achieved other than those of unit weight and effective opening size, for which the following tolerances will be permitted:

(a) Single layered geo-textiles:			
Unit weight	-		minus 10%
O_{90}	-		plus or minus 20%
(b) Composite geo-textiles:			
Total weight	-		minus 15%
Single layer weight	-		minus 20%
O_{90}	-		plus or minus 20%

3.3 Expenses for Tests

All expenses for the tests as stated in the above Sub-sections would be borne by the Contractor unless otherwise provisions are made in the BOQ.

Any tests instructed by the Engineer both in type and quantity beyond those specified above shall be paid to the Contractor.

4. STRUCTURES

4.1 Traffic Maintenance

4.1.1 General

From the date of commencement of the Contract to the date of issue of Certificate of Completion for the whole of the Work as provided in the Contract, the Contractor shall at all time bear the full technical and statutory responsibility in maintaining the public and vehicular access along the existing roads, rivers and canals.

The Contractor shall so conduct his operations as to offer the least possible obstruction and inconvenience to the public.

Areas of roadway designated in the Contractor's Working Plans for the use of traffic shall not be obstructed or used in any way by the Contractor or his suppliers or sub-contractors. Materials dumped or Contractor's equipment parked in any public roadway area shall be promptly removed by the Contractor at the direction of the Engineer.

At least 30 days before commencing work, the Contractor shall submit to the Engineer his proposals for the maintenance of traffic including Working Drawings of traffic arrangements, showing all detours, temporary roads, temporary bridges, necessary barricades, warning lights, road signs, etc.

4.1.2 Traffic Operation

The Contractor shall provide and maintain all detours, temporary roads, temporary bridges, necessary barricades, warning lights and guide signs as well as other equipment at all hours during the day and night throughout the period of construction.

The passage of traffic in one-way operation shall be controlled by the Contractor either manually by posting flagmen or using signals.

4.1.3 Maintenance of Existing Road

Within the limits of the site all sections of existing carriageway, shoulder and sidetracks which are being used by traffic shall be maintained in a safe and trafficable condition by the Contractor during the period of the Contract. Potholes, cracks washouts and pavement defects shall be promptly repaired to a safe condition.

The Contractor shall take care that the construction equipment and vehicles do not damage weak bridges on adjacent sections of road. Weak bridges required to carry loads in excess of their apparent capacity shall be propped or otherwise strengthened. The Contractor shall be responsible for the replacement, at his own cost, of weak bridges damaged by his overloaded vehicles, flood damage or other causes initiated by his activities and will have no claim on the Engineer for time lost or disruption of his work due to collapse of a weak bridge, which provides access to his Work. In the event of a bridge failure, which severs public access through his Contract area the Contractor will provide temporary bridging or a serviceable by-pass without delay and in no case more than 48 (forty eight) hours following the severance of access.

4.1.4 Barriers

Barriers shall be used for closing of lanes or roads, the protection of workmen and guidance of vehicular traffic. The barriers shall be distinctly visible and be mounted with red lamps during all hours of darkness. These shall be strong and inviolable.

4.1.5 Removal of temporary works

Immediately upon completion of the Contract all temporary roads, temporary bridges, barricades, signs and other equipment shall be completely removed.

4.1.6 Measurement and payment

Provision for Traffic shall not be measured. The construction, maintenance and ultimate removal of all temporary construction as well as provision and maintenance of barricades, signs and other equipment shall be paid for at a Lump Sum price. This sum shall be the full compensation for all works and responsibilities required for the Contractor in accordance with the Specification and all labours, materials, equipment, incidentals, etc. provided for accomplishing the job i.e. it shall cover all earthworks, temporary bridges, detours, pavement and surfacing materials, warning signs, lights, control of traffic, including single lane working by day and night and all other associated items to ensure smooth and safe flow of traffic and for their removal after the period of construction.

Item of payment

	Unit
Maintenance and Protection of Traffic	Lump sum

4.2 Office Space and Facilities for the Engineer**4.2.1 Field Office**

In addition to the office space required for his own use, the Contractor shall provide and maintain Field Office with toilet facilities, furniture and office equipment for the use of the Engineer and his staff.

Field Office for the Engineer shall mean a building having a minimum 15 square meter net clear internal floor area exclusive of walls and partitions, staircase and toilet and have number of rooms as required by the Engineer. It shall be constructed in 250mm thick brick wall in appropriate cement mortar with C.I. sheet roofing and a protective ceiling made of hard board and timber to the satisfaction of the Engineer. The floor shall be 75mm thick lean concrete with 30mm thick mortar on the top with a neat cement finish to give a smooth look. The foundation of this building shall be sound to the satisfaction of the Engineer. The building shall have required number of doors and windows. Uninterrupted power supply facility, if necessary, shall be made available by means of arranging a stand-by generator.

Access road to the Field Office, sufficient parking accommodation and hard standing sheds for vehicles along with boundary fencing shall be constructed by the Contractor.

The Contractor shall provide, for each office, one office table and four chairs of standard, approved by the Engineer. Safety helmets in adequate numbers always be made available for use of the staff and the visitors.

Offices shall be maintained watertight and shall be provided with ventilation. All doors shall be fitted with approved locks. Windows shall be provided with separate screens and blinds and shall have interior locking devices too.

All offices, complete with furnishings, fittings, access roads and hard standings shall be ready for occupation by the Engineer within four weeks of the date when the Contractor first occupies the site.

All offices shall be regularly and properly cleaned as long as they are in use.

All access roads and hard standings shall be maintained in a convenient trafficable condition throughout the Contract period.

The general location of the Field Office shall be decided by the Engineer in consideration of the Contractor's Work Plans. The Field Office shall be situated at locations that shall be free from flooding.

The Contractor shall submit for the approval of the Engineer, along with the Tender, Plans and Drawings showing the details for the building including Plans and Designs for foundations, access roads, sheds, etc. Plans shall also be submitted showing architectural and structural details and the proposed layout of electrical and running water supply, roads and hard standings thereto. The Engineer may require revision of the said Plan prior to the approval for construction.

Prior to the occupation of the office, the Engineer may specify to the Contractor the defects in the works whereupon he may occupy the office and withhold payment for the works in this item until the Contractor remedies and makes good the said defects to the satisfaction of the Engineer.

On completion of the Contract the Field Office including furnishings shall become the property of the Employer.

4.2.2 Office Equipment and Stationary articles

The Contractor shall require to purchase and supply the following Office equipment and consumables to the Engineer:

(i)	One Computer (English) of approved brand
(ii)	One Photocopy Machine (A3 size)
(iii)	Minor items of field office equipment such as file trays, punches, staplers etc. in reasonable number/quantities as requested by the Engineer.
(iv)	Consumables such as papers, pens, files etc. in reasonable number/quantities as requested from time to time by the Engineer.

Upon completion of the Contract, the office equipment listed above shall remain the property of the Employer.

4.2.3 Survey Equipment

As per requirement of the program, survey equipment shall be provided on each contract Site for use by the staff of the Contractor and the Engineer. A tentative list of such survey equipment is given below:

Optical square	1 no.
Spirit level (metal 1m long)	1 no.
Steel measuring tape 25m long	1 no.
Steel measuring tape 5m long	1 no.
Leveling staff 3m long	1 no.
Ranging poles	5 nos.
Surveyor's plumb bob	1 no.
Wild T-1A Theodolite with tripod (or equivalent)	1 no.
Wild NA-2 Automatic level with tripod (or equivalent)	1 no.
Traversing targets with tripods.	1 no.
Magnetic Compass.	1 no.

Miscellaneous tools and minor items of survey equipment such as umbrellas, hammers, knives etc. shall be made available at site in reasonable numbers at all times for use by the staff of the Contractor and the Engineer.

Consumables such as pegs, stakes, string lines, paint, marking crayons, etc., shall be made available at site in reasonable numbers and quantities at all times for use by the staff of the Contractor and the Engineer.

Upon completion of the Contract, the survey equipment listed above shall remain the property of the Contractor.

4.2.4 Offices and Equipment

The Contractor shall provide and maintain an inventory of all furnishings and equipment and shall replace any equipment, which is lost or irreparably damaged subject to the condition that the Engineer shall ensure his staff to take all reasonable precautions in the handling, operation and transportation of such equipment.

The Contractor shall pay all expenses in respect of water, electricity (where available), garbage cleaning etc. necessary for running the Office and maintaining conducive environment.

The Contractor shall place all necessary support staff such as office boys, cleaners, messengers, road-men, chain-men etc. in required number to the Engineer and his personnel in smooth performing of his responsibilities.

4.2.5 Signboards

The Contractor shall supply, erect and maintain in good condition at least two Identification Signboards of sizes to be specified by the Engineer to be fixed one at each end of the Work at a place clearly visible to the public. The Signboards shall be mounted on steel pipe frames with the required sizes at a height 2m above the ground and shall be sufficiently strong to withstand the wind forces. The board shall be fabricated from steel angle and plates and painted with suitable colours and written in English and/or Bengali as per direction of the Engineer.

Each board shall display:

- The name of the Project
- The name of the Work
- The name of the Employer
- Other particulars, which will be asked by the Engineer.

4.2.6 Progress in Photographs and Videos

Photographs and videos showing the progress of works and special photographs showing particular features or other matters of interest in connection with the Work or their surroundings shall be taken every month by an approved qualified photographer/cameraman to the choice of the Engineer. Number of photographs/video clips shall not be less than 10 (ten) per month.

Four colour un-mounted prints of a size 250mm on approved photographic paper of every such photograph inscribed with its serial number, date of shooting and a short title shall be furnished to the Engineer every month.

All negatives and video clips shall be numbered, filed and retained at the Site. On completion of the Contract, those shall become the properties of the Employer and shall be handed over to the Employer by the Contractor.

6 (six) complete sets of colour prints of the finished permanent Work, not exceeding 20 (twenty) photographs in number, shall be taken when and as directed by the Engineer prior to finally granting the Contractor the Certificate of Completion and shall be suitably mounted, titled and supplied to the Engineer.

4.2.7 Measurement and Payment

Provisions for Office Space and Facilities for the Engineer shall not be measured.

Payment for all the items as stated below shall be for the full period of the Contract including any extension, if allowed.

Payment for all equipment, signboards, photographs, video clips, services etc. of the Field Office detailed in this Sub-section shall be made as described below, where price and payment shall be the full compensation for complying with this Section of the Specification and the Conditions of the Contract.

Payment of rates for the pay items shall be the full compensation for supplying, erecting and maintaining the Field Office for the Engineer including all furniture, fixtures and fittings, access roads, office equipment, signboards, photographs, video clips etc. all in full compliance with the requirements of this Section.

No separate payment shall be made to the Contractor for providing the requisite tools, minor items and the consumables. Compensation for these items shall be deemed to be included in the other pay items of the BOQ.

Item of payment

	Unit
Supply, erection and maintenance of Signboards	Lump sum
Providing, erection and maintenance of Office for the Engineer including all office equipment and consumables	Lump sum
Providing photographs, video clips, etc.	Lump sum

5. DEMOLITION AND REMOVAL OF EXISTING STRUCTURE**5.1 Description**

This work shall consist of the satisfactory dismantling, removal and disposal or salvage, wholly or in part, of all existing structures and sub-structures within the site as indicated on the Drawings or as instructed by the Engineer.

5.2 Precautions Prior to Demolition

Danger sign shall be posted round the property. All entrances shall be barricaded or manned. Warning lights shall be placed above all barricades during night and dark hours. Watchmen shall be provided to prevent unauthorized entry of the public in the danger zone.

All utility lines shall be disconnected upon the approval of the relevant Authorities. Temporary service connection for the demolition work shall be taken separately.

Workmen shall be provided with all necessary safety appliances prior to the start of work. Safety precautions for fire shall be provided and the site shall be thoroughly cleaned of combustible materials.

5.3 Materials

All materials so removed/salvaged shall be the property of the Employer unless otherwise specifically stated in the Contract. Any materials not required by the Employer shall be classed as waste.

5.4 Performance Methods

Where a structure is to be replaced, the existing structure shall be demolished to a level up to the bottom of the foundation of the new structure or as directed by the Engineer.

If the salvaged superstructure or any portion of the structure is deemed fit for re-use elsewhere, the usable portions shall be marked and removed without any damages and stockpiled neatly at an accessible point above the highest water level within the site or at a place as directed by the Engineer.

Recovered structural steel and Portable Steel Bridge components shall be removed from site and stockpiled in a yard as instructed by the Engineer (generally in the office compound of the respective Executive Engineer of the District).

All other usable materials shall be stockpiled within the site.

All materials, classed as waste and not considered of value by the Engineer, shall be removed by the Contractor from the site but within the limits of the site at his own expenses.

Use of explosives will not be permitted except directed by the Engineer.

The Contractor shall have to arrange at the site all machinery and equipment at his own initiative together with making necessary techniques, arrangements and methods.

5.5 Measurement

The Work shall be measured according to the types of structures and shall be measured in cubic meter/ metric ton.

5.6 Payment

Removal of existing structures as measured above shall be paid at the contract unit price per cubic meter or metric ton depending upon the type of works and the price quoted in the Contract. The payment shall be in full compensation for all dismantling, removal and disposal of all materials and debris with carriage, staking of all usable materials, all labour, equipment, tools and incidentals necessary to complete the work strictly in accordance with the Specifications.

Item of payment

	Unit
Removal of existing structures (C.C, R.C.C, Brick work, Timber)	Lump Sum
Removal of existing steel structure	Metric ton

6. EXCAVATION AND BACKFILL FOR STRUCTURES

6.1 Description

This item of work shall consist of excavation in any type of soil/material for the foundation of structures, disposal of excavated materials, construction and removal of cofferdams, sheeting and other temporary works in protecting the stability and safety of the excavated foundations, pumping, de-watering/bailing water from foundations, back-filling of completed structures with suitable back-fill.

No separate payment shall be made for the excavation and back-fill for structures when the works will involve use of cofferdams. The costs of this temporary work shall be deemed included as part of the Tender sum.

The Work shall be carried out at the locations and according to the lines, levels, grades and dimensions shown on the Drawings or as directed by the Engineer.

6.2 Materials

Excavated material

All excavated materials shall be classified by the Engineer either as suitable for fill or as waste.

Approved suitable excavated material free of large lumps, wood or other objectionable materials shall be placed as backfill above the level of pile except where other materials are shown on the Drawings or required by the Engineer.

Ordinary fill

Ordinary fill consists of earth having Liquid Limit not exceeding 50 (STP T3.2) and Plasticity Index not exceeding 20 (STP T3.2) and shall be used as backfill material above the level of pile caps and areas except where other materials are shown on the Drawings or required by the Engineer.

Sand

Unless otherwise stated on the Drawings or ordered by the Engineer, backfill material below the top level of pile caps shall consist of sand free from chemical contamination with not more than 10% of the material passing the No. 200 sieve (U.S. size). All other specifications should conform to what have been illustrated under the relevant Sub-section of this Specification. The sand to be used shall be approved by the Engineer prior to placing.

Aggregate

75mm downgraded brick aggregate, shall be placed adjacent to any abutment or wing wall in which weep holes have been provided. The aggregate to be used shall be approved by the Engineer prior to placing.

Blinding Concrete

Blinding concrete shall be placed as backfill as shown on the Drawings or ordered by the Engineer. The material shall conform to the specifications stated below:

Cement

Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.

Cement shall be free from any hardened lumps and foreign matter. It shall have a minimum of 90% of particles by weight passing the 75micron sieve, an initial setting time in excess of 45 minutes and a final setting time of less than 375 minutes.

All other specifications should conform to what have been illustrated under the relevant Sub-sections of this Specification.

Coarse aggregate

Except otherwise stated, coarse aggregate shall consist of hard, durable angular fragments of crushed stone and/or crushed natural gravel conforming all other specifications illustrated under the relevant Sub-section of this Specification.

Fine aggregate

All specifications should conform to what have been illustrated under the relevant Sub-section of this Specification.

Water

Water shall be subject to the approval of the Engineer and shall be reasonably clear, free from oil, alkali, salts, acid and organic substances and other deleterious materials or objectionable quantities of suspended materials. All other specifications shall be in accordance with the requirements illustrated under the relevant Sub-section of this Specification.

6.3 Construction Methods

Excavation

The Contractor shall notify the Engineer before commencing excavation of the foundation trenches so that the cross-section, elevations and measurements of the undisturbed ground may be taken. The natural ground adjacent to the structure shall not be disturbed without taking any permission from the Engineer.

Trenches and foundation pits for structures shall be excavated to the lines, grades and elevations as shown on the Drawings or as directed by the Engineer. The elevations of the bottom of the foundations shown on the Drawings are approximate only and the Engineer may order such changes as deemed necessary to provide a secured foundation.

Where unstable soil is encountered at the bed level, it should be brought to the notice of the Engineer and all such unstable soil shall be removed as directed and replaced with suitable materials to provide adequate support for the structure.

On acceptance of the materials forming the bottom of any excavation by the Engineer subsequently becoming unacceptable to him due to exposure to weather condition or due to flooding or have become puddled, soft or loose during the work process, the Contractor shall remove such damaged, soft, or loose materials and excavate additional. Such further excavation shall be held as excess excavation and the cost of the excess excavation and subsequent replacement with a suitable back-fill shall be at the expenses of the Contractor.

Any erroneous excavation or excess excavation for the conveniences of the Contractor, or over excavation performed by the Contractor for any purpose or reasons shall be at the expenses of the Contractor. If the excavation for foundations exceeds the depths specified, the Contractor shall brought it back to the specified levels with sand, mass concrete or other approved materials conforming Standard Specifications at the Contractor's own expenses.

Excavation shall be sufficiently large to provide necessary working space, shuttering and any other Temporary Works required during construction.

Boulders, roots and any other objectionable materials encountered in excavation, shall be removed. The excavated foundation shall be cleared of all loose materials and cut to a firm surface.

When the footing is to rest on the ground and not on piles, special care shall be taken not to disturb the bottom of the excavation and excavation to final grade shall be deferred until immediately before the footing is placed. If foundation fill material is required, it shall be placed and compacted in layers not more than 150mm thick or as directed by the Engineer. The dry density on compaction within 300mm below the top level shall not be less than 100% maximum dry density as determined in accordance with STP T4.5 (standard compaction).

In excavating foundation trenches, the last 150mm layer shall not be excavated until immediately before commencing the construction work except that the Engineer shall permit otherwise. Any damage to the work due to the Contractor's operation shall be repaired at the expenses of the Contractor.

The Contractor shall be solely responsible for the safety and stability of the excavation and shall provide all protective supports, bracing, sheet piles, shoring etc. as required. Shoring should be adequate to provide enough safety to all the adjacent structures and land.

Excavated materials, classified as suitable for fill, shall be stockpiled. Waste materials and suitable fill materials in excess of requirement, shall be disposed of by the Contractor outside the limits of the site.

The foundation material shall be cleared of all loose and displaced materials and cut to a firm surface, either leveled, stepped or serrated, as specified or shown on the Drawing or directed by the Engineer leaving a smooth solid bed to receive foundation.

No footing, bedding material or structure shall be placed on any foundation until the Engineer has inspected and approved the depth of excavation and the foundation materials.

Poor foundation material

When, in the opinion of the Engineer, the bottom of any excavated foundation is of soft or otherwise unsuitable material, the Contractor shall remove the unsuitable material and fill with sand or blinding concrete at the direction of the Engineer. The sand or concrete shall be placed following the procedures specified for back-filling. Sand shall be clear, all passing a No.4 sieve (U.S. size).

When the ground between the piles is too soft to support the green concrete, the Contractor shall submit his proposal for a bottom form to the Engineer for his approval. Extra excavation and foundation-fill or concrete-fill in such case will not be paid separately.

If the bottom form is carried out by such strengthening of the ground, the Contractor shall, if requested, submit calculations showing that the pile cap will not be harmed during hardening due to differential settlements between the piles and the strengthened ground.

Disposal of excavated material

All excavated materials, so far accepted by the Engineer as suitable, shall be utilized as back-fill or embankment- fill. The surplus materials shall be termed as waste.

Excavated materials, suitable for use as back-fill, shall be deposited by the Contractor in spoil heaps at points convenient for re-handling of the materials during the back-filling operations.

Excavated materials shall be deposited in such places and in such a manner as not to cause damage to roads, services or properties either within or outside the project area and so as to cause no impediment to the drainage of the site or surrounding areas. The location of spoil heaps shall be subject to the approval of the Engineer.

Waste materials shall be disposed of in accordance with the instruction of the Engineer.

Pumping and bailing

The foundation shall be kept free from water at all times during the construction period. The ground water level shall be maintained at a minimum of 0.9m below the lowest designed excavation level.

Pumping and bailing from any foundation shall be done so as to preclude the possibility of the movement of water through or alongside any concrete being placed. No pumping or bailing will be permitted during the placing of concrete and for at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall or from well points.

The Contractor shall be solely responsible and include in his rates all costs in designing the de-watering system, providing all equipment and accessories required for de-watering. The rates shall also include cost for transportation, furnishing, installation, safe operation and maintaining of the system including operators, mechanics, the supply of power, fuel, lubricants, spares, repairing, etc. throughout and the removal of the equipment at the end of the construction period under this Contract.

Excavations shall be as dry as possible prior to and during placing concrete. Concrete, placing under water will only be permitted if indicated on the Drawings or approved by the Engineer.

Back-filling

All excavated spaces shall be back-filled around the permanent structure to original ground level. Prior to placing back-fill, all trash, metal, debris, lumber, bricks, soft materials and similar objectionable foreign materials shall be removed from the area to be back-filled. No back-fill shall be placed against any structure without the prior permission of the Engineer.

Any protective support, bracing or shoring shall be removed, as the back-filling progresses in such a manner as to prevent caving-in.

Back-fill shall be of approved materials that will produce a dense and well-compacted filling. The material shall be free from large lumps, organic or extraneous materials.

Ordinary fill placed as back-fill shall be laid and compacted. The moisture content of the fill materials, before compaction, shall be within + 5% of the Optimum Moisture Content. Each layer of materials shall be compacted uniformly using approved compaction equipment and procedures. The materials shall be compacted to achieve not less than 90% Maximum Dry Density beneath the bottom level. The dry density, after compaction within 300mm below the top level, shall not be less than 95% Maximum Dry Density as determined in accordance with STP and soaked CBR (4 days) should be greater than 4% at 95% Maximum Dry Density (STD). The compacted layer shall be approved by the Engineer before the Contractor can commence a new layer.

Sand back-fill shall be placed and thoroughly compacted in layers of not more than 150mm. Sand should be clear, all passing a No. 4 U.S. Standard Sieve and conforming generally to ASTM C 144 for fine aggregate with F.M. not less than 1.2 or as required by the Engineer.

Layers of filling shall be tested as directed by the Engineer. Each compacted layer shall not be covered until the Engineer is satisfied that the specified degree of compaction has been achieved.

In placing back-fill, the material shall be placed, in as far as possible, to approximately the same height on each side of the structure. If conditions require appreciable higher back-filling on one side, the additional material shall not be placed until permission is given by the Engineer on being satisfied by himself that the structure has enough strength to withstand any created pressure.

In general, no structure shall be subject to the pressure of back-filling until 3 (three) days on expiry of the period designated for removal of forms. This period shall be extended if subnormal curing conditions exist.

Adequate provisions shall be made for drainage during back-filling.

Cofferdams

The term “cofferdam” denotes any temporary or removable structure, constructed to hold the surrounding earth, water or both, out of the excavation whether such structure is constructed of earth, timber, steel, concrete or any combination of these. The term includes earth dikes, timber cribs, sheet piling, removable steel shells and all bracing and it shall be understood to include excavation enclosed by pumping wells and well points.

Cofferdams shall be constructed so as to control water to preclude sliding and caving-in of the walls of the excavation.

The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction and removal of any required forms and the inspection of the interior and to permit pumping.

If possible, cofferdams shall be so designed that no cross bracing shall be left in place. If this is not possible, bracing left in place shall be of structural steel. The end of such structural members that would be exposed when the structure is completed shall be boxed back at least 50mm behind the face. The resulting holes shall be completely filled with concrete.

In general, sheet-piling cofferdams shall extend well below the bottom of the footings and shall be well braced and made maximum watertight.

When conditions are encountered which, in the opinion of the Engineer, render it impossible to de-water the foundation before placing of brickwork or concrete, the Engineer may require the construction of a concrete foundation or seal. This shall be placed as directed by the Engineer. The foundation shall then be de-watered and the footing placed.

When foundation piles are to be driven inside a cofferdam and it is judged impossible to de-water the cofferdam before placing concrete, the excavation may be extended below the design level to a depth sufficient to allow for swell of the material during pile driving operations. Any materials that rise above the design level shall be removed.

Where it is possible to de-water the cofferdam, the foundation material shall be removed to exact grade after the foundation piles are driven.

The natural stream bed adjacent to the cofferdam shall not be disturbed without the permission of the Engineer. Any excavation adjacent to the cofferdam shall be back-filled to the original ground level to the satisfaction of the Engineer.

Unless otherwise provided, cofferdams shall be removed on completion of the structure without disturbing or marring the finished work. The Engineer may order the Contractor to leave any part or the whole of the cofferdam in place and this shall not entitle the Contractor to claim for any additional payment.

The Contractor shall submit Drawings showing his proposed methods of cofferdam construction. However, the Contractor shall remain fully responsible for the adequacy of the design for strength and stability and for the safety of the people working therein.

6.4 Measurement

The volume of excavation and back-fill shall be measured in cubic meter of excavated materials.

The quantity of excavation for structures to be measured for payment shall include excavation for all structures. The measured volume shall be bounded on the bottom by the plane of the bottom of the footing and on the top by the surface of the existing ground and on the sides by vertical planes of the footings.

Backfilling with previously excavated material shall not be measured or paid separately but shall be deemed included within the rate for excavation.

Volumes to be excavated for blinding concrete shall not be measured and the price for the excavation thereof shall be included in the above measured item for excavation and back-fill.

Back-fill with concrete or sand, where directed by the Engineer, including concrete seals shall be measured separately as the volume within the plan outline and top and bottom surfaces. Concrete or sand, placed to back-fill excavation beyond the excavation required, will not be measured for payment.

If sand fill is ordered over top level of pile cap, the fill shall be the specified filling volume measured on the Drawings up to the profiles agreed upon in writing by the Engineer.

In the case of structures for which a lump sum price is called for, the volume of excavation as stated above for the work as shown on the Contract Drawings shall be subtracted from the volume measured as above, and the price to be paid or deducted shall be based on the measured increase or reduction of the excavation shown on the Drawings.

Removal of cofferdams, cave-ins, silting or filling shall neither be measured nor paid for.

6.5 Payment

The work measured shall be paid for at the Contract unit prices per cubic meter as shown in the Bill of Quantities. The payment shall be the full compensation for all excavations and back-filling for structures including supply of all materials, labour, equipment, tools and incidentals necessary to the successful completion of the work. The payment shall also be the full compensation for excavation and subsequent back-filling of working space around the foundation structure for shoring and other protective supports, for construction and removal of cofferdams, for de-watering and for disposal of surplus excavated materials by hauling to any distance at approved locations.

Should it be necessary, in the opinion of the Engineer, to lower the footings to an elevation below the level shown on the Drawings, payment for the excavation and backfill for structures required below plan level down to and including an elevation 1.5m below plan level for any individual footing will be made at a unit price equal to 115% of the Contract unit price, and payment for the excavation from an elevation greater than 1.5m below plan level down to and including an elevation 3m below plan level will be made at a unit price equal to 125% of the Contract unit price for "Excavation and Back-filling for Structures". No additional extra compensation will be allowed for any required cofferdam adjustments arising from such lowering of footings.

In case where the extra depth required for any footing or footings exceeds 3m, a supplementary agreement shall be made covering the quantities recovered from depths in excess of 3m below the plan grade.

Payment for back-filling shall be included in the pay item for "Excavation and Back fill for Structures" except for sand fill and concrete fill. These fill types shall be measured as provided above and paid for at the concerned Contract unit prices, but no compensation in the pay item "Excavation and Back-filling for Structures" shall be made for less back filling with excavated materials or more surplus to waste.

All payment for the back-filling and compaction of those areas, which were removed as structural excavation shall be included in the appropriate unit rates below.

Cofferdams for structures without excavation, for example for pile caps over water, shall be deemed to be included in the unit prices for the concerned pile cap.

Item of payment

	Unit
Excavation and back-fill for structures	Cubic Meter
Concrete back-fill for structures	Cubic Meter
Sand back-fill for structures	Cubic Meter

7. DE-WATERING SYSTEM

7.1 Types of De-watering System

One or both of the following de-watering systems shall be adopted considering the actual field conditions and requirements for proper execution of work.

- De-watering by Sub-surface Water Control System
- De-watering by Surface Water Control System

7.2 Contractor's Responsibilities

The Contractor shall be solely responsible and include in his rates for the following tasks:

- The design of the de-watering system including the collection of the requisite data, preparation of Plans and Drawings of the necessary de-watering system.
- Providing all equipment and accessories required for de-watering by the Surface Water Control System and Sub-surface Water Control System for satisfactory execution of the work.
- Transportation, furnishing, installation, safe operation and maintaining of the system including operators, mechanics, supply of power, fuel, lubricants, spares, repairing, etc. throughout and the removal of the equipment at the end of the construction period under this Contract.

The Contractor shall provide continuous supervision of the system by the persons competent to recognize adverse conditions as they develop and take immediate corrective measures. The supervisor whose name and hours of duty duly furnished to the Engineer by the Contractor, shall have thorough knowledge of the system including the ability to make minor emergency repairs.

The control of water throughout the time of this Contract shall be the full responsibilities of the Contractor. The ground water table shall be maintained at minimum of 0.9m below the lowest designed excavation level. Control methods shall be subject to the approval of the Engineer including the Contractor's equipment, plans, methods, installation and operation procedures, etc.

The control methods adopted by the Contractor shall be subject to the approval of the Engineer including equipment, plans, methods, installation, operation, monitoring, maintenance procedures and precautions against the failure of any part of the system. The precautions shall include sufficient standby pumping plant and essential spare parts. The standby pumping plant shall comprise at least one pump and the standby pumping capacity shall be at least 10% of the total working capacity.

7.3 Site Information

Any sub-soil investigation conducted by the LGED will be made available for the Contractor's review. The LGED assumes no responsibility regarding the correctness of these data. It is the responsibility of the Contractor to verify all sub-surface conditions prior to submitting his tender.

7.4 De-watering by Sub-surface Water Control System

General

De-watering by Sub-surface Water Control System is defined as controlling water accumulated from any source requiring the use of well point or tube-well system

Works to be performed under this Section include furnishing, installing, maintaining, operating and removing the sub-surface water control system including observation wells, so that the required excavation can be safely and properly performed and the structure built and back-filled to the elevation as shown on the Drawings.

Pre-cautionary measures

Excavation shall not be made below a level 1m above the ground water level shown to exist by the water level in the observation wells. If the distance to the ground water table becomes less than 1m or the Engineer has any reason to believe that rising ground water is likely to endanger either the open excavation or the structure, back-filling may be ordered by the Engineer as a precaution against failure.

If for any reason, ground water control is lost and ground water appears in any portion of the excavation, the Contractor shall take immediate action to control and confine the flow. Any portion of the final grade which, in the opinion of the Engineer, has been damaged by the action of the ground water shall be excavated as directed by the Engineer and back-filled in accordance with the Specifications at no extra cost to the Contract.

If it becomes necessary for any reason to stop the sub-surface de-watering operations before the construction of sub-structure is complete, the Engineer may order the site to be flooded up to the surrounding ground water level as de-watering is discontinued. Under no circumstance shall the site be flooded by allowing the ground water to rise through the soil. If it becomes necessary to flood the site as described above, all equipment that can be damaged shall be removed to safety/a safe place.

The cost of all such back-filling, flooding and subsequent draining and re-excavation shall be included in the lump sum price for de-watering and no extra payment beyond the Contract price will be allowed.

Operation

The sub-surface De-watering System shall be operated 24 hours of a day on all days of a week during the period that de-watering is required. The Contractor shall take prior precautions against failure of any part of the system.

Monitoring wells

Observation wells of 40mm diameter GI pipes with 1.25m long wire mesh strainer and full filters shall be installed by the Contractor to suitably monitor the ground water levels maintained by the Contractor's de-watering system. The depth of wells shall be a minimum of 3m below the lowest level of the foundation excavation. The Contractor shall provide a secured means for blocking access to the observation wells and shall maintain a log book with daily readings of sub-soil water levels recorded every three hours, which shall be made available at all times for inspection. The logbook shall be periodically checked and authenticated by the Engineer's Representative.

Removal of system

The de-watering system shall be removed when the construction has progressed to a stage that site de-watering is no longer required; but only after receiving a written permission from the Engineer. Certain portions of the Contractor's de-watering system may be left in the ground when construction procedures will so require and when written permission of the Engineer is obtained. Any such portion of the de-watering system shall be plugged, capped and/or otherwise rendered harmless to the Work and the public.

7.5 De-watering by Surface Water Control System**General**

Evacuation of surface water is defined as controlling surface water levels within the ring bunds by use of pumps, sump pump, gravel drain or other mechanical devices; but without requiring the use of a well point or tube well system. Such water may accumulate from percolation, rain or pumping floodwater into the area or any other source or combination of sources. The water level inside the ring bunds shall not exceed the level as directed by the Engineer.

Work to be performed under this Sub-section include furnishing, installing, maintaining, operating and removal of the surface water control system for de-watering the accumulated water from the area within the ring bunds so that the desired construction can safely and properly be performed. The discharge line or the drainage system for the disposal of the evacuated water shall be constructed by

the Contractor at his own costs in accordance with the approved Drawing along with the arrangement of private land, if needed.

Operation of de-watering system

The Contractor shall make all arrangements for pumps, fuel, lubricants, maintenance and operation of the equipment and the whole Surface De-watering System and shall take precautions in advance against failure of any part of the system.

Removal of system

The Surface De-watering System shall be removed upon obtaining written permission from the Engineer when the construction has progressed at a stage that site de-watering is no longer required.

7.6 Measurement

The work shall be measured for payment as an item on a lump sum basis as specified in the Schedule of Items.

7.7 Payment

Payment shall only be admissible on implementation of the items of the BOQ and on the basis of the Engineer certifying that the work was necessary and implemented for the proper execution of construction work satisfying all specifications described above. Payment shall be made at Lump Sum rate as quoted in the Contract. The rate shall cover the full compensation for all measures including the cost of labour, equipment, materials, tools required for this purpose and other incidentals necessary to complete the work as accepted by the Engineer.

Item of payment

	Unit
Pumping and bailing out water/De-watering of work Site	Lump sum

8. EARTHEN RING/CROSS BUNDH

8.1 Description

This Work shall consist of construction of the earthen Ring/Cross Bundh by furnishing, placing, compacting and shaping with suitable fill in accordance with the specifications and direction of the Engineer including palisading. The earthen Ring/Cross Bundh shall be maintained in proper condition by the Contractor until the completion of work for which this temporary structure has been constructed.

8.2 Construction Method

The work of this temporary structure shall be carried out with adequate height as instructed by the Engineer to protect the permanent Work and shall provide required clearance around the permanent structure.

The Contractor shall submit, upon request, Drawings showing his proposed method of construction of the earthen Ring/Cross Bundh. Approval of the Drawings shall not, in anyway, relieve the Contractor of his responsibilities for the adequacy of the design for strength and stability of this temporary structure and for the safety of the people working therein.

The interior dimensions of the Ring Bundh shall be such as to give sufficient clearance for the construction work of the permanent structure, the inspection of the interior and to permit the pumping.

In constructing the earthen Ring Bundh, palisading wall shall be erected on both sides with bullah/ bamboo posts/pins walling with double Tarja mat or bitumen drum sheets forming an enclosed area for filling earth. The local soil, which will meet the requisite criteria shall be arranged by the Contractor from the locality, carried to the site and to be filled inside the enclosed area with manual compaction layer by layer. When necessary, bailing out water shall be carried out by the Contractor through pumping with pumps or by any other appropriate methods.

The temporary earthen Ring/Cross Bundh shall be removed on completion of the permanent structure. The removal of this temporary structure shall be effected in such a manner as not to disturb the finished permanent work. The Engineer may order the Contractor to leave any part or the whole of the earthen Ring/Cross Bundh in place and this shall not entitle the Contractor to any additional payment.

The responsibility shall remain with the Contractor to keep the enclosed area at the level of the foundation bottom of the permanent structure dry by ensuring all arrangements to prevent percolation of water from the surroundings during the construction of the permanent structure for a period as required by the Engineer.

8.3 Measurement

The work shall be measured for payment as an item on a lump sum basis as specified Schedule of Items and in the BOQ.

8.4 Payment

The payment shall be made for the completed work which shall include the design, construction, maintenance of the temporary structures until the completion of work for which the temporary structures are made and removal of this temporary structure on completion of the Work or as directed by the Engineer. This item shall include the full compensation for the cost of all labour; arranging, carrying and dumping of the full quantity of earth or sand or any other fill as required by the work; shoring, sheeting, palisading and cost of all materials, tools, equipment and all incidentals necessary to complete the work as per specifications contained in this Sub-section and acceptance of the Engineer.

Item of payment

	Unit
Earthen Ring/Cross Bundh	Lump sum

9. WATER PROOFING POLYTHENE SHEET

9.1 Description

The work covered under this item shall consist of supplying and laying in place one layer of 0.18mm thick polythene sheets in accordance with the applicable plans, schedules and these specifications.

9.2 Construction Requirement

The sheets shall be laid covering the entire inside area under the Cement Concrete or for any other purpose as desired by the Engineer. Before laying the sheets, the surface shall be cleaned to give a surface free from damage, tear or other imperfections and shall be laid such that there is a minimum of 225mm overlap of the adjacent strips.

9.3 Measurement

Measurement for payment shall be made in square meter of area covered by the sheets. No allowance shall be made for overlaps.

9.4 Payment

The amount of completed and accepted work measured as provided above shall be made at the Contract unit price per square meter and the payment shall constitute full compensation for furnishing all materials, equipment including their storage, handling and transport and all labours, cleaning, preparing, cutting, laying, fixing and all incidentals necessary to complete the work as per specifications contained in this Sub-section and acceptance of the Engineer.

Item of payment

	Unit
Supplying and laying polythene sheet	Square meter

10. SUB-SOIL BORING AND TESTING

10.1 General

Confirmatory Sub-Soil investigation shall be carried out at the actual locations of each foundation. In order to ascertain the actual soil strata at the location, the engineering properties at each stratum and to ascertain the level at which the foundation can be laid. The investigation shall be carried out as per the following specifications and as directed by the Engineer.

10.2 Boring

Boring shall be carried out in accordance with the specifications of ASTM D 1586 and D 1587. The bore holes shall have a minimum diameter of 100mm and shall be lined throughout. Minimum depths shall be 20m unless otherwise directed by the Engineer. The toe of the lining shall at no time be more than 1m above the level to which the soil has been removed from the bore hole.

Before taking any undisturbed sample or making any in-situ test, the lining shall be carried down to the bottom of the bore hole at the test depth.

Auger of proper size shall be used in very soft to soft clays and silts to avoid suction. The use of shell shall only be restricted to moderately stiff to very stiff and hard clays and also in sandy strata below water table. The use of a chisel would be permitted only in case of boulder or rock formation or through local obstructions or other situation demanding its use as would be decided by the Engineer.

Uncased bore holes may be permitted only up to a depth where the sides of the hole can stand unsupported. In case of side fall or squeezing, steps shall be taken immediately to stabilize the sides of the bore hole by casing pipes as directed by the Engineer. Use of Bentonite slurry of 5% concentration may be permitted to stabilize the bore hole.

No water shall be added while boring through cohesive soils and non-cohesive soils above the water table. While boring through non-cohesive soil below water table, water level in the casing shall always be maintained at or above the water table.

The cutting brought up by the auger shell or the split-spoon or undisturbed sampler shall be carefully examined and the soil description duly recorded after performing field identification tests.

On completion of boring at any bore hole, a bore log shall be prepared in an approved standard format in consultation with the Engineer and submitted to the Engineer in triplicate. Position of the water table shall be observed after 24 hours and back filling of the bore hole shall be carried out with approved materials in a manner as directed by the Engineer.

10.3 Disturbed Samples

Disturbed samples shall be taken from bore hole cuttings and split-spoon for visual classification tests at the site. The samples shall be taken at 1.5m interval or at every identifiable change of strata, whichever is met earlier to give a reliable record of the variation in the conditions of the soils. Disturbed samples shall be sent to the laboratory in airtight plastic container with proper label for the purpose of record and laboratory testing.

10.4 Undisturbed Samples

Undisturbed samples from cohesive soil layers shall be taken from the bore holes at an interval of 1.5m.

Size of the thin walled sampler should be such that a sample having a minimum size of 50mm diameter and 900mm length can be recovered. The sampler shall be pushed strictly by jacking in soft to firm deposit and no hammering shall be allowed. Where this is not possible, the sampler may be driven in the blows of a monkey having sufficient weight. Area ratio of all samplers shall be limited to

10% for soft to firm cohesive deposit and use of thick walled samplers may be permitted in case of deposits of very high consistency subject to the approval of the Engineer. Recovery ratio shall be observed and reported in the bore-logs for every sample. The top and bottom of a sample must be indicated clearly on the sample tube to facilitate the laboratory testing in proper orientation.

10.5 Handling and labeling of Samples

The following conditions of handling and protection of undisturbed samples shall be undertaken on undisturbed sample.

- Immediately after being taken from the bore hole, the ends of the sample shall be cut and removed to a depth of about 2.5cm (or more in the top to cover any obviously disturbed soil). Several layers of molten wax should then be applied to each end to give a plug about 2.5cm thick. If the sample is very porous, a layer of waxed paper should first be placed over the ends of the sample.

Any space left between the end of the sample tube and the top of the wax should be tightly packed with saw dust or other suitable materials and a close fitting lid or screwed cap shall be placed on each end of the sample tube.

The lids should, if necessary, be held in position by adhesive tape.

- A label bearing the number of the sample, bore hole no, depth of sample, date, etc. preferably typed, shall be placed inside the container just under the lid. It shall be placed at the top of the sample. In addition, the number of the sample shall be painted on the outside of the container and the top or bottom of the sample shall be indicated.
- Undisturbed soil sample tubes shall be placed in a strong wooden box and packed with moist saw dust, paper, etc. to prevent damage during dispatch to the laboratory.

10.6 Standard Penetration Test

Standard penetration test shall be conducted as per ASTM D 1586 at an interval of 1.5m or at every identifiable change of strata, whichever is earlier.

The driving of split-spoon shall be recorded for every 150mm penetration till the total penetration is 450mm.

Driving of the split-spoon shall be terminated when standard penetration resistance value, $N > 100$ blows/30cm of penetration is received, unless otherwise directed by the Engineer. The test shall be conducted after driving the casing to the bottom of the bore hole and after cleaning it. N-values, as observed in the field, shall be reported in the bore logs without any correction.

10.7 Dispatch of Samples

Samples shall be dispatched to the laboratory as soon as possible after being obtained and shall not be allowed to accumulate at site. In the event a danger of sample's deterioration through further storage is noticed, the Contractor shall dispatch such samples immediately on receiving direction from the Engineer.

10.8 Laboratory Tests

General

Laboratory tests shall be carried out as per relevant ASTM or BS Procedures. The results of all tests shall be submitted in the format as approved by the Engineer.

Preparation of the test specimens

Preparation of test specimens for the various tests shall be carried out as per the procedures laid down in the various relevant ASTM or BS Codes.

In case of soft to firm cohesive undisturbed soil samples, test samples for all types of shear tests shall be prepared strictly by hand trimming on soil lathe. Care shall be taken against bending of soil samples at the time of horizontal ejection of the samples from the sampling tubes. Samples shall be ejected from the sampling tubes preferably in the same direction of travel in which the samples entered the sampling tubes.

Similarly test specimens for consolidation tests shall also be prepared to the required size by hand trimming only and the ring of the consolidation apparatus shall be inserted by pressing gently with the hands and carefully removing the material around the ring. In no case the ring should be forced into the soil. Great cares shall be taken during trimming of the sample from the top and the bottom of the ring. The test specimen shall be prepared in the same orientation as that to the actual strata so that the laboratory test load compresses the soil in the same direction relative to the soil strata as the applied load in the field.

Unconfined compression test

Unconfined compression test shall be conducted both on natural and remoulded soil samples. Remoulded soil specimen shall be prepared by the dynamic method of compaction.

Each unconfined compression test (natural or remoulded) shall comprise tests on minimum of three soil specimens, not less than 30mm diameter and a height to diameter ratio of 2 together with the determination of natural moisture content and density. Water content of the specimen shall be taken from the failure zone of the specimen. Test results shall be observed and reported as per the standard practice.

Triaxial test

Triaxial test shall be conducted on the undisturbed samples selected by the Engineer. Each test shall be conducted on a minimum of three specimens tested at different cell pressures (0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm²). The moisture content before and after the test and the density shall be determined.

The stress-strain diagrams as well as the Mohr circle envelop for these tests shall be submitted.

Consolidation test

Consolidation tests shall be conducted on undisturbed samples selected by the Engineer. The coefficient of consolidation (Cv.), the coefficient of volume compressibility (Mv.), Laboratory Compression Index (Ccl.), Field Compression Index (Ccf.) including field virgin slope and the coefficient of permeability (k) shall be determined and results shall be submitted.

The loading on the test specimens shall be applied at the stages of 0.1 kg/cm², 0.25 kg/cm², 0.5 kg/cm², 1.0 kg/cm², 2.0 kg/cm², 4.0 kg/cm² and 8.0 kg/cm².

Unloading of the test specimens shall be done at suitable stages.

Routine test

All routine tests like natural moisture content, bulk density, liquid and plastic limits, grain size distribution, specific gravity, shall be conducted on selected representative samples as directed by the Engineer.

Report and records

On completion of each bore hole, three copies of a bore hole log shall be submitted to the Engineer together with one copy of the list of disturbed and undisturbed samples taken from the bore hole.

These bore logs shall show:

1. Ground level referred to the reduced level.
2. Locations of the bore holes on a plan.
3. Detailed description of each stratum.
4. Position, type and identification of each sample and SPT value.
5. Any other site test results available.
6. Levels at which each separate ground water level is first encountered and at which it comes to rest (standing water level).

On completion of all field and laboratory tests, all results shall be submitted to the Engineer in 3 (three) copies in the form of reports with comments and views.

10.9 Measurement

The work will be measured for payment as an item on a lump sum basis as specified in the Schedule of Items and BOQ.

10.10 Payment

Payment shall only be admissible on completion of the item as measured and provided above and on being certified by the Engineer that the investigations have been carried out as per specifications as contained herein. Payment shall be made as lump sum rate, which shall cover the full costs of boring, collection and dispatch of samples, standard penetration test and all necessary Laboratory tests, preparation and submission of records, cost of all labour, equipment, materials, tools, test fees and all incidentals required for undertaking the test and submission of requisite reports to the Engineer. No payment shall be made until the testing results and other information in the form of reports with requisite number of copies are submitted to the Engineer.

Item of payment

	Unit
Sub-soil investigation	Lump sum

11. BORED CAST IN SITU PILES

11.1 Description

This work shall comprise of boring and construction of bored cast in place piles for foundation of the bridge structures. The item includes the provisions of all labour, materials, equipment, boring and all incidentals necessary to complete the work in accordance with these Specifications, in conformity with the requirements of the Drawings, as required in the other places of the Contract Document and/or as per direction of the Engineer.

Piles through the water and soft upper soil layers shall be provided with permanent steel casing, if shown on the Drawings.

Under certain circumstances the Contractor may be permitted to bore all or part of the pile without casing under water or using drilling fluid to stabilize the bore hole.

Concrete and reinforcement of the piles shall be strong enough to resist pile loads and horizontal forces on the pile caps.

11.2 Accessories

Steel casing

Temporary steel casing

Temporary steel casing pipe of required diameter shall be used at least for the upper 6m from the ground level during drilling to stabilize the hole. The casing pipe shall be fabricated to the specified size and shape from mild steel. It shall be smooth, clean, water tight and sufficiently strong to

withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. It shall be free from significant distortion and shall have uniform cross-section throughout each continuous length. Size of the shaft shall be less than the inside diameter of the casing. However, it shall not be less than 10mm. During pouring of concrete, it shall be free from internal projections and encrusted concrete, which might prevent the proper formation of piles.

Permanent steel casing

The steel of the permanent steel casing shall conform to the ASTM A 36 or approved equivalent having sufficient strength and rigidity to prevent distortion by soil pressure or for drilling of adjacent piles.

Minimum wall thickness of the permanent steel casing shall be 6mm. Minimum length shall be from 100mm above the bottom of the pile cap to 5m inside the ground or into firm strata or as shown on the Drawings or as directed by the Engineer. If the permanent casing is used in the boring operation or if the handling and transport require a greater thickness to avoid deformation or buckling, the increase in thickness shall be provided by the Contractor at his own expenses.

The steel casing shall be furnished in appropriate length and the joints shall be approved by the Engineer.

Casing pipes may be transported to the site at suitable lengths in pieces and shall be welded as per specifications to fabricate the designed length. The casing shall be handled and stored in a manner that shall prevent buckling and other deformation as well as accumulation of dirt, oil and paint. When placed in the work, it shall be free from dirt, oil, grease, paint, mill scale and loose or thick rust or any deleterious substance that may affect the concrete.

The outside surface of the permanent casing of piles to river piers, for a maximum depth of 5m from the underside of the pile cap, shall receive two coats of anti-corrosive Tar type paint. The paint shall be approved by the Engineer and its application shall follow the manufacturer's instructions.

Tremie pipe

A Tremie shall consist of a steel tube having a diameter of not less than 200mm, sufficiently long to reach the bed of water keeping its one end above the water level, constructed in sections having flanged couplings fitted with gaskets. The tube shall be fitted with a hopper at its upper end for pouring concrete inside the tube. The Tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work so as to permit rapid lowering when necessary to retard or stop the flow of concrete.

11.3 Materials

Concrete

The concrete for bored cast-in-place piles shall conform all requirements as described under the Section on 'Concrete Work' of this Specification. Cement Type 1 shall be used and the characteristic cylinder strength shall not be less than 30 N/mm² or as shown on the Drawings.

Concrete placed under water or drilling mud by Tremie shall have cement content of not less than 370 kg/m³.

The density and consistency of the concrete shall conform to the Tremie Casting Method. Sufficient workability (slump) of all concrete shall be maintained during the casting and casing handling period. Reasonable calculated delays shall be secured by a design mix (including the necessary retarders and plasticisers) which is tested by trial mixes prior to the pile construction.

All relevant concrete properties such as slump, time of setting, temperature and strength shall be measured on the trial mixes.

Reinforcement

Reinforcement bar and binding wires used in the construction of bored cast-in-place piles shall conform to the requirements stated under the Sub-section on 'Reinforcement for RCC' of these Specifications.

Welding electrodes

Where welding is specified for fabrication of the reinforcement, the electrodes shall conform to the American Welding Society (AWS) Standards and shall be of the size and classification number recommended by the manufacturer.

Drilling fluid

The following instructions shall be complied with, if Bentonite mud is used to stabilize the bore hole:

➤ Supply

Bentonite, if required and supplied at the Site shall be in accordance with the specifications conforming to DFCP 4 of the Oil Companies Materials Associations.

The Contractor shall obtain a certificate from the manufacturer of the Bentonite powder showing the properties of the consignment delivered at the site. This certificate shall be made available to the Engineer on request. The properties to be given by the manufacturer are the apparent viscosity range and the gel strength range for solids in water.

Any other materials for the drilling fluid shall receive approval from the Engineer.

➤ Mixing

Bentonite and any other materials shall be mixed thoroughly with clean water to make a suspension, which shall maintain the stability of the pile excavation for a period, necessary to pour concrete and complete construction. Where saline or chemically contaminated groundwater occurs, special precautions shall be taken to modify the Bentonite in fresh water so as to render it suitable in all respect for the construction of piles.

➤ Tests

The frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor and approved by the Engineer prior to the commencement of the work. The frequency may subsequently be varied as required depending upon the consistency of the results obtained. The control tests shall cover the determination of density, viscosity, gel strength and pH values.

For average soil conditions, the results shall generally be within the ranges stated in the Table shown below. The tests shall be carried out until a consistent working pattern has been established.

Property to be measured	Range of Results at 20°C	Test Method
Density	1.03 – 1.1 g/ml	Mud density balance
Viscosity	30-90s or less than 20 cP	Marsh cone method Fann viscometer
Shear strength (10 minute gel strength)	1.4 - 10.0 N/m ² or 4.0 – 40.0 N/ m ²	Shearometer Fann Viscometer
pH value	9.5 – 12.0	pH indicator paper strips or electrical pH meter

The Contractor shall supply all equipment and engage experienced operators required for carrying out tests on the drilling mud. No additional payment shall be made to the Contractor for these tests, which shall be considered as an essential part of the drilling operations.

11.4 Construction Method

General

➤ Preparation

Before starting drilling operation, the Contractor shall plan the sequence and stages of operation for different piles and establish levels, grades and alignment of all piles with reference to Bench Marks (BM) previously established at site. The Contractor shall have all casing pipes and reinforcing bars fabricated as per design and shall be ready for lowering the pipes on completion of drilling. All necessary equipment such as pump, welding set, etc. and materials for concrete work including Tremie pipe shall be made available before the start of drilling operation.

➤ Drilling

The Engineer shall approve the drilling method and the equipment to be used for this purpose. The Contractor shall prepare all suitable cofferdam/artificial island/staging or any other approved means, if required, for the drilling operation and pouring concrete of the piles in water. Bentonite slurry, if required, shall be used to stabilize the hole.

➤ Pile cluster

Where there are more than 4 (four) piles in a cluster, the centre pile shall be installed first. All piles in a cluster shall be of the same depth.

➤ Obstruction during drilling

When obstructions make it extremely difficult to drill certain holes in the location shown and upto the proper bearing strata, the Contractor shall take all usual methods to install piles as required including jetting, cutting, drilling or other feasible means. If in the judgment of the Engineer the Contractor is unable to complete properly any pile by resorting to such methods, the Engineer may order for an additional hole drilled at another selected location at the Contractor's own expenses.

➤ Depth of hole

The depth of hole shall be checked by the Engineer by lowering suitable drop to determine the length of pile. Immediately after approval of the bore, the steel casing pipe shall be installed up to the design depth, if provided in the BOQ and then the reinforcement cage shall be lowered.

Pile type and construction methods shall ascertain that the pile shaft shall not be weakened by contamination of the concrete, by sectional reduction, by washing out of cement, by breaking during pulling of temporary casings or by any other way including construction of neighbouring piles.

Assumed procedure

The following construction procedures shall be assumed in the Design. The Engineer shall approve the final construction procedures or any subsequent modification prior to commencing piling operations.

- If required, placing the permanent steel casing in position and embedding the casing toe in to the firm strata. If no permanent steel casing is specified, a sufficient length of temporary steel casing shall be used to stabilize the upper part of the bore hole.
- Boring and excavating the inside of the steel casing down to the casing toe level or to a level approved. Excavating up to the final pile tip level using either temporary casing under water or using drilling mud. Water level inside the casings shall, at all times, be at least 2m higher than the outside of the casings.
- Cleaning carefully all mud or sediments from the bottom of the bore hole.
- Placing reinforcement cage, inspecting pipes, etc.

- Pouring concrete continuously under water or drilling fluid following the Tremie method.
- Withdrawing the temporary casing concurrently with pouring of concrete up to the instructed level.
- Breaking the top section of the concrete pile after hardening in order to reach sound concrete.

Approval of construction method

In the Tender, the Contractor shall describe his proposed construction methods, which shall include information on boring equipment, materials, methods of work, quality control and bearing capacity and also the name of the Sub-contractor, if any. The Contractor shall submit references from similar jobs carried out by him or by the Sub-contractor.

Prior to making Contract, the Contractor shall submit all requested supplementary information in writing.

After the Contract has been awarded to the Contractor, he shall prepare a detailed programme and establish a procedure for the pile construction in accordance with the above information.

The detailed programme shall contain all information as requested on materials, equipment, methods of work, etc. and be approved in writing by the Engineer. Such approval shall not relieve the Contractor of his full responsibilities for the entire pile construction.

No boring equipment or material shall be imported at Site before the Contractor has received the approval of the Engineer as stated above.

Setting out piles

Before starting drilling operation the Contractor shall plan the sequence and stages of operation for different piles and establish levels, grades and alignment of all piles with reference to Bench Marks, previously established at Site. The Contractor shall have all casing pipes and reinforcing bars fabricated as per design and ready for lowering on completion of drilling. All necessary equipment and materials for concrete work including Tremie pipe shall be made available before the start of drilling operation.

The positions of the piles shall be set out in accordance with the Drawings from established Bench Mark. The position of each pile shall be approved by the Engineer before drilling commences.

Where there are more than four piles within a cluster, the center pile shall be constructed first. No concrete shall be placed until all drilling within a radius of 2.5m has been completed. If this is not possible, no drilling shall be done within 2.5m radius of a cast-in-situ pile until the concrete has set for at least four days after pouring.

Diameter of piles

The diameter of a pile shall be not less than the specified diameter.

Tolerances

Bores shall be accurately drilled in the locations as shown on the Drawings. All piles shall be drilled with a lateral tolerance of not more than 75mm from the point specified. Pile that deviates by more than 75mm in lateral location or pile whose slope deviate from the vertical by more than 2%, shall be rejected. Additional piles shall then be furnished and installed by the Contractor in such locations as the Engineer may direct. The Contractor shall provide suitable equipment, such as an inverted pendulum, to check the verticality of the bore holes at intervals during drilling and prior to pouring concrete. All costs for such additional piles as required to suit the changed pile locations, shall be borne by the Contractor at his own costs.

Boring

Method

Generally two methods are followed while excavation. One is Percussion Drilling Method and the other is Rotary Drilling Method. However, method of excavation shall be proposed by the Contractor and approved by the Engineer. Water or air jetting for boring of the piles shall not be allowed.

Boring near recently cast piles

Piles shall not be bored so close to other piles which have recently been cast and which contain workable or unset concrete so that flow of concrete could be induced from or damage caused to any of the piles. Boring and excavation for a pile shall not be commenced until 96 hours after completion of any pile within a radius of 2.5m center to center.

Steel casing

A temporary steel casing pipe of approved quality and specifications stated earlier shall be used and lowered simultaneously with the progress of drilling for the purpose of stabilizing at least the top 6m of the hole. Where a permanent steel casing pipe is specified in the Drawings, this shall either be lowered as drilling progresses instead of the temporary pipe, or installed immediately on completion of drilling. The inside of the casing pipe shall be cleaned of oil, grease, paint and other deleterious substances before lowering.

A pile constructed in a stable cohesive soil without the use of temporary casing or other form of support shall be bored and concreted without prolonged delay and in any case soon enough to ensure that the soil characteristics are not significantly impaired.

Stability of pile excavation using drilling fluid

Where a bore hole is formed without casing under water or using drilling fluid for maintaining the stability of a boring, the level of water or fluid in the excavation shall be maintained so that the water fluid pressure always exceeds the pressure exerted by the soils and external ground water. The water or fluid level shall be maintained at a level not less than 2m above the level of the outside water level or any artesian pressure level.

Drilling mud shall be used at least from the level of sub-soil water or from the level of the bottom of the guide casing depending on site conditions and the hole shall then always be kept almost full with fluid, which should preferably be kept in motion. The density and composition of the fluid shall be such as to suit the requirements of the ground condition and to maintain the fine materials from the boring in suspension. A five percent Bentonite suspension would generally be suitable.

Where saline or chemically contaminated ground water occurs, special precautions shall be taken to modify the Bentonite suspension or pre-hydrate the Bentonite in fresh water so as to render it suitable in all respect for construction of the piles.

In the event of a rapid loss of water or Bentonite suspension from the pile excavation, the excavation shall be backfilled without any delay and the instructions of the Engineer shall be obtained before excavation at the location is resumed.

Disposal of excavated material

No excavated material shall be dumped into the river or any connecting waterway without the written approval of the Engineer. Excavated materials shall be removed, from the site and dumped either beyond areas affected by dredging, or taken to the Contractors dumping areas on land. The Contractor shall be fully responsible for all costs involved in removing the excavated materials to spoil.

Pumping from bore holes

Pumping from a bore hole shall not be permitted unless a casing has been placed in to a stable stratum, which prevents the flow of water from other strata in significant quantities in to the boring, or unless it can be shown that pumping will not have a detrimental effect on the surrounding soils and/or properties.

Obstructions

Where boulders or other obstructions render it impossible to bore the pile, excavation operations inside the pile casing, as directed by the Engineer, shall be carried out to remove the obstructions. The Contractor shall be reimbursed for such operations only when the largest dimension of the obstruction exceeds 250mm and the obstruction is found more than 4m below the ground level or water bed. However, the amount of compensation shall be proposed by the Contractor and agreed by the Engineer beforehand the removal works start.

Unexpected ground conditions

The Contractor shall report immediately to the Engineer any circumstances, which indicates that in the Contractor's opinion the ground conditions differ from those expected by him from his interpretation of the Site Investigation Reports.

Boring records

During the boring of the pile, the Contractor shall compile a boring log indicating depths and types of the various soil layers encountered. Disturbed samples shall be submitted to the Engineer, as per requests.

The Contractor shall carry out sampling and tests to check soil strengths and shall not be reimbursed for this work.

Final pile toe level

The final pile toe level shall be as indicated on the Drawing(s) or as instructed by the Engineer after due consideration of the Contractor's proposals, boring logs and test results.

The final toe level of other piles may subsequently be altered according to the results of the test loading detailed under Sub-section captioned 'Pile Load Testing' of this Specifications.

Inspection and cleaning of bottom of excavation

The time between final excavation and bottom cleaning and the start of pouring concrete shall be reduced as much as possible and shall not exceed six hours. To achieve this, the final 2m of excavation shall not start until all preparations for cleaning, reinforcing and pouring concrete are finished. In case of unexpected delay, the Contractor shall dump sand or gravel in the bore up to 2m above the toe level.

Immediately after excavation, the bottom of the excavation shall be carefully cleaned for mud and sediments and other soft materials. A short interruption is recommended to allow the fine materials to settle.

The cleaning shall be made by an approved method. Before cleaning of every pile, notice shall be given to the Engineer.

The Contractor shall carry out 'Sedimentation Tests' in presence of the Engineer.

For boring without casing, the diameter of the boring hole for a representative number of piles shall be measured by a Caliper prior to the pouring of concrete. The verticality of the bore holes shall be maintained by the Contractor using approved equipment for which the Contractor shall not be paid any compensation.

Placing reinforcement

The reinforcing steel cage consisting of the steel shown on the Drawings along with cage stiffener bars, spacers, centralizers, and other necessary appurtenance shall be completely assembled and placed as unit immediately after the excavation is inspected and accepted and prior to concrete placement.

The reinforcement shall be placed as indicated on the Drawings. Reinforcement in the form of a cage shall be assembled with additional support, such as spreader forks and laciness, necessary to form a rigid cage. Hoops, links or helical reinforcement shall fit closely around the main longitudinal bars and

be bound by approved wire, the ends of which shall be turned into the interior of the pile or pour. Hoops, links or helical reinforcement may also be placed and fitted with main longitudinal bars by staggered spot or line welding of approved quality.

The reinforcing steel shall be tied and supported so that it will remain within allowable tolerances until the concrete will support the reinforcing steel.

The cover to all reinforcement shall be not less than 75mm.

Joints in longitudinal steel bars shall be permitted unless otherwise specified. Joints in reinforcement shall be such that the full strength of the bar is effective across the joint and shall be made so that there is no relative displacement of the reinforcement during the construction of the pile.

Joints in longitudinal steel bars in piles with tension (for instance for test loading) shall be carried out by welding unless another method has been approved by the Engineer.

In case the final pile toe level, instructed by the Engineer, is deeper than that indicated on the Drawings, the section of the pile, deeper than the toe level indicated on the Drawings, will not require any reinforcement.

Placing concrete

➤ Approval

No pouring of concrete shall take place before the bottom of the excavation has been cleaned, the bore hole inspected and approval has been obtained in writing from the Engineer.

➤ Method

The method for mixing the concrete shall be as specified under the relevant Sub-section on 'Concrete for a Structures' of this Specification. The concrete shall be placed using a Tremie pipe long enough to reach the bottom of the hole and having an internal diameter of not less than 150mm. The Tremie pipe shall be gradually withdrawn as the pouring of the concrete progresses but shall always be kept below the surface of the poured concrete.

The method of placing and the workability of the concrete shall be such that a continuous monolithic concrete pile of the full cross-section is formed.

The concrete shall be placed continuously and without such interruption as would allow the previously placed batch to have hardened. In this respect the Contractor shall submit details of his contingency plans, standby plant, etc. to be utilized in the event of any equipment breakdown.

The use of pumped concrete and the methods in its use shall be approved by the Engineer.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a casing. No spoil, liquid or other foreign matters shall be allowed to contaminate the concrete.

➤ Workability of concrete

Slump measured at the time of discharge into the pile boring shall be minimum 100mm and maximum 150mm.

➤ Placing concrete under water or drilling fluid

Concrete to be placed under water or drilling fluid shall be placed by Tremie and shall not be discharged freely into the water or drilling fluid.

The internal diameter of the pipe of the Tremie shall be not less than 200mm. It shall be so designed that external projections are minimized allowing the Tremie to pass through reinforcing cages without causing damage. The internal face of the pipe of the Tremie shall be free from projections.

Before placing concrete, all measures shall be taken to ensure that there is no accumulation of silt or other materials at the base of the boring and the Contractor shall ensure that heavily contaminated Bentonite suspension that could impair the free flow of concrete from the pipe of the Tremie, has not accumulated at the bottom of the hole.

A sample of the Bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.25, pouring of concrete shall not proceed. In this event, the Contractor shall modify the mud quality.

The concrete shall be a rich coherent mix of high workability in accordance with the provisions stated in the item of 'Concrete' under the Sub-section on 'Materials' of this Sub-section.

The concrete shall be placed in such a manner that segregation does not occur.

During and after pouring concrete, all cares shall be taken to avoid damage to the concrete from pumping and de-watering operations.

The hopper and pipe of the Tremie shall be clean and watertight throughout. The pipe shall be sufficiently long to reach the base of the boring and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the pipe of the Tremie and the water or drilling fluid. The discharge end shall be sealed closed at the start of work so as to prevent water from entering the tube before the tube is filled with concrete. After placement of concrete has started the Tremie pipe shall be kept full of concrete upto the bottom of the hopper. The pipe shall, at all times, penetrate the concrete, which has previously been placed and shall not be withdrawn from the concrete until the concrete pouring is completed. The bottom of the Tremie pipe shall be kept at least 1.5m under the surface of the concrete. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water or drilling fluid. If water enters the tube after placement of concrete has started, the Tremie shall be withdrawn, the discharge end resealed and the placement restarted. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow shall be continuous until the work is completed.

The Contractor shall maintain a continuous record of the volume of the concrete used and the level of the concrete in the pile. Any deviation from the theoretical or expected volume/ level relationship shall immediately be reported to the Engineer.

➤ Placing concrete in dry

When the top of the pile elevation is above the ground, portion of the pile above the ground shall be formed with a removable form or permanent casing when specified.

The concrete shall be vibrated to a depth of 1.5m below the ground surface except where soft uncased soil or slurry remaining in the excavation will possibly mix with the concrete.

After placement, the temporarily exposed surfaces of the shaft concrete shall be cured in accordance with the provisions of curing of concrete described under the Sub-section captioned "Concrete for Structure" of this Specification.

For at least forty-eight hours after concrete has been placed, no construction operation other than mild vibration shall be conducted that would cause soil movement adjacent to the shaft.

Portions of the pile exposed to a body of water shall be protected from the action of water by keeping the forms in place for a minimum of seven days after concrete placement.

11.5 Extraction of Temporary Casing

Workability of concrete

Temporary casing shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted.

Concrete level

When the casing is being extracted, a sufficient quantity of concrete shall be maintained within it to ensure that pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in section nor contaminated. The toe of the temporary casing shall be kept minimum 2m under the outlet of the Tremie.

No concrete shall be placed in the boring once the bottom of the casing has been lifted above the top of the concrete. It shall be placed continuously as the casing is extracted until the desired head of concrete is obtained.

Adequate precautions shall be taken in all cases where excess head of water or drilling fluid could be caused as the casing is withdrawn because of the displacement of water or fluid by the concrete as it flows into its final position against the walls of the shaft.

The pile shall be concreted at least one pile diameter above the designed cut off level to allow for chiseling off the top concrete down to sound hard concrete.

The pile top shall, after clean cutting, be embedded 75mm in the foundation.

Vibrating extractors

The use of vibrating casing extractors shall be permitted.

Reinforcement cage

When concrete is placed by Tremie method, temporary hold-down devices shall be used to prevent uplifting of the steel cage during concrete placement. Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals not exceeding 1.5m along the drilled depth to insure concentric location of the cage within the boring. When the size of the longitudinal reinforcing steel exceeds 25mm, such spacing shall not exceed 3m.

Supervision

The execution of the pouring of concrete in the pile shall be supervised by a qualified person of the Contractor's staff in addition to the Engineer's representative(s), who will keep records on the relation between quantity of concrete used, level of concrete and withdrawal of casing.

11.6 Temporary Support

The Contractor shall ensure that free standing piles are temporarily braced or stayed immediately after driving to prevent loosening of the piles in the ground and to ensure that no damage resulting from oscillation, vibration or movement of any free-standing pile length can occur.

11.7 Records

The Contractor shall keep records as indicated below for the installation of each pile and shall submit two signed copies of these records to the Engineer no later than noon of the next working day after the pile has been installed. The signed records shall form a record of the work.

- ① Contract
- ① Pile reference number (location)
- ① Pile type
- ① Nominal cross-sectional dimensions or diameter
- ① Date and time of boring
- ① Date and time of pouring of concrete

- ① River bed level at commencement of installation of pile
- ① Working level
- ① Pile toe level
- ① River water level
- ① Pile head level
- ① Length of temporary casing
- ① Length of permanent casing
- ① Soils samples taken and in-situ test carried out
- ① Standing water level
- ① Length and details of reinforcement
- ① Concrete mix
- ① Volume of concrete supplied to pile and corresponding levels of concrete and casings
- ① All information regarding obstructions, delays and other interruptions to the sequence of work.

11.8 Measures in Case of Rejected Piles

If any pile is found unsatisfactory in the opinion of the Engineer for utilization in the structure, it shall be cut off below the pile cap when so ordered by him.

The pile shall be replaced as directed by the Engineer. All additional expenses shall be borne by the Contractor, which would not be reimbursable.

When the safe bearing value of any pile is found by tests to be less than the design load, longer piles or additional piles shall be installed as ordered in writing by the Engineer.

11.9 Other requirements

Reinforcement cages of piles selected by the Engineer shall be fitted at the Contractors expenses with watertight 50mm diameter G.I pipe from datum level down to pile toe level. Bottom of the pipes shall be closed waterproof. Piles with diameter above 800mm shall have four G.I pipes while piles with diameter below or equal to 800mm shall have three G.I pipes.

The Contractor shall test piles by an electronic ultrasonic device as per the instruction of the Engineer. The Contractor shall submit a report in two samples within two days of testing. Ultrasonic testing will not be paid separately and the Contractor shall make provisions that piles shall be tested in several lots as required by the work.

The Contractor shall cut off pile heads carefully but shall not cut, bend or damage starter bars. If required, the Engineer may instruct the Contractor to cut starter bars to the top level indicated on the Drawings.

11.10 Measurement

The unit of measurement shall be the linear meter in case of boring. The payable length shall be measured from the ground level upto the toe level of each pile.

The unit of measurement for concrete shall be in cubic meter. The payable length of the satisfactory bored piles shall be measured from the toe level to cut-off level of pile cap as shown on the Drawing. In case of bent-up piles, the length of the satisfactory pile shall be measured from the top of the permanent casing up to the toe level.

The mass measured for injection of grout material shall not include the mass of water.

Breaking of pile heads shall be measured in linear meter.

Permanent casing shall be measured in linear meter for each size.

11.11 Payment

The amount of completed and accepted boring works, as measured above, shall be paid at the Contract unit price per linear meter. The payment shall constitute the full compensation for furnishing all related accessories and equipment related to boring with all support arrangements like Rigs, Crane, Jets, Frames, Leads etc. including temporary casing, drilling and removal of obstruction in course of drilling, drilling fluid circulation, disposal of excavated materials, all labour and incidentals to complete the Work as provided in this Sub-section.

The amount of completed and accepted work, as measured above in cubic meter of concrete, shall be paid at the Contract unit price. The payment shall constitute the full compensation for all costs for furnishing all materials of concrete including setting out piles, placing of reinforcement cage and keeping it in proper position, placing concrete by Tremie casting method, testing of cement, concrete, sand, all costs of labour, equipment and plants, inspection and control, all related tools and all incidentals necessary to complete the work as per Specifications. The payment shall exclude the costs for reinforcement.

Breaking of Pile Heads shall include removal of the dismantled materials such as concrete to a safe distance including scrapping and removing concrete from steel/M.S. rods, preparation and making platform where necessary, leveling and dressing the site and clearing the river bed, etc.

Permanent casing shall be paid for at the Contract unit price per linear meter for permanent casing. Such payment shall be the full compensation for furnishing and placing the casing above the costs attributable to the work paid for under associated pay items.

No payment shall be made for unauthorized, defective, unsound or unsatisfactorily piles or for any costs incurred by the Contractor for such piles.

Item of payment

	Unit
Bored Cast in Place Piles (Percussion method) (Diameter as stated in the Bill of Quantities/Drawings)	
a) Boring	Linear Meter
b) Concrete	Cubic Meter
Bored Cast in Place Piles (Rotary Drilling method) (Diameter as stated in the Bill of Quantities/Drawings)	
a) Boring	Linear Meter
b) Concrete	Cubic Meter
Breaking of Pile Heads	Cubic Meter
Permanent Casing	Linear Meter

12. PRE-CAST REINFORCED CONCRETE PILES**12.1 Description**

This work shall consist of the production and driving of pre cast reinforced concrete piles in accordance with these specifications and of the types and dimensions designated on the Drawings or as directed by the Engineer.

General

Pre-cast piles shall be manufactured in a casting yard in accordance with the Drawings.

Concrete shall be placed in one continuous pour for each pile. Pouring of concrete shall begin at the head and be progressed to the driving end of the pile.

Each pile shall be indelibly marked with its sequential number and date of manufacture.

12.2 Materials

Concrete

The concrete for pre-cast piles shall conform to the requirements illustrated under the Sub-section on 'Concrete for Structures' of this Specification with a minimum concrete strength (cylinder) of 25 - 30 N/mm² at 28 days.

Reinforcement

Reinforcing bar and binding wire used in the production of pre-cast piles shall conform to the requirements illustrated under the Sub-section on 'Reinforcing for RCC' of this Specification.

The reinforcement shall be assembled before placing in the moulds and all hoops and links shall be of uniform length firmly wired into position. Ends of helical reinforcement shall be firmly secured. Diagonal fork spacers shall be of an approved pattern.

Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided at agreed centres, designed to develop the full strength of the bar across the joint, provided with adequate links or stirrups and staggered in position from those of adjacent longitudinal bars, all to the acceptance of the Engineer.

The main longitudinal reinforcing bars in piles, not exceeding 12m in length, shall be in one continuous length unless otherwise specified. In piles exceeding 12m long, joints will be permitted in main longitudinal bars at 12m nominal intervals. Joints in adjacent bars shall be staggered at least 1m apart along the length of the pile.

Joints in reinforcement shall be such that the full strength of the bar is effective across the joint.

Welding of joints in main longitudinal bars will not be permitted unless agreed in writing by the Engineer.

Concrete cover shall be maintained at the joints.

Formwork

Formwork shall comply with the provisions under the Sub-section on 'False Work and Forms' of the Section 'Concrete for Structures' of this Specification except as specified below.

When the sides of adjacent piles are used as formwork, an approved method shall be used to prevent adhesion between concrete surfaces.

Holes for toggle bolts shall be at right angles to the faces of the pile and lined with steel tubes or other approved materials. Holes for lifting, handling and pitching shall be formed in the positions and according to the details shown on the Drawings or otherwise approved by the Engineer and lined with steel tubes.

Details of all pile shoes shall be submitted to the Engineer for approval prior to fabrication or supply. All shoes shall be fitted to the reinforcement as shown on the Drawings.

Pile shoes/helmet

Where applicable, pile shoes shall be manufactured by an approved supplier and consist of cast iron, cast steel or fabricated steel as shown on the Drawings.

Cast iron shoes shall be formed from chill hardened iron grade 10 in accordance with BS 1452 "Specification for Grey iron castings". Cast steel shoes shall be formed from steel to grade A, of BS 3100 "Specification for steel castings for general engineering purposes". Fabricated steel shoes shall be formed from steel to grade 43 A1 and steel straps and fastenings to Grade 43 A of BS 4360 "Weldable structural steels".

Castings shall be free from sand, honeycomb, porosity, blowholes or other defects. For cast shoes, straps and fastenings shall be of mild steel or wrought iron, cast into and running continuously through the base.

12.3 Production of Pre-Cast Reinforced Concrete Piles

Length of piles

The pile lengths shown on the Drawings are based on site investigations prior to driving of test piles. The lengths of the piles shall be finally determined and ordered by the Engineer, after driving of pilot piles. Pilot piles shall be produced to the lengths shown on the Drawings.

Pile dimensions

Piles shall be cast to the cross-sectional dimensions shown on the Drawings. The cross-section on dimensions shall not be less than those specified and shall not exceed them by more than 6mm.

The head of each pile shall be square to the longitudinal axis. The edges of the head and of the pile for a distance of 30mm from the head, shall be chamfered 25mm x 25mm. Any face of a completed pile shall not deviate by more than 1/1000th of the length of the pile from the straight line connecting the centroids of the end faces.

Casting of piles

All pre-cast concrete piles shall be cast on the site or at the Contractor's pile casting yard. In case where piles are manufactured off-Site, the Contractor shall ensure that adequate notices have been given to the Engineer and he has been provided with appropriate facilities for inspection of the manufacturing process.

Piles shall be cast in a horizontal position on an accurately leveled casting platform. The formwork shall conform to the requirements defined under the relevant clause of this Specification.

Reinforcing bar shall be of the types and dimensions and shall be placed, as shown on the Drawings. The construction method for reinforcement shall conform in all respect to the requirements defined under the relevant Sub-section (Reinforcement for RCC) of this Specification.

The formwork and reinforcement for each pile shall be inspected and approved by the Engineer before pouring of concrete commences.

Concrete shall be placed continuously and shall be compacted by mechanical vibration. Special cares shall be taken to produce a pile free from air pockets or honeycomb.

The forms shall be slightly overfilled, the surplus shall be scraped off and the top surface shall be finished to a uniform texture similar to that specified to be produced by the forms. The pile surfaces shall be true, smooth and even.

Casting tolerances

The cross sectional dimensions of piles shall not be less than those specified or shown on the Drawings and shall not exceed such dimensions by more than 6mm.

Unless otherwise directed by the Engineer, any face of a pile shall not deviate by more than 6mm from a straight edge 3m long laid on the face and the centroid of any cross section of the pile shall not deviate by more than 10mm from the straight line connecting the centroid of the end faces of the pile.

Curing and removal of formwork

Curing shall conform to the requirements defined in the relevant portion of the Sub-section on 'Concrete for Structures' of this Specification. Side forms may be removed not less than 24 hours after placing the concrete, but the entire pile shall remain fully supported for at least seven days. When accelerated curing is used, the curing procedures shall have to be accepted by the Engineer.

12.4 Marking of Piles

The head of each pile shall be permanently marked with its date of casting and reference number. The pile shall be indelibly marked at 1m interval along its length showing the distance from pile shoe. The top 3m of the pile shall be marked at 250mm interval.

12.5 Protection of Finished Piles

Protection of finished piles against aggressive soil conditions shall be provided by one of the following methods:

- (a) Impervious liners to LWL – 2m
- (b) Tanking/waterproofing of the piles to the depth referred under (a) above
- (c) Painting with an approved two parts coal tar epoxy paint product suitable for mixing at Site immediately before application.

12.6 Handling and Storage of Piles

Pre-cast piles shall be lifted, handled, transported and stacked so that no damage occurs. The lifting points for each size of pile shall be marked as shown on the Drawings and as stated above with waterproof paint and to be approved by the Engineer. The piles shall be transported and stacked with supports at the lifting points.

Piles are to be handled only when concrete has reached its characteristic strength as determined by field control test cylinders. Piles shall be handled carefully to avoid being dropped or severely jarred.

12.7 Pilot (Test) Piles

The Contractor shall construct and drive pilot piles prior to commencement of piling for the permanent works. The permanent work piles shall not proceed until the testing of the pilot piles has been completed meeting all requirements of acceptance to the satisfaction of the Engineer

Pilot piles shall be furnished for the lengths ordered and driven at the locations and to the elevations directed by the Engineer. In general, the ordered length of pilot piles will be greater than the estimated length of production piles in order to provide for variation in soil conditions.

The driving equipment used for driving pilot piles shall be identical to that which the Contractor shall propose to use in case of production piling.

Pilot piles shall be driven in positions specified by the Engineer. The Contractor shall notify the Engineer in advance of driving and shall supply the Engineer daily with a detailed record of the driving of the pilot piles.

Pilot piles shall be driven to a hammer blow count established by the Engineer at the estimated tip elevation. Pilot piles which do not attain the hammer blow count specified above at a depth of 0.3m above the estimated tip elevation shown on the plants, shall be allowed to “set-up” for a period of 12 to 24 hours as determined by the Engineer, before being re-driven. If the specified hammer blow count is not attained on re-driving, the Engineer may direct the Contractor to drive a portion or all of the remaining pilot pile length and repeat the “set-up”– re-drive procedure.

Driving of a pilot pile shall continue until the Engineer directs that it shall cease, in order to demonstrate that driving resistance continues to increase.

12.8 Driving of Piles

The Contractor shall establish all lines, levels and be responsible for the correct positioning of all piles. Setting out shall be carried out from the main grid lines of the proposed structure. Immediately before installation, the pile position shall be marked with suitable identifiable pins or markers.

The position of the piles shall be set out in accordance with the Drawings from the established Bench Mark.

The pre-cast piles shall be driven to a pre-planned sequence approved by the Engineer and in the presence of the Engineer's authorized representative in order to minimize the detrimental effects of heave and lateral displacement of the ground. No pile driving will be allowed at night unless prior permission is obtained from the Engineer.

Piles shall be protected with an approved cushion and cap while being driven. Pile driving shall be stopped when the maximum blows per 0.3m or the number specified on the Drawings are reached or if the pile head is damaged due to improper driving.

Piles shall be rigidly secured by leads or temporary guide structure against lateral movement during driving and shall be driven without interruption right from the first blow of the hammer until the required penetration has been attained.

Piles shall be driven to the positions, lines and elevations shown on the Drawings so that the pile center is within 75mm of the specified location point and with a deviation from the vertical of not more than two percent. If any pile is damaged or driven out of the specified tolerance, the Contractor shall immediately submit proposals for remedial measures to the Engineer for his written approval. Notwithstanding the Engineer's approval, the Contractor shall be solely responsible for the design and cost of the remedial measures.

The Contractor shall keep a pile driving register in a format approved by the Engineer, where he shall record all data covering dimensions, elevation of point, top elevation after cut off, type, make and weight of hammer, height of fall of hammer, average penetration per blow under the last 20 blows and blow count per 0.3m throughout the full length of that pile. Five copies of the report shall be submitted to the Engineer before any payment will be made for this work.

Driving equipment

Before any driving takes place, the Contractor shall submit to the Engineer, for his approval, full details of all pile driving equipment, including the driving hammer, hammer cushion, drive head, pile cushion and other appurtenances and the proposed methods to be followed. The Contractor's proposal shall not be on using water-jetting method.

Piles shall be driven by continuous vibratory percussion using steam, air, diesel or gravity hammers. The equipment shall have sufficient capacity to drive the pile to the design depth and set without damaging the pile.

Pile driving hammers, other than gravity hammers, shall be of the size needed to develop the energy required to drive piles at a penetration rate of not less than 2.5mm per blow at the required bearing value.

Gravity hammers shall not be used for concrete piles or for piles where design load capacity exceeds 30 MT. When gravity hammers are permitted, the ram shall weigh not less than 900 kg and the height of drop shall not exceed 4.5m. In no case the ram weight of a gravity hammer shall be less than the combined weight of the drive cap and pile. All gravity hammers shall be equipped with hammer guides to insure concentric impact on the drive head or pile cushion.

Open-end (single acting) diesel hammers shall be equipped with a device to permit the Engineer to determine hammer stroke at all times during pile driving operations. Closed-end (double acting) diesel hammers shall be equipped with a bounce chamber pressure gauge, in good working order and mounted near the ground level, to facilitate easy reading by the Engineer. The Contractor shall provide a correlation chart on bounce chamber pressure and delivered hammer energy.

Vibratory or other pile driving methods may be used only when specifically allowed by the special provisions or in writing by the Engineer. Except when pile lengths have been determined from load test piles, the bearing capacity of piles driven with vibratory hammers shall be verified. Such verification shall be carried out by re-driving the first pile driven in each group of 10 piles with an impact hammer of suitable energy to measure the pile capacity before driving the remaining piles in the group.

In case the required penetration is not obtained by the use of a hammer complying with the above minimum requirements, the Contractor shall be required to provide a hammer of greater energy or, when permitted, resort to supplemental methods such as jetting or pre-boring.

Driving appurtenances**Hammer cushion**

All impact pile driving equipment, except gravity hammer, shall be equipped with a suitable thickness of hammer cushion material to prevent any damages to the hammer or pile and to insure uniform driving behaviour. Hammer cushions shall be made of durable manufactured materials, which will retain uniform properties during driving. Wood, wire rope, and asbestos hammer cushions shall not be used. The Contractor shall replace the hammer cushion before driving is permitted to continue whenever there is a reduction of hammer cushion thickness exceeding twenty-five percent of the original thickness.

Pile drive head

Pile, driven with impact hammer, shall be fitted with an adequate drive head to distribute the hammer blow to the pile head. The drive head shall be axially aligned with the hammer and the pile. The drive head shall be guided by the leads and not be free-swinging. The drive head shall fit around the pile head in such a manner as to prevent transfer of torsion forces during driving while maintaining proper alignment of hammer and pile. The pile head shall be plain and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts from the drive head.

Pile cushion

When the nature of the driving of a concrete pile is such as to unduly injure it, shall be protected by a pile cushion. When plywood is used, the minimum thickness placed on the pile head, prior to driving, shall not be less than 100mm. A new pile cushion shall be provided, if the cushion is either compressed more than one-half the original thickness or begins to burn during driving. The pile cushion dimensions shall be such, as to distribute the blow of the hammer throughout the cross-section of the pile.

Leads

Pile driving leads, which support the pile and the hammer in proper positions throughout the driving operation, shall be used. Leads shall be constructed in a manner that allows movement of the hammer while maintaining alignment of the hammer and the pile to insure concentric impact for each blow. The leads shall be of sufficient length to make the use of a follower redundant and shall be so designed as to permit proper alignment of battered piles.

Followers

Followers shall only be used when approved in writing by the Engineer, or when specifically allowed as special provision. The follower and pile shall be held and maintained in equal and proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the length determined necessary from the driving of the full-length piles.

Driving procedure

Pile heads shall be squared up prior to driving. In addition, pile shoes may be used to protect the piles when hard driving is anticipated. The pile shoes shall be of the types and quality as shown on the Drawings and as specified in this Specification and/or as directed by the Engineer. They shall be used at the locations specified or ordered by the Engineer either.

Each pile shall be driven continuously until the specified set or depth has been reached except that the Engineer may permit the suspension of driving, if he is satisfied that the rate of penetration prior to the cessation will be substantially re-established on resumption or if he is satisfied that the suspension of driving is beyond the control of the Contractor.

Pile shall be driven to the minimum tip elevations and bearing capacity shown on the plans, specified in the special provisions or approved by the Engineer. Piles that heave more than 6mm upward during the driving of adjacent piles shall be re-driven.

Piles shall be driven with a variation of not more than 6mm per 0.3m from the vertical or from the batter shown on the Drawings, except that piles for trestle bents shall be so driven that the cap may be placed in its proper location without inducing excessive stresses in the piles. Foundation piles shall not be out of the position as shown on the Drawings by more than one-fourth of their diameter or 150mm, whichever is greater after driving. Any increase in footing dimensions or reinforcing due to out-of-position piles shall be at the Contractor's own expenses.

At the start of work and in new sections, sets shall be taken at intervals during the last 3m of the driving to establish the behavior of the piles.

The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check the driving resistance. A set shall be taken only in the presence of the Engineer unless otherwise approved.

The final set of each pile shall be recorded either as the penetration in millimeter per 10 blows or as the number of blows required to produce a penetration of 250mm. The exposed part of the pile and the driving equipment shall be in good condition when the final set is measured.

The Contractor shall inform the Engineer immediately in the event of an unexpected change in driving characteristics is noted.

When required, levels and measurements shall be taken to determine the movement of the ground or any pile resulting from the driving process.

When problems are encountered in the resistance to the pile being driven or with a pile rising as a result of driving of an adjacent pile, the Contractor shall seek and comply with the instructions of the Engineer on methods and procedures to overcome the problem. One of the methods may be that the Contractor shall provide a heavier hammer as decided by the Engineer or resort to jetting at his own expenses. The drop hammers shall be equipped with proper leads and hoisting equipment to handle the work efficiently. The fall of hammer shall not be more than 2.43m.

Jets

Jetting shall only be permitted, if approved in writing by the Engineer or when specifically allowed in the special provisions. The Contractor shall be responsible for all damages to the site caused by the jetting operations.

When water jetting is followed, the number of jets, and the volume and pressure of water at the jet nozzles shall be adequate to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times a minimum pressure of 293 kg/cm² at two number 20mm jet nozzles. In either case, unless otherwise indicated by the Engineer, jet pipes shall be removed when the pile tip is a minimum 1.52m above the prescribed tip elevation and the pile shall be driven to the required bearing capacity with an impact hammer to secure the final penetration.

All jet water shall be controlled, treated if necessary and disposed of by the Contractor in a manner satisfactory to the Engineer.

Driving records

The Contractor shall keep a record of the installation of each pile and shall submit two signed copies to the Engineer, not later than noon of the next working day after the pile is installed. The record shall include the following data:

- (a) Pile location
- (b) Pile reference number
- (c) Pile type
- (d) Nominal cross-sectional dimensions
- (e) Length of preformed pile
- (f) Date and time of driving or re-driving
- (g) Ground level at the commencement of installation of pile
- (h) Working level
- (i) Pile toe level

- (j) Type, weight, drop and mechanical condition of hammer and equivalent information for other equipment
- (k) Numbers and type of packing and type and condition of dolly used.
- (l) Final set of pile
- (m) If required, the sets taken at intervals during the last 3m of driving
- (n) If required, temporary compression of ground and pile from the time of a marked increase in driving resistance until the pile reaches its final level
- (o) All information regarding obstructions, delays and interruptions to the sequence of work.

12.9 Repair of Pile Heads

When repairing the head of a pile, the head shall be cut off square at sound concrete and all loose particles shall be removed by wire brushing followed by washing with water.

If the pile is to be subjected to further driving, the head shall be replaced with concrete of an approved grade. Repaired piles shall not be driven until the added concrete has reached the specified strength of the concrete of the pile.

If the driving of a pile has been accepted but sound concrete remained below the cut-off level, the pile shall be made good to the cut-off level with concrete of a grade not inferior to that of the pile.

12.10 Extension of Piles

Where it is necessary to extend a pile, the concrete at the end of the pile shall be broken away to leave the reinforcing bars exposed for a length of 40 bar diameters. Additional reinforcement shall be attached as per the relevant Section of this Specification and in line with the pile axis. The additional concrete shall be of the same quality as that used in the pile. Prior to placing concrete, a construction joint shall be made in accordance with the specifications of the relevant Section of this Specification. Forms shall remain in place for a minimum of seven days.

12.11 Defective Piles

The driving procedure shall not subject the piles to excessive abuse producing crushing and spalling of the concrete or deformation of the steel. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, shall not be permitted. Any pile damaged by reason of internal defects or improper driving, or driven out of its proper location or below the specified elevation, shall be corrected at the Contractor's expenses by one of the following methods approved by the Engineer.

(1)	The pile shall be withdrawn and replaced by a new and if, necessary, a longer pile.
(2)	4 A second pile shall be driven adjacent to the defective or low pile.
(3)	5 The pile shall be spliced or built up, or a sufficient portion of the footing shall be extended to properly embed the pile.
(4)	6 All piles, pushed up by the driving of adjacent piles or by any other cause, shall be driven down again.

12.12 Cutting off Pile Heads and Bonding

On completion of installation of piles, they shall be cut off to the required level as shown on the Drawings and to a tolerance of + 20mm or otherwise instructed by the Engineer. For pre-cast reinforced concrete piles, the main reinforcement shall be exposed and left reasonably straight for bonding into the pile cap. The minimum bond length of main reinforcement to be exposed shall be as given in the following table.

7	Grade of Pile Cap Concrete	8	30	9	40 or more
10	High Tensile Steel ($f_y = 460 \text{ N/mm}^2$)	11	37D	12	32D
13	Mild Steel ($f_y = 250 \text{ N/mm}^2$)	14	30D	15	25D

D = nominal diameter of bar.

In the stripping of pile heads, the concrete shall be stripped to such a level that the remaining concrete will project 75mm into the pile cap.

Where a pile has been formed below the required cut-off level, it shall be built-up and the reinforcement shall project for such length as given above.

The method of cutting the pile heads shall be accepted by the Engineer.

12.13 Measurement

This work shall be measured separately for production of piles, pile driving and providing pile shoe.

Production of piles for concrete shall be measured in cubic meters of pre-cast reinforced concrete produced and accepted on the basis of specified pile length.

Driving of pile shall be measured in linear meters of the length of pile driven complete and accepted. Cut off length shall not be measured for payment. The length of pile driven shall be measured from the pile toe to the cut-off level.

Pile shoe shall be measured by number.

12.14 Payment

The concrete work as measured above shall be paid for at the Contract unit prices per cubic meter of pile produced and linear meter of pile driven, as shown in the Bill of Quantities. The payment shall be the full compensation for the production of concrete, transportation of piles, all materials used, equipment and all labour, tools and incidentals necessary to complete the work but excluding the cost of reinforcement with its fabrication and pile shoe. Reinforcement and pile shoe shall be paid separately as shown in the Bill of Quantities. No payment shall be made for precast pile concrete until concrete test results demonstrate that the piles have achieved the specified strength.

The pile driving work as measured above shall be paid for at the Contract unit prices per linear meter of pile driven. The payment shall be the full compensation for the driving of the piles including, pile head breaking and repair, squaring up pile heads, construction and removal of any cofferdam, arranging rigs, cranes, hammers, leaders and all other necessary driving equipment, driving and all labour, tools and incidentals necessary to complete the work as described in this Section. No payment shall be made for driving piles until the piles have been driven to the specified depth.

The pile shoe as measured above shall be paid for at the Contract unit prices per number, as shown in the Bill of Quantities.

When pilot piles are incorporated in the foundation as working piles, no additional payment shall be made for the piles so utilized other than as for a pilot pile. Pilot piles which the Enquiry for no fault of the Contractor, refused to include in the foundations as working piles shall be paid for.

No payment shall be made for unauthorized, defective, unsound or unsatisfactory driven piles for any cost incurred by the Contractor for such piles.

Item of payment

Item of payment	Unit
Supply of pre-cast reinforced concrete piles (excluding cost of reinforcement)	Cubic meter
Driving of pre-cast reinforced concrete piles including pile head breaking and repair	Linear meter
Supply and fitting of pile shoe for pre-cast piles	Each

13. WELL FOUNDATION FOR STRUCTURES

13.1 Description

This work shall consist of construction of well, taking it down to the desired founding levels by open dredging or any other approved method of sinking through all kinds of soil strata and other materials, plugging the bottom, filling the inside and plugging the top of well in accordance with the details shown on the Drawings and these Specifications, or as directed by the Engineer.

A well foundation is also known as caisson.

13.2 General

The well foundations shall rest on a firm stratum satisfying the desired bearing capacity at that level as indicated in the working Drawing. The Contractor shall undertake confirmatory sub-soil investigations at the actual location of such well foundations prior to taking up the work of each well foundation.

Unless otherwise specified or directed by the Engineer, all works for the construction of well foundations shall conform to the provisions of brickwork, concrete, formwork and reinforcement made in the relevant sections of this document.

All items of concrete work shall conform to the relevant Sub-section of these Specifications under 'Concrete for Structures'. The concrete classes used in the well foundations shall be as tabulated below:

Well Component	Concrete Class
Bottom plug	B-1
Curb	A-5
Steining	A-5
Top plug	A-5
Reinforced Concrete Capping	A-5

The steining members shall be constructed to the lines and levels shown on the Drawing either from appropriate Class of Concrete or brick masonry.

The well curb and steining shall be of Reinforced Cement Concrete in conformity with grades of concrete as indicated in the drawings and in the Specifications hereinafter.

At the top of the well steining, an adequately designed 'well cap' is laid to transmit the loads and forces from the sub-structures to the foundations.

The cutting edge shall be of mild steel of specified grade and to details as shown on the Drawings and shall be strong enough to facilitate sinking of well through the types of strata likely to be encountered.

The appropriate method for construction of well shall depend upon field conditions, i.e. depth and flow of water actually encountered at the location of well foundation.

In case of dry beds, the site shall be excavated down to 0.30m above the sub-soil water level and properly leveled before the cutting edge is placed.

The curb and steining have to be specifically designed for special loading when pneumatic sinking is adapted.

13.3 Setting Out and Preparations for Sinking

Necessary reference points shall be fixed, away from the zone of blow-ups or possible settlements resulting from well sinking operations. Such reference points shall be connected to the permanent Theodolite stations with the base-line on the banks. The centre of the individual well shall be marked with reference to these stations. The distance, wherever practicable, shall be checked with the help of accurate tapes and precision distomat.

Reference points shall also be fixed to mark X-X axis (usually traffic direction) and Y-Y axis (normal to X-X axis) accurately.

A temporary Bench Mark shall also be established near the well foundation, away from the zones of blow-ups or possible settlement. The Bench Mark shall be checked regularly with respect to the permanent Bench Mark established at the bridge site.

13.4 Artificial Island and other Temporary Works

When the wells are to be pitched in shallow water of depth less than 1m, an earthen/sand island shall be constructed raising the site of work, so as to make the construction in the dry. If the water depth is less than 1.0m, simple sand islands shall be constructed protected by laying a few rings of sand bags. Where the water depth is in between 1.0m and 5.0m, the sand island be made by driving sheet piling and filling inside or by driving two rings of poles with their inside filled with sand bags or other materials and the central space filled with sand. The island can also be constructed by driving timber piles at requisite spacing and bamboo pins in between and with tarja or drum sheet walling.

The plan dimensions of sand islands shall be such as to have a working space of at least 2.0m all around the steining. The dimension of the sand islands shall however, be not less than twice the dimension in plan of the well or caisson. Sand islands shall be maintained to perform their functions until the well is sunk to a depth below the bed level at least equal to the depth of water. Sand island shall be protected against scour and the top level shall be sufficiently above the prevailing water level to be decided by the Engineer so that it is safe against wave action. The top surface of the island shall be adequately leveled and curb placed or constructed thereon.

For greater depths or in fast flowing rivers or for locations where soil is too weak to sustain an ordinary sand island, 'floating caissons' may have to be adopted.

Floating caissons may be of steel or of reinforced concrete or a combination of the two. They should have at least 1.5m free board above water level and increased, if considered necessary, in case there is a possibility of caissons sinking suddenly owing to reasons such as scour likely to result from the lowering of caissons, effect of waves, sinking in very soft strata, etc.

Stability of floating caissons shall be ensured against overturning and capsizing while being towed and during sinking for the action of water current, wave pressure, wind etc.

For floating caissons, a detailed method statement for fabrication, floating and sinking of caissons shall be prepared and furnished to the Engineer. Such statement shall include the total tonnage of steel involved, fabrication and welding specifications, list of materials and plant and a description of operations and manpower required for the work. The caisson shall be tested for leakages before being towed at site.

Appropriate method to be adopted during actual construction shall receive the approval of the Engineer well in advance.

The Contractor shall construct the diversion channel, if found necessary from site conditions.

13.5 Equipment

Equipment shall be deployed for construction of well foundation as required and as directed by the Engineer. Generally, the following equipment may be required for the work:

Crane with grab buckets of capacity 0.5 to 2.0 Cubic meter.

Submersible pumps.

Air compressors, air locks and other accessories where pneumatic sinking of well is anticipated.

Chisels of appropriate sizes.

Aqua-header for cutting rocky strata.

Diving helmets and accessories.

Equipment for concrete production, transportation, placing and compaction.

Jackdown facilities where specified.

Air jetting facilities with piping and compressors.

Water jetting facilities with nozzles, piping and compressors.

13.6 Cutting Edge

The cutting edge shall be fabricated from mild steel rolled sections, angles, plates and flats, as per details shown on the Drawings. Steel materials shall conform to the specifications of AASHTO M 270 (ASTM A 709) Grade 36.

The fabrication may be carried out in the shop or at site. Steel sections shall not be heated and forced into shape. However, 'V' cuts may be made in the horizontal portion, uniformly throughout the length, to facilitate cold bending. After bending, such 'V' cuts should be closed by welding. Joints in the lengths of structural sections, unless otherwise specified, shall be fillet welded using single cover plate to ensure the requisite strength of the original section.

After staking out the bridge centerline, the location of the centre point of well shall be correctly marked and the cutting edge placed, truly in position, commensurate with both the axes of the well. The cutting edge shall be placed on a leveled ground over dry bed and the starter bars shall be placed on proper position, as indicated on the Drawings, by means of welding. For checking the correctness of level plane, leveling instrument of spirit level method may be used. Care must be taken to see that the bars are properly fixed to the cutting edge in correct position with sufficient length for anchoring to the well curb and not to be displaced during pouring concrete. The cutting edge may be supported on flat bottomed wooden sleepers underneath at appropriate intervals depending on the diameter of well for uniform distribution of load over the bed on which the cutting edge is placed. The sleepers shall however, be removed after the shuttering of the well curb has been striped off once the concrete of the well has set. Proper precaution must be taken at the time of removing the sleepers so as not to develop any tilt of well curb that may occur during settlement of well curb due to the self weight.

When there are two or more compartments in a well, the bottom end of the cutting edge of the inner wall of such wells shall be kept at about 300mm above that of outer wall.

13.7 Well Curb

The well curb may be pre-cast or cast in situ. Steel formwork for well curb shall be fabricated strictly in conformity with the dimension and shape of the curb as shown on the Drawings. It should satisfy the following requirements:

- should have a shape offering the minimum resistance while the well is being sunk.
- be strong enough to be able to transmit super-imposed loads from the steining to the bottom plug. To satisfy this requirement, the shape and the outline dimensions of the curb shall be as given on the relevant Drawings. The curb shall invariably be reinforced concrete of mix not leaner than $f'_c = 250 \text{ kg/cm}^2$ with minimum reinforcement of 72 kg per cubic meter excluding bond rods. This quantity of steel shall be suitably arranged as shown on the relevant Drawing to prevent spreading and splitting of the curb during sinking and in service.
- in case pneumatic sinking is indicated, the internal angle of the well curb shall be made steep enough to provide easy access for the pneumatic tools.
- in case blasting is anticipated, the outer faces of the curb shall be protected with suitable steel plates of thickness not less than 6mm upto half the height of the well curb on the outside and on the inner face not less than 10mm thick upto top of well curb, suitably reduced to 6mm to a height of 3.0m above the top of the curb. The steel plates shall be properly anchored to the curb and steining. The curb in such a case shall be provided with additional hoop reinforcement of 10mm diameter mild steel or deformed bars at 150mm centres. The latter reinforcement shall also extend upto a height of 3.0m into the well steining above the curb, in which portion the mix of concrete in the well steining shall not be leaner than 1 : 1½ : 3. The grade of concrete in bottom 3.0m of steining shall not be leaner than A-5 or as shown on the Drawings.

The outer face of the curb shall be vertical. Steel reinforcements shall be securely assembled as shown on the Drawings. The bottom ends of vertical bond rods of steining shall be fixed to the cutting edge with check nuts or by welding.

The cutting edge shall be properly anchored to the well curb so that the well curb will be able to transmit superimposed loads from the steining to the bottom plug.

Care must be taken to see that the vertical bars have been projected sufficiently beyond the top of the well curb to facilitate proper lapping with vertical bars of well steining.

Pouring of all concrete in the well curb shall be done in one continuous operation upto its full height. The formwork on outface of the curb may be removed within 24 hours on pouring concrete but the inner face shall be removed at least after 72 hours.

Since the pouring of concrete of well steining will be done with some time lag, provision of concrete shear keys at suitable intervals in zigzag manner shall be kept on the top finished level of well curb.

13.8 Well Steining

Well steining may be built of either brick masonry or concrete.

The dimensions and the shape of the well shall strictly conform to those shown on the Drawings. The steining member of the well shall be built in one straight line from bottom to top in such away that if the well is tilted, the next stage of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb Bob or Spirit Level shall not be used for alignment.

Steining built in the first stage above the well curb shall not be more than 2m and in subsequent stage it shall not exceed the diameter of the well or the depth of well sunk below the adjoining bed level at a time, whichever is less. For stability, the first stage of steining shall be constructed only after sinking the curb at least partially for stability.

After sinking of a stage is complete, damaged portions, if any, of steining at top of the previous stage shall be properly repaired before construction of the next stage begin.

The height of steining shall be calibrated by making at least 4 gauges distributed equally on the outer periphery of the well each in the form of a 10 cm wide strip painted on the well, with every meter mark shown in red paint. Further, sub-division mark shall be shown in black paint. The gauges shall start with zero at the bottom of the cutting edge. Marking of the gauges shall be done carefully with a measuring steel tape.

In case of steining member built with concrete, concrete strength and reinforcements of the well shall strictly conform to those shown on the Drawings. At the completion of each stage construction, before the concrete sets, concrete shear keys in requisite numbers shall be constructed so as to make the concrete in the successive stages monolithic with the previous ones.

Once the first lift is complete, all pouring of concrete of steining may be carried out on subsequent lifts of about 2m to 2.5m. Attempts should be made to minimize the number of construction joints. The pouring layers of concrete shall be limited to about 450mm restricting the free fall of concrete to not more than 1.5m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, work stages shall be planned to avoid construction joints at the location of laps in the vertical steining bars.

Any concrete surface in the well steining, which shows excessive honeycomb and exposure of reinforcement or exhibits any fault, which in the opinion of the Engineer seriously impairs its function, may be declared defective concrete. Such defects shall be rectified to the satisfaction of the Engineer by the Contractor at his own cost.

3.9 Well Sinking

General

The process of taking down the well to the founding level is known as 'Well Sinking'.

All precautions shall be taken against possible damages to the foundations of structures in the vicinity of the wells prior to commencement of dredging of the material from inside the well. Dredging may be undertaken by manual or mechanical means.

The well shall as far as possible be sunk true and vertical through all types of soils. The method of sinking shall ensure that the well does not go out of position or out of plumb beyond the specified tolerance through all types of soils.

The well shall be sunk to the minimum depth of founding level shown on the Drawing provided the bearing capacity of the stratum at that level is not less than the desired minimum for that level as indicated in the working Drawing. Failing to satisfy this, the sinking of well shall continue to a further depth. The well shall be founded at a firm stratum deeper than the minimum depth shown, satisfying the desired bearing capacity for the level as indicated in the working Drawing.

The well shall be sunk by excavating materials uniformly from inside the dredge hole. Pneumatic sinking, whenever necessary, may have to be resorted to where obstacles such as tree trunks, large size boulders, etc., are met at the bottom or when there is hard patches which cannot be removed by open dredging. The necessity for pneumatic sinking shall be decided by the Contractor and shall be undertaken only with prior written permission of the Engineer with additional precautions as per standard practice. Nothing extra shall be paid to the Contractor for adopting pneumatic method of sinking.

Sinking or loading of the well with kentledge shall be commenced only after the steining has been cured for at least 48 hours.

During the operation of sinking of a well, the Contractor shall keep record of various strata of soil obtained, their respective depths and samples of soil in each stratum and behaviour of sinking of well through the various strata. This record shall be countersigned daily by the authorized representative of the Engineer and when completed shall be handed over to the Engineer.

The Contractor shall obtain approval of the Engineer with regard to the depth upto which a well is to be sunk. During final stage of sinking when the well will reach the final foundation level, suitably designed cofferdam shall be constructed to prevent outside soil from falling inside the dredge hole, if necessary.

Kentledge or sinking load

Kentledge shall be placed in an orderly and safe manner and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well. Where the tilts are present or there is a danger of well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

De-watering of well

Normally de-watering of well shall not be permitted as a means for sinking the well. It also shall never be resorted to, if there is any danger of sand blowing under the well.

Water jetting

Sinking of well may also be expedited, if necessary by water jetting along the external surface of the well. All jets shall be arranged symmetrically to induce straight sinking. The water jet shall be capable of exerting a pressure of 100 to 150 bars without any failure and or in-efficiency in the system.

Air jetting

Air jetting would be used for reducing the soil friction on the outer periphery of caisson to facilitate the sinking. In this method, PVC pipes shall be left on periphery of steining just touching the surface of formwork in first four lifts after casting of curb. After removal of formwork 4mm diameter holes at maximum 1m spacing are to be made on the pipes from outside and the holes are to be protected with rubber flaps so that those do not get choked inside by soil. The pipes of each row are to be carried right upto the top in subsequent lifts of the steining.

Compressed air from compressors are to be blown through these pipes and nozzle holes to facilitate sinking. Intensity and extent of air jetting have to be controlled by operating one or more rows of pipes at a time or even on one side of the caisson. Pressure of air at any stage of sinking shall be kept 50% more than the water pressure at the bottom of the caisson. Maximum air pressure shall be limited to 7 bars. After the bottom plugging, cement grouting of soil mass around the caisson, in order, shall be taken up through these pipes and nozzles.

Use of explosives

Explosives shall not be generally used as an aid for well sinking. However, in the cases when explosives are to be used, prior approval of the Engineer shall be obtained. Blasting of any sort shall only be done in presence of the Engineer and not before the concrete in the steining has hardened sufficiently and is more than 7 days old. For wells going through boundary strata requiring use of explosives as an aid for well sinking, the entire inside surface of the well curb, shall be protected by a 6mm thick mild steel plate, which shall be suitably stiffened.

If blasting has been used for setting the well after it has reached the design foundation level, 24 hours shall be normally allowed to lapse before the bottom plug is laid.

The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances of any damages to the curb or to the steining of the well.

All prevalent laws concerning handling, storing and using of explosives shall be strictly followed.

There should be no equipment inside the well nor shall there be any labour in the close vicinity of the well at the time of exploding the charges.

Jackdown methods**Use of divers**

Use of divers may be made both for sinking purpose like removal of obstructions, rock blasting and for inspection. All safety precautions shall be taken as per any acceptable safety code for sinking with divers or any statutory regulations in force.

Only persons trained for the diving operation shall be employed and shall be certified to be fit for diving by an approved doctor.

They shall work under expert supervision. The diving and other equipment shall be of acceptable standard and certified to this effect by an approved independent agency. It shall be well maintained for safe use.

Arrangement for ample supply of low-pressure clean cool air shall be ensured through an armoured flexible hose pipe. Standby compressor plant shall be provided in case of breakdown.

Separate high-pressure connection for use of pneumatic tools shall be made. Electric lights, where provided, shall be at 50 volts (maximum). The raising of the diver from the bottom of wells shall be controlled so that decompression rate conforms to the rate as laid down in appropriate regulations.

Use of pneumatic sinking

The Engineer shall familiarize himself with particular reference to 'caisson diseases' and working of the medical airlock. A doctor competent to deal with cases of 'Caisson Diseases' or other complications arising as a result of working under high pressure, shall be stationed at the construction site when pneumatic sinking is under progress.

The Contractor shall provide complete facilities including the issuing of orders to ensure strict enforcement of the requirements outlined in these specifications.

The basic principal of jackdown method is to push down the caisson into the ground by applying load from top of steining through jacks which will take reactions from soil anchors. Soil anchors shall firstly be installed at the pre-determined locations in the bed as per requirement outside the periphery of the caissons and below the depth of the caisson nature of subsoil strata and load to be applied on each anchors. The vertically downward load is to be applied through hydraulic jacks on the steining walls through fabricated steel girders, which are placed on top of steining. The jacks shall be operated individually or collectively and load on each jack shall be varied to control the tilts of caissons during sinking.

The design of the full system of jack down method including the ground anchors, steel girders and jacks shall be taken up by the Contractor and shall have to be approved by the Engineer prior to its implementation. Any such approval by the Engineer on the material, equipment or the system as a whole will not relieve the Contractor for any failure of the system in terms of rate of progress, breakdown of any component or endangering safety of personnel and property or any modification necessary arising out of sinking by jack-down method.

13.10 Precautions during Sinking

When the wells have to be sunk close to each other and clear distance between them is not greater than the diameter of wells, sinking shall be taken up on all wells and they shall be sunk alternately so that sinking of wells proceeds uniformly. Simultaneous dredging shall be carried out in the wells in such a manner that the difference in the levels of the sump and cutting edge in the adjacent wells does not exceed half the clear gap between them. Plugging of all the wells shall be done together.

A sinking history record be maintained at site.

Bore chart shall be referred to constantly during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

Before seasonal floods all wells, on which sinking is in progress, shall be sunk to sufficient depths below the designed scour level. Further, they shall be temporarily filled and plugged so that they do not suffer from any tilt or shift during floods.

All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

The dredged material shall not be allowed to accumulate over the well. It shall be dumped and spread, as far away as possible from the well and then continuously and simultaneously be removed as directed by the Engineer. In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank but on the side on which the river current flows.

Very deep sump shall not be done below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to one-sixth of the outer diameter/least lateral dimension of the well in plan. Normally, the depth of sump shall not exceed 3m below the level of the cutting edge unless otherwise specifically permitted by the Engineer.

In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction of the Engineer to see that no damage has occurred to it.

In pneumatic sinking, the well shall not, at any time, be dropped to a depth greater than 500mm by the method of "blowing down".

When sinking in clay, the work may be done in dry by de-watering but precautions shall be taken regarding the heaving or bursting of the base soil.

De-watering shall be avoided, if sand blows are expected. Any equipment and men working inside the well shall be brought out of the well as soon as there are indications of a sand blow. Sand blowing in wells can often be minimized by keeping the level of water inside the well higher than the water table and also by adding heavy kentledge.

In soft strata, prone to settlement/creep, the construction of the abutment wells shall be taken up only after the approach embankment for a sufficient distance near the abutment has been completed.

13.11 Tilts and Shifts

The inclination of the well from the vertical is known as tilt and the horizontal displacement of the centre of the well at founding level from its theoretical position is known as shift.

Unless otherwise specified, the tilt of any well shall not exceed 1 (horizontal) in 80 (vertical), and the shift at the well base shall not be more than 150mm in any resultant direction inclusive of any shift caused due to tilts.

Tilts and shifts of each well shall be carefully checked, measured and recorded in the format given by the Engineer regularly during sinking operations. Observations to this effect shall be taken at each stage of casting of the steining. Simultaneously as the sinking proceeds, necessary corrective measures be taken to contain the tilts and shifts within the permissible limits.

For the purpose of measuring the tilts along the two axes of the bridge, reduced level of the marks painted on the surface of the steining of the well shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axes with reference to fixed reference points.

Remedial measures to be undertaken

Wherever any tilt is noticed, adequate preventive measures like placing eccentric kentledge, pulling, strutting, anchoring or dredging unevenly and depositing dredge material unequally, putting obstacles below cutting edge, water jetting etc., shall be adopted before any further sinking. After correction, the dredged material shall be spread out uniformly.

A pair of wells close to each other have a tendency to come closer while sinking. Timber struts may be introduced in between the steining of these wells to prevent tilting.

Tilts occurring in a well during sinking in dipping rocky strata can be safeguarded by suitably supporting the curb.

In case of wells where the permissible limits of tilt and or shift are exceeded, approved remedial measures shall be taken by the Contractor to bring the tilt and/or shift within the permissible limits at no extra cost to the Employer.

Acceptance of wells with excessive tilt and/or shift

If the tilt and/or shift of any well exceed the specified permissible values, the well so sunk shall be regarded as not conforming to specifications and may be accepted by the Engineer, provided:

- the tilt and/or shift in any direction do not exceed the extreme limits of 1 in 50 tilt and 300mm shift.
- calculations for foundation pressures and steining stresses, accounting for the actual tilt and shift, furnished by the Contractor, shall show that the well is safe. Any remedial measures, required to bring the stresses within the permissible values (such as increase in the dimension of the well cap, provision of dummy weights on the well cap, adjustment

of span lengths and redesign of superstructure etc.), shall get approved by the Engineer and shall be carried out by the Contractor without claiming for any extra costs.

Action on rejection of a well

In the event of a well being rejected on account of noncompliance with the extreme tilt and/or shift mentioned above, the Contractor shall dismantle the rejected well to the extent directed by the Engineer and remove the debris. The Contractor shall further at his own risk and expenses, complete the bridge with modified span arrangement acceptable to the Engineer.

13.12 Seating of Wells

The well shall be uniformly seated at the founding strata. It shall be ensured by test borings that the properties of the soil encountered at the founding strata and upto a depth of one and a half time the well diameter is identical to that adopted in the Design. The procedure for test borings shall satisfy the provisions of these specifications. In case the encountered soil is inferior to that adopted in the design, the well shall be re-designed by the Engineer adopting the soil properties actually encountered and the founding level intimated to the Contractor, who shall carry out the work.

In case of seating of wells in hard rocky strata, where the rock profile is steeply sloped, pneumatic methods of sinking may be adopted to seat the well evenly as directed by the Engineer. The decision of adopting pneumatic sinking shall be taken by the Engineer. The cutting edge may also be embedded for a suitable depth in the rocky strata, as decided by the Engineer keeping in view the quality of rock. As an additional measure of safety, the well shall be anchored to the rocky strata by anchor bars provided in the steining of the well, as shown on the Drawing irrespective of tension develops or not at the base of the well under design loads.

Inspection of bedding of wells

After the well has been evenly seated on good hard strata, arrangements shall be made by the Contractor to facilitate proper inspection by the Engineer in dry and visible conditions before the bottom plug is laid at no extra cost to the Employer.

13.13 Bottom Plugging

Before plugging the bottom, it shall be ensured by test borings that the soil properties of the founding strata encountered are identical to those adopted in the design and that the founding strata extends for a sufficient depth below the founding level i.e. not less than twice the diameter or the least dimension of the well. The procedure for test borings shall satisfy the stipulations contained under the relevant Sub-section of 'Sub-soil Boring and Testing'. In case the soil encountered is inferior to that adopted in the design, the well shall be redesigned adopting the soil properties actually encountered and the founding level of the well duly revised.

Each well, after being sunk to its final position and ensuring that the curb and whole steining has not developed cracks for its entire length, shall be suitably plugged at its bottom.

For bottom plug, the concrete mix shall be designed (in dry condition) to attain the concrete strength as shown on the Drawing and shall contain 10 percent more cement than that required for the same mix placed dry, to cater for pouring concrete under water. However, the total cement content shall not be less than 363 kg per meter cubic of concrete with a slump in the range of 150mm to 200mm. Admixtures may be added to the concrete to impart the required characteristics indicated herein.

Concrete for the bottom plug shall be laid by 'Tremie Pipe' method. Tremie concreting, when started, shall be continued without interruption for full pouring of concrete in the bottom plug. The concrete production equipment and placement equipment should be sufficient to enable pouring concrete under water within stipulated time. Necessary standby equipment should be made available for emergency situation.

Pouring of Concrete shall be done in one continuous operation till the dredge hole is filled upto the required height and thereafter sounding shall be taken up to ensure that the concrete has been laid to the required height. Least disturbance shall be caused to the water inside the well while laying concrete in the bottom plug. Concrete shall not be disturbed in any way for at least 14 days.

13.14 Testing Wells

In order to check any rise in the level of the bottom plug, soundings shall be taken at the close of laying concrete and for 3 days thereafter once every day. Soundness of each bottom plug, if considered necessary by the Engineer, shall be tested by de-watering the well by 5.0m below the surrounding water level and checking the rise of water. The rate of rise shall preferably be less than 10 cm per hour. In case the rate of rise is higher than that, suitable remedial measures, acceptable to the Engineer, shall be taken. The test shall be done not earlier than 14 days after pouring concrete.

The test shall be carried out by the Contractor at his own cost.

13.15 Filling the Well

The well shall be filled with sand not before a minimum period of 3 days after the bottom plug has been accepted by the Engineer.

Before filling with sand the height of the bottom plug shall be verified.

Sand fill shall be clean and free from earth, clay clods, roots, boulders, shingles etc. Filling shall be carried up to the height shown on the Drawings or as directed by the Engineer.

13.16 Top Plug

After filling the sand up to the required height, top plug shall be laid over it. Thickness of this plug and the grade of concrete to be used shall conform specifications shown on the Drawings or as directed by the Engineer.

13.17 Well Cap

A Reinforced Cement Concrete well cap will be provided over the top of the steining in accordance with the provisions of the Drawings. Formwork will be prepared conforming the shape of well cap. Pouring concrete shall be carried out in dry condition. A properly designed false steining may be provided where possible to ensure that the well cap is laid in dry conditions.

The bottom of the well cap shall be laid preferably as low as possible taking into account the water level prevalent at the time of casting.

Bond rods of steining shall be anchored into the well cap.

13.18 Tolerances

The permissible tilt and shift shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150mm in any resultant direction.

For the well steining and well cap the permissible tolerances shall be as follows:

(a)	Variation in dimension	+50mm – 10mm
(b)	Misplacement from specified position in Plan	15mm
(c)	Surface irregularities measured with 3m straight edge	5mm
(d)	Variation of levels at the top	+25mm

13.19 Load Testing of Foundations

It may be necessary to test wells for acceptance or otherwise to the requirement and satisfaction of the Engineer. Load test shall be performed after the wells are sunk to their designed levels or to the levels as may be decided by the Engineer and before plugging.

The loading shall be normally in the form of sand bags and rolled steel channel sections. However, application of test load by using hydraulic jacks and or any other suitable device may be permitted entirely at the cost and risk of the Contractor.

The Contractor shall prepare all necessary calculations and details of arrangements for such load test. The magnitude of the test load made and method of carrying out the test load and the

observations to be made during and after placing the test loads in position, etc. shall all be done at no extra cost to the Employer. The test loading of well shall be carried out on lines of following specifications in general.

The well to be tested shall first be relieved of all kentledge and other superimposed loads, if any and then filled inside to a depth of at least 3m above the cutting edge with sand. The sand filling may be done through water, if there is water standing in the well, but it shall be ascertained that the well has been evenly filled to a depth of not less than 3m as stated above. Standing water need not be pumped out. But before commencing the loading it shall be allowed to attain a permanent level. No extra cost shall be payable for sand filling in the well before the test or for its removal after the test.

Marks for taking levels will then be made on the well steining at upstream and downstream and on the left and right side of the well. The reduced levels of all these marks shall be recorded carefully before commencing the test load.

The test load to be applied to a particular well will be determined by the Engineer. The procedure of computing the test load shall be:

$$\text{Test Load} = \frac{\text{Steining Area}}{\text{Total Area of Well}} \text{ is it a multiplication (Dead Load} + 2 \times \text{Live Load)}$$

The test load to be determined by the Engineer shall then be applied to a particular well in equal increments. The load will then be allowed to remain for 12 hours and the levels of all the marks taken herein are recorded.

Unloading shall be done in regular decrements of test increments adopted with an interval of 12 hours between each unloading operation and the levels observed at each stage just after unloading as well as 12 hours after that i.e. just before further unloading.

The results of settlement, if any against test load, recovery of settlement against removal of test load and permanent settlement of the well if any shall be noted. For this purpose average of the reading of all marks shall be adopted. Necessary report together with all graphical details and the tabulated results of loading unloading observations made regarding settlement recovery etc., respectively for the loading and unloading condition drawn therefrom shall be furnished to the Engineer by the Contractor.

No extra cost shall be paid for sand filling in the well before the test or for its removal after the test.

Should any well be determined unacceptable from the results of the load test, the said well shall be sunk further and additional load test shall be undertaken by the Contractor and the acceptable founding level shall be determined.

13.20 Measurements

All quantities shall be measured from the Drawing, or as ordered by the Engineer, excepting those required to be provided by the Contractor at his cost which include all setting out, making islands/cofferdams or floating caissons and all other works incidental to concrete well construction excluding the items of measurement indicated below.

The cutting edge shall be measured in tons based on the net weight of metal actually used in it as shown on the Drawing.

The concrete in curb, well steining and well cap shall be measured in cubic meters actually used in each of the items as per the relevant Sub-section. The reinforcements shall be measured separately in tons actually used in each of the items, as per the requirements shown of the Drawings.

The measurement for well sinking shall be made in running meters for different depths irrespective of types of strata/soil. The depth of sinking shall be measured from the level specified in the Contract. If no level has been specified in the Contract, sinking shall be measured from the low water level or from the level at which the cutting edge was laid, whichever is higher.

The quantity of concrete in bottom and top plug shall be measured in cubic meters actually used as per the relevant Sub-section.

The quantity of sand filling shall be measured in cubic meters. The sand filling made to fill up the excess excavation below the bottom plug shall not be measured nor paid for.

Pneumatic sinking, where required, shall be paid as a separate item and shall be measured in cubic meters of material to be excavated.

The Jack Down method, where required, shall be measured as follows will be divided in two items:

Employed number of reusable assembly of jack down system comprising a set of jacks along with associated oil pumps, piping and control system, reaction girders and anchor holding attachments required for one well sinking. One complete reusable assembly of Jack Down system adequate for one well fabricated, assembled and ready for use shall be treated as one unit on lump sum basis. This termed as "recoverable assembly of Jack Down system" complete set for one well shall be measured as number of sets ordered and actually used at site.

All non-recoverable items in sinking of one well by Jack Down method like supply and installation of necessary ground anchors, transport and installation of assembly of Jack Down system, its use in jacking down (sinking) the wells to the specified or required depth of bottom plugging, removal of assembly of Jack Down systems and clearance of undesirable debris for the site along with associated labour and equipment as lump sum per well shall be treated as one unit. The whole operation termed as sinking of well by Jack Down method shall be measured as number of wells where Jack Down method have been ordered and successfully accomplished.

Artificial island shall be measured per number.

13.21 Payment

The Contract unit rates of cutting edge shall cover all costs of labour, material, tools, plant and equipment, including placing in position, sampling, testing, supervision, all incidentals and as described under the relevant Sub-Section of this Specifications.

The Contract unit rates for concrete in curb, steining, bottom plug, top plug and well cap, shall cover all costs of labour, material, tools, plant and equipment, formwork and staging including placing in position, sampling, testing and supervision, all as per Sub-section titled 'Concrete for Structures', all incidentals and for the works as described under the relevant the Sub-section of this Specification.

The Contract unit rates for reinforcement in curb, steining and well cap, shall cover all costs of labour, material, tools, plant and equipment, including bending to shape, placing in position, sampling, testing and supervision, all as per the Section titled 'Reinforcing Steel', all incidentals and for the work as described under the relevant Sub-section of this Specification.

The Contract unit rates for sand filling shall cover all costs of labour, material, tools, plant and equipment, including placing in position, sampling, testing and supervision, all incidentals and all as described under the relevant Sub-section of this Specifications.

The unit rates for sinking shall cover the costs of formation and removal of sand island with or without cofferdams or cost of floating caisson, all costs of labour, tools and equipment and plant and for all operations and other incidentals for sinking of well including seating. It shall also include other operations required like diversion channel, de-watering, excavation and bailing out material, providing and placing kentledge on the top of well and removing the same, sand filling and contingencies warranting provision of temporary top plug in the event of floods being expected at site making further sinking not possible and also other incidental works to sink the well to the level shown on the Drawings. It shall also include blasting or use of divers for removal of obstacles from under the cutting edge of the well. The rate shall be applicable for all types of soils including gravel, pebbles, boulders etc.

The Contract unit rates of material to be excavated by pneumatic sinking shall cover all costs of labour, material, tools, plant and other equipment and other incidentals and safety provisions and supervision required for pneumatic sinking as per the relevant Sub-section of this Specification.

The Contract unit rates for sinking by Jack Down method shall be treated as extra over the unit rate of sinking by conventional method indicated above. The rates shall cover the costs of labour, tools and equipment and plant and for all operations and other incidentals for sinking of wells

including seating. The payment will be divided in two items of measurement as indicated under the Sub-Section 'Measurements' stated above.

The Contract unit rates for artificial island shall be the full compensation for the cost of furnishing all materials like timber piles, bamboo pins, drum/tarja sheets, nails, earth/sand etc. all labours for driving, walling, earth/sand filling, all equipment and incidentals for doing all other works in completing the artificial island in all respect.

Sl.No.	Item of payment	Unit
1.	Cutting edge	M.Tons
2.	Concrete in curb, well steining and well cap	Cubic Meter
3.	Well sinking	Running Meter
4.	Concrete in bottom and top plug	Cubic Meter
5.	Sand filling	Cubic Meter
6.	Pneumatic sinking	Cubic Meter
7.	Jack-down sinking(re-usable assembly)	Set
8.	Jack-down sinking (non-recoverable)	Lump sum
9.	Making artificial island	Each

Reduction in Contract unit rates for sinking as a penalty, in pursuance of the Sub-section titled 'Tilts and Shifts' as stated above.

If any well with tilt and/or shift exceeding beyond permissible values is accepted by the Engineer, the Contractor shall give a reduction in the rates as follows:

Sl. No.	Amount of tilt and/or shift	Percent deduction on the rate(s) for sinking of whole well
1.	Tilt exceeding the specified permissible value but equal to or within 1 in 60	5 percent
2.	Tilt exceeding 1 in 60	10 percent
3.	Tilt exceeding 1 in 50	20 percent
4.	Shift exceeding the specified permissible value but equal to or within 200mm	2 percent

14. TIMBER PILES

14.1 Description

This work shall consist of supplying and driving foundation piles made of timber of the type and dimension in accordance with these specifications and as shown on the Drawings or as directed by the Engineer.

14.2 Materials

Timber piles shall adhere to the requirements of the Specifications for Wood Products, AASHTO M 168. The grades of timber to be used shall be as shown in the Plans or in the special provisions. They should be sound and free from sharp crooks and bends or decay and sufficiently straight so that a line drawn from the centre of the head to the point at the bottom will be wholly within the pile.

14.3 Preservatives and Treatments

Timber piles shall be treated or untreated. When specifications demand treatment of timber piles it should follow strictly the requirements and methods conforming AASHTO M 133. Unless and otherwise specially required on the design Drawings, timber piles those are required to be treated should be impregnated with solignum, creosote or treated with some such anti-rot compounds. Timber piles those are required to be painted may be treated with pentachlorophenol with a Type C solvent or with a water borne preservative. Preservative treatment may not be necessary for piles, which will be completely and permanently submerged in waterlogged ground. In this case seasoning is not necessary and piles may be stored in water prior to use.

14.4 Handling and Storage of Piles

Timber piles shall be lifted, handled, transported and stacked in a way, which will keep the damages to the piles at minimum.

Untreated material shall be open-stacked on supports at least 300mm above the ground surface to avoid absorption of ground moisture and allow free circulation of air. When necessary, the Contractor shall provide shade or appropriate protection from the weather by a suitable covering. The storage area shall be such that no water shall collect under or near the stored timber pile.

14.5 Driving of Piles

The Contractor shall establish all lines, levels and be responsible for the correct positions of all piles. Setting out shall be carried out from the main grid lines of the

proposed structure. Immediately before installation of the pile, the pile position shall be marked with suitable identifiable pins or markers.

The position of the piles shall be set out in accordance with the Drawings from established Bench Marks.

The bark of the piles shall be removed before driving. The bottom is shaped conically for a length of from 1½ to 2 times the diameter or about 0.3m and where the ground is hard it is protected with an iron shoe of V shape. Piles protected by shoes should have a blunt end 100mm to 200mm in diameters. The top is provided with an iron ring or band of size 75mm.

The piles shall be driven to a pre-planned sequence approved by the Engineer in presence of the Engineer's authorized representative in order to minimize the detrimental effects of heave and lateral displacement of the ground. No pile driving shall be allowed at night without prior permission from the Engineer.

The pile heads shall be cut squarely and a drive head provided to hold the longitudinal axis of the pile in line with the axis of the hammer. Pile driving shall be stopped, if the pile head is damaged due to improper driving.

Piles shall be rigidly secured by leads or temporary guide structure against lateral movement during driving and shall be driven without interruption from first blow of the hammer until the required penetration has been attained.

Piles shall be driven to the positions, lines and elevations shown on the Drawings so that the pile centre is within 75mm of the specified location point and with a deviation from the vertical of not more than 2%. If any pile is damaged or driven out of the specified tolerance, the Contractor's proposed remedial measures shall be submitted to the Engineer for his written approval. Notwithstanding the Engineer's approval, the Contractor shall be solely responsible for the design and cost of the remedial works.

Piles should never be driven to "refusal". Piles are considered to be sufficiently driven when five blows fail to drive more than 12mm or when the last blow does not sink the head more than 7mm.

If concrete cap is provided, the piles should be embedded for a depth sufficient to ensure transmission of load. The concrete should be at least 150mm outside the piles and be suitably reinforced to prevent splitting.

The Contractor shall keep a pile driving register in a format approved by the Engineer recording all data covering dimensions, elevation of point, top elevation after cut off, type, make and weight of hammer, height of fall of hammer, average penetration per blow under the last 5 blows. Five copies of the report shall be submitted to the Engineer before any payment will be made for this work.

14.6 Pile Driving Procedure

Pile driving equipment shall secure that it will not damage the pile during driving. List of all driving equipment and appurtenances shall be furnished by the Contractor, which shall be approved by the Engineer in advance of any driving taking place. However, approval of pile driving equipment shall not relieve the Contractor of his responsibilities of driving piles without damage.

Collars, bands or other devices shall be provided to protect piles against splitting and brooming as and when it would be necessary under the driving conditions. Pile shall be pointed where soil conditions would demand it. If necessary, metal shoes of a design, approved by the Engineer, shall be provided. The points of the piles shall be carefully shaped to secure an even and uniform bearing of the shoes.

Each pile shall be driven continuously until the specified set or depth has been reached except that the Engineer may permit the suspension of driving, if he is satisfied that the rate of penetration prior to the cessation will be substantially re-established on resumption or if he is satisfied that the suspension of driving is beyond the control of the Contractor.

At the start of work and in new sections, sets shall be taken at intervals during the last 3m of the driving to establish the behavior of the piles.

The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check the driving resistance. A set shall be taken only in the presence of the Engineer, unless otherwise approved.

The final set of each pile shall be recorded either as the penetration in millimeter per 10 blows or as the number of blows required to produce a penetration of 250mm. The exposed part of the pile and the driving equipment shall be in good condition when the final set is measured.

The Contractor shall inform the Engineer immediately in the event of an unexpected change in driving characteristics is noted.

When required, levels and measurements shall be taken to determine the movement of the ground or any pile resulting from the driving process.

When problems are encountered in the resistance to the pile being driven or with a pile rising as a result of driving of an adjacent pile, the Contractor shall seek and comply with the instructions of the Engineer on methods and procedures to overcome the problem.

14.7 Pile Cut-off

Timber piles shall be cut-off to a true plane at the elevations required and anchored to the structure, as shown on the Drawings. All cut-off lengths of piling shall remain the property of the Contractor and shall be properly disposed of.

Timber piles, which support timber caps or grillage, shall be sawed to conform to the plane of the bottom of the superimposed structure. In general, the length of piles above the elevation of cut-off shall be sufficient to permit the complete removal of all materials injured by driving, but piles driven to very nearly the cut-off elevation shall be carefully adzed or otherwise freed from all broomed, splintered, or otherwise injured materials.

Immediately after making final cut-off on treated timber foundation piles, the cut area shall be given two liberal applications of preservative followed by a heavy application of approved sealer. Treated timber piles which will have the cut-off exposed in the structure shall have the cut area treated with three coats of a compatible preservative material meeting the requirements of American Wood Preservers Association (AWPA) Standard M4-A minimum time period of 2 hours shall elapse between each application.

14.8 Measurement

This work shall be measured separately as the length in linear meters of timber pile supplied and accepted and the length in linear meters of pile driven complete and accepted. The length of pile produced shall be measured as the specified length. The length of piles driven shall be measured from the pile toe to the cut-off level.

14.9 Payment

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit prices per linear meter of pile supplied and linear meter of pile driven, as shown in the Bill of Quantities. The payment shall constitute the full compensation for the supply, treatment, handling and driving of piles including all driving, equipment and all incidentals. Pile shoe shall be paid separately as shown in the Bill of Quantities.

Item of payment

	Unit
Supply of timber piles	Linear meter
Driving of timber pile	Linear meter
Supply and fitting of pile shoe	Each

15. PILE LOAD TESTING**15.1 Description**

In carrying out the Initial Test, the works shall consist of the application of compression load tests to pre-cast and driven or cast in-situ piles selected by the Engineer to determine the potential bearing capacity and adequacy of the piles by measurement of their settlement behavior under the test loads.

15.2 General

This Sub-section deals with the testing of a pile by the application of an axial load or force. It covers vertical piles tested in compression.

15.3 Definitions**Allowable load**

The load which may be safely applied to a pile after taking into account its ultimate bearing capacity, negative friction, pile spacing, overall bearing capacity of the ground below and allowable settlement.

Compression pile

A pile, which is designed to resist an axial force such as would cause it to penetrate further into the ground.

Kentledge

The dead weight used in a load test.

Maintained load test

A loading test in which each increment of load is held constant either for a defined period of time or until the rate of movement (settlement or uplift) falls to a specified value.

Pilot pile

A pile installed before the commencement of the main piling works or a specific part of the works for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimensions and bearing capacity. Pilot piles may be utilized as working piles, subject to the Engineer's approval.

Proof load

A load applied to a selected pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed 200% of the working load on a pile except in the circumstances where special provisions are provided for the testing of pre-cast piles driven to a set. In these circumstances 300% is specified.

Reaction system

The arrangement of kentledge, piles, anchors or rafts that provides a resistance against which the pile is tested.

Tension pile

A pile, which is designed to resist an axial force such as would cause it to be extracted from the ground.

Test pile

Any pile to which a test loading is or is to be applied.

Ultimate bearing capacity

The load at which the resistance of the soil becomes fully mobilized.

Working load

The load which the pile is designed to carry.

Working pile

One of the piles forming the foundation of a structure.

15.4 Supervision

All tests shall be carried out under the direction of an experienced and competent supervisor conversant with the test equipment and test procedures. All personnel, operating the test equipment, shall have been trained in the use.

15.5 Safety Precautions**General**

When preparing for conducting and dismantling a pile test, the Contractor shall carry out the requirement of the various regulations and other statutory requirements those are applicable to the work for the provision and maintenance of safe working conditions and shall, in addition, make such other provisions as may be necessary to safeguard against any hazard that is involved in the testing or preparations for testing.

Kentledge

Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any crib work, beams or other supporting structure in such a manner that there will be no differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it falling apart or becoming unstable because of deflection of the supports.

The weight of kentledge shall be greater than the maximum test load and if the weight is estimated from the density and volume of the constituent materials, an adequate factor of safety against error shall be allowed.

Tension piles and ground anchors

Where tension piles or ground anchors are used, the Contractor shall ensure that the load is correctly transmitted to all the rods or bolts. The extension of rods by welding shall not be permitted unless it is known that the steel will not be reduced in strength by welding. The bond stresses of the rods in tension shall not exceed normal permissible bond stresses for the type of steel and grade of concrete used.

Testing equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring devices are mounted on the pile head, the whole system shall be stable upto the maximum load to be applied. Means shall be provided to enable dial gauges to be read from a position clear from the kentledge stack or test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure and so on might constitute a hazard to personnel.

The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum working pressure without leaking.

The maximum test load or test pressure, expressed as a reading on the gauge in use, shall be displayed and all operators shall be aware of this limit.

15.6 Construction of a Pilot Pile to be Test Loaded

Notice of construction

The Contractor shall give the Engineer at least 48 hours notice of the commencement of construction of any pilot pile, which is to be test loaded.

Method of construction

Each pilot test pile shall be constructed in a manner similar to that to be used for the construction of the working piles and by the use of similar equipment and materials. Any variation shall only be permitted with prior approval of the Engineer.

Extra reinforcement and concrete of increased strength shall be permitted in the shafts of pilot piles at the discretion of the Engineer.

Boring or driving record

For each pilot pile, which is to be tested, a detailed record of the soils encountered during boring or of the progress during driving shall be made and submitted to the Engineer daily not later than noon on the next working day.

Cut off level

The pile shaft shall terminate at the normal cut off level or at a level required by the Engineer.

The pile shaft shall be extended where necessary above the cut-off level of working piles so that gauges and other apparatus to be used in the testing process are not damaged by water or falling debris.

Pile for compression tests

A pile shall not be tested until the curing period is over. In the case of a driven pile, the period shall not be earlier than 72 hours after the driving of the pile is complete.

For a pile that is tested in compression, the head of the test pile shall be cut off, leveled and capped with a steel plate to produce a level bearing surface, square to the axis of the pile and sufficiently large to accommodate the loading and settlement measuring equipment and adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment.

15.7 Preparation of a Working Pile to be Tested

If a test is required on a working pile the Contractor shall cut down or otherwise prepare the pile for testing as required by the Engineer in accordance with the provisions of the relevant Sub-sections of this Specifications.

15.8 Reaction System**Compression tests**

Compression tests shall be carried out using kentledge, tension piles or specially constructed anchorage.

Where kentledge is to be used, it shall be supported on crib work disposed around the pile head so that its centre of gravity is on the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack. Kentledge shall not be carried directly on the pile head, except when directed by the Engineer.

Working piles

Where working piles are used as reaction piles, their movement shall be measured within an accuracy of 0.5mm.

Spacing

Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall be not less than 1.3m.

The center to center spacing of vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2m, whichever is the highest.

Adequate reaction

The size, length and number of the piles or anchors, or the area of rafts, shall be adequate to transmit the maximum test load to the ground in a safe manner without excessive movement or influence on the test pile.

Care of piles

The method employed in the installation of any reaction pile, anchor or raft shall be such as to prevent damage to any test pile or working pile.

Loading arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out at the site.

15.9 Equipment for Applying Load

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The total capacity of the jacks shall be at least equal to the required maximum load. The jack or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test load required for the test.

15.10 Measurement of Load

The Contractor shall supply measuring devices to determine the load on the pile, which shall require the Engineer's approval. Certificates of calibration shall be supplied to the Engineer.

In addition, large diameter (exceeding 1.2m) test piles shall be instrumented at 5 (five) different depths to measure the load distribution along the piles. The instrumentation shall consist of both a mechanical system and strain gauges for measuring the pile deformation. The mechanical system shall consist of 6mm steel rods or high tensile steel wires (Gauge No. 23) placed in steel tubes down to the various depths and connected to dial gauges at the top. The strain gauges shall be of a stable type, wholly protected by a steel capsule. They shall be welded to the steel reinforcement, 2 (two) gauges at each depth.

The approval of the Engineer shall be obtained on the type of gauges to be used and other details on the instrumentation.

15.11 Adjustability of Loading Equipment

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of a maintained loading test.

15.12 Measuring Movement of Pile Heads

General

In a maintained load test, movement of the pile head shall be measured by two of the methods as described below. One method for settlement measurements and the other for control.

Leveling method

An optical or any other leveling method by reference to an external datum may be used.

Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5mm. A scale attached to the pile or pile cap may be used instead of a leveling staff. At least two datum points shall be established on permanent objects or other well-founded structures, or deep datum points shall be installed. Each datum point shall be situated so that only one setting up of the level is needed.

No datum point shall be affected by the test loading or other operations at the site.

The written approval of the Engineer shall be required in the case any other method of leveling is proposed.

Independent reference frame

An independent reference frame may be set up to permit measurement of the movement of the pile. The supports for the frame shall be founded in such a manner and at such a distance from the test pile, kentledge support cribs, reaction piles, anchorage and rafts that movements of the ground in the vicinity of the equipment do not cause movement of the reference frame during the testing. Check observations of any movement of the reference frame shall be made and a check shall be made of the movement of the pile head in relation to an external datum during the progress of the test. In no case shall the supports be less than 3 (three) test pile diameters or 2m, whichever is greater, from the center of the test pile.

The measurement of pile movement shall be made by two dial gauges rigidly mounted on the reference frame that bear on surfaces normal to the pile axis fixed to the pile cap or head. Alternatively the gauges may be fixed to the pile and bear on the surfaces on the reference frame. The dial gauges shall be placed in diametrically opposite positions and be equidistant from the pile axis. The dial gauges shall enable the readings to be made within an accuracy of 0.1mm.

The reference frames shall be protected from sun and wind.

Other methods

The Contractor may submit for approval of the Engineer any other method for measuring the movement of pile heads.

15.13 Protection of Testing Equipment

Protection from weather

Throughout the test period, all equipment for measuring load and movement shall be protected from weather.

Prevention of disturbance

Construction equipment and persons who are not involved in the testing process shall be kept at away a sufficient distance from the test to avoid disturbance to the measurement apparatus.

15.14 Supervision

Notice of test

The Contractor shall give the Engineer at least 24 (twenty four) hours notice of the commencement of the test.

Records

During the progress of a test, the testing equipment and all records of the test as required under this Specification shall be available for inspection by the Engineer.

15.15 Test Procedure

Loading procedures

The test load shall be concentrically applied to the pile by such a method that the load acting on the pile at any time may be determined, adjusted and controlled. The load shall be applied to the pile as near to the ground surface as possible.

The load shall be applied and removed in increments based on the anticipated working load of the pile with the following schedule.

Load as Percentage of Working Load		Minimum Time of Holding Load
Bored Piles	Driven Piles	
25	50	1 hour
50	100	1 hour
75	125	1 hour
100	150	1 hour
75	125	10 minutes
50	100	10 minutes
25	50	10 minutes
0	0	1 hour
100	150	6 hours
125	200	1 hour
150	250	6 hours
175	275	1 hour

Load as Percentage of Working Load		Minimum Time of Holding Load
Bored Piles	Driven Piles	
200	300	24 hours - Proof Load
175	275	10 minutes
150	250	10 minutes
125	225	10 minutes
100	200	10 minutes
75	150	10 minutes
50	100	10 minutes
25	50	10 minutes
0	0	1 hour

Following application of each increment of load, the load shall be held for not less than the period shown in the Table and until the rate of settlement is less than 0.25mm per hour and is slowing. Readings of settlement and of the time at which they are made, shall be taken immediately before and after the application of each load increment and at intermediate intervals 20 (twenty) minutes apart for the first four hours and 60 (sixty) minutes apart thereafter.

Each stage of unloading shall proceed to the schedule shown in the Table. During unloading, readings of rebound and of the time at which they are made, shall be taken immediately after each increment of load is removed and at intermediate intervals of 20 (twenty) minutes. A final rebound reading shall be taken 24 (twenty-four) hours after the entire test loads have been removed.

A check for the accuracy of the measurement of settlement shall be made from a fixed reference point on a permanent object or well founded structure. This reference point shall be at least 3m off from the nearest point of the test pile.

During the progress of the test, all readings taken shall be available for inspection by the Engineer.

Safe load through initial test (Single pile)

The safe load on single pile shall be the smallest of the following:

- (a) Two thirds of the final load at which the total settlement attains a value of 12mm unless it is established that a total settlement different from 12mm is permissible in a given case on the basis of nature and type of structure. In the latter case the actual total settlement permissible shall be used for assessing the safe load instead of 12mm.
- (b) Two-thirds of the final load at which the net settlement attains a value of 6mm.
- (c) 50 percent of the final load at which the total settlement equals one tenth of pile diameter.

Pile foundation design and construction

The safe load on groups shall be the smallest of the following:

- (a) The final load at which the total settlement attains a value of 25mm unless a total settlement different from 25mm is specified in a given case on the nature and type of structure.
- (b) Two-thirds of the final load at which the total settlement attains a value of 40mm.

Presentation of results

Within 24 hours of completion of the test, the Contractor shall submit a summary of results to the Engineer stating, for each stage of loading and unloading, the period for which the load was held and the maximum settlement or rebound.

Within seven days of completion of the test the Contractor shall submit a full schedule of test data to the Engineer, which shall include the following:

a) General

- ① Project.
- ① Contract identification.
- ① Proposed structure.
- ① Date of test.

b) Pile details

- ① Date of casting.
- ① Pile reference number and location.
- ① Type of pile.
- ① Length on ground.
- ① Level of toe.
- ① Ground level at pile position.
- ① Head level at which test load applied.
- ① Condition of pile head.
- ① Details of permanent casing.

c) Installation details

- ① Dates and times of boring, driving and pouring concrete of test pile and adjacent piles.
- ① Date and time of casting concrete.
- ① Driven length of pile or temporary casing at final set.
- ① Hammer type, size or weight.
- ① Dolly and packing, type and condition before and after driving.
- ① Driving length (depth, blows per 250mm, interruptions or breaks in driving).
- ① At final set and at re-drive set, for drop of single action hammer the length of the drop or stroke, for diesel hammer the length of the stroke and the blows per minutes, for double-acting hammers the number of blows per minute.
- ① Condition of pile head or temporary casing after driving.

d) Test procedure

- ① Weight of kentledge
- ① Tension pile, ground anchor or compression pile details
- ① Plan of test arrangements showing position and distances of kentledge supports,
- ① Rafts, tension or compression piles and reference frame to test pile
- ① Jack capacity
- ① Method of Load measurement
- ① Method(s) of penetration measurement
- ① Relevant dates and times

e) Full test results

- ① In tabular and graphical form detailing loads, time and movement. The graphical presentation shall consist of:
- ① Load verses Time
- ① Load verses gross settlement and rebound for each cycle of loading
- ① Load verses net settlement and rebound for each cycle of loading.

15.16 Completion of a Test**Measuring equipment**

On completion of a test all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in further tests or removed from the site.

Kentledge

Kentledge and its supporting structure shall be removed from the test pile and stored so that they are available for use in further tests or removed from the site.

Temporary piles

On completion of a preliminary test, temporary tension piles shall be cut off below ground level, removed from the site and the ground made good with approved materials as specified.

15.17 Measurement

This work shall be measured as the number of pile compression load tests satisfactorily conducted and completed.

15.18 Payment

The amount of completed and accepted work measured as provided above shall be paid for at the Contract unit prices per load test as shown in the Bill of Quantities. The payment shall constitute the full compensation for conducting the test including all test equipment, provision of kentledge, carrying out tests, dismantling of equipment and removal from site, cleaning of site, preparation of all reports, materials, personnel, tools and all incidentals necessary to complete the entire tests.

Item of payment

	Unit
Load Test on piles	Each

15.19 Integrity Test

Integrity test of cast-in-situ pile by placing a small accelerometer on the top of a pile while hitting the pile head with a small hammer. The shock wave traveling through the pile propagate with the velocity of sound in concrete which is 3000-3500 m/s approximately or as decided by the Engineer, as per approved method. (For up to 10 nos. pile of a single bridge).

Item of payment

	Unit
Integrity test (For up to 10 nos. pile of a single bridge)	Each

16. CONCRETE FOR STRUCTURES

16.1 Description

This work shall consist of construction of all Portland Cement Concrete in structures, with or without reinforcement, which shall involve furnishing, placing, finishing and curing of concrete. All items of concrete work shall include elements of structures constructed by cast-in-place and pre-cast methods using either plain, reinforced or pre-stressed concrete or any combination thereof and shall conform to these specifications, Sub-sections and requirements. All structures shall be built in a workman like manner to the lines, grades and dimensions shown on the Drawings or as directed by the Engineer.

All concrete works shall be carried out in accordance with BS 8110 or AASHTO M-241 or ASTM C-685 and as specified by the Engineer.

All sampling and testing of constituent materials shall be carried out in accordance with the provisions of the appropriate British or American Standard and all sampling and testing of fresh and hardened concrete shall be carried out in accordance with the provisions of BS 1881 "Method of Testing Concrete" or similar under AASHTO T 22 or ASTM C 39.

16.2 Materials

Concrete shall be manufactured with the essential ingredients of Portland cement, fine aggregate, coarse aggregate and water as specified and shall be well mixed and brought to the proper consistency. Type and source of ingredients used in concrete shall conform to the approved samples and shall not be varied. The requirement for concrete, its constituent materials, methods and procedures shall conform to any of the Standard Specifications of AASHTO, ASTM, or BS unless otherwise specified herein or directed by the Engineer.

Cement

Cement used in the works shall be Ordinary Portland Cement complying with the requirements of ASTM C150 Type 1 or BS 12 or equivalent standard and those stated under the Section on 'Construction Materials' of this Specification. Special cements shall conform to the requirements laid down by the Engineer.

Use of cement

Cement of different manufacturers and with different brands or types shall be kept separately and shall not be used in the same mix.

Consignment of cement shall be used in the order of delivery.

Only one brand, grade or kind of cement shall be used in a given structure, except upon the written permission of the Engineer.

Coarse aggregate

Coarse aggregate for all types of Concrete with the exception of blinding concrete shall conform to the requirements of AASHTO Standard Specifications M 80.

Coarse aggregate shall be hard, durable, clean, free from dust and other deleterious materials. The grading of the coarse aggregate shall be such that when combined with the approved fine aggregate and cement, it shall produce a workable concrete of maximum density.

Materials shall conform to the requirements specified and in the relevant Sub-section under Section titled 'Construction Materials' of this Specifications.

Different sizes of coarse aggregates should be mixed in proportions, which would be determined during trial mixes. The coarse aggregate to be used in the concrete mix shall be dry mixed from different sizes in specified/selected proportion one day before casting.

Nominal size

Nominal size of the coarse aggregate shall not be larger than one-fifth of the narrowest dimension between sides of forms or one-third the depth of slabs or three-fourth the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, or pre-stressing tendons or ducts. These limitations regarding the size may be waived, if in the judgement of the Engineer, workability and methods of consolidation are such that concrete can be placed without honeycomb or voids.

Fine aggregate

Fine aggregates shall be non-saline clean natural sand and have a specific gravity not less than 2.6, a Fineness Modulus not less than 1.8 and conform to the requirement of AASHTO Standard Specification M-6.

Materials shall conform to the requirements specified in the relevant Sub-section titled 'Construction Materials' of this Specification.

Water

All sources of water for use in concrete shall be subject to the approval of the Engineer. Water shall be reasonably clear, free from injurious quantities of oil, alkali, salts and organic substances and shall not contain any visibly solid materials. Water whose concentration of chloride ion is in excess of 3,000

ppm (parts per million) shall not be used for the production of concrete. If requested by the Engineer, water shall be tested by comparing with water of known satisfactory quality. Such comparison shall be made by means of standard cement tests for soundness, time of setting and mortar strength. Any indication of unsoundness, change in time of setting of plus or minus 30 minutes or more, or reduction of more than 10 percent in mortar strength shall be sufficient cause for rejection of the water in question. Water submitted for tests to determine its compliance with these Specifications shall be tested by the latest revision of AASHTO Method T 260.

Admixtures

Suitable admixtures may be used in concrete mixes with the prior acceptance of the Engineer. The type and source of admixture, and the amount added and method of use shall be to the acceptance of the Engineer, who shall be provided with the following data:

- The manufacturer's recommended dosage and detrimental effects of under-dosage and over-dosage.
- The chemical name of the main active ingredients in the admixture.
- Whether or not the admixture contains chloride and, if so, the chloride content of the admixture expressed as a percentage of equivalent anhydrous calcium chloride by weight of admixture.
- Whether or not the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage.
- Evidence of previous satisfactory performance of concrete containing the additive.

Admixtures containing chloride other than impurities from admixture ingredients shall not be used in concrete containing embedded aluminium, or in concrete cast against permanent galvanized metal forms.

In admixtures for use in reinforced concrete the chloride ion content shall not exceed one percent by weight of the admixture. Admixtures in excess of 0.1 percent shall not be used in pre-stressed concrete.

If more than one admixture is used, the admixtures shall be compatible with each other and shall be incorporated into the concrete mix in correct sequence so that the desired effects of all admixtures are obtained.

All admixtures shall be used strictly in accordance with the manufacturer's instructions. A literature of compliance of the admixture shall be furnished to the Engineer for each shipment of admixture used in the work. The said literature shall be based upon laboratory test results from an approved testing facility and shall authenticate that the admixture meets all requisite specifications.

Air entraining admixtures shall be of such a type that the air content can be maintained within the limits specified irrespective of extension of mixing time to 30 minutes.

Fly ash or other pozzolans used as admixtures shall conform to 'Specification for Fly Ash and Raw or Calcined Natural Pozzolan for use as a Mineral Admixture in Portland Cement Concrete (ASTM C 618)'. All air entraining admixtures shall conform to 'Specification for Air entraining Admixtures for Concrete (ASTM C 260)'.

All concrete used to fill temporary construction access holes in the viaduct girders shall be provided with an approved shrinkage compensating admixture.

Air entraining and chemical admixtures shall be incorporated into the concrete mix in a water solution. The water so included shall be considered to be a portion of the allowed mixing water. Admixtures shall be incorporated through a dispensing system sufficiently accurate to deliver within + 5% of the approved dosage rate.

16.3 Testing of Materials

Part-8: Bridge & Culverts

Cement

Hydraulic cement shall be sampled and tested in accordance with the standard methods referred to in STP Section 10 and AASHTO M 85.

Cement may be sampled either at the factory or at the site of the Work as provided in the above specification.

The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement, either at the factory or upon delivery. If this is not done or if additional tests are necessary, the Contractor may be required to re-handle the cement in the store for the purpose of obtaining the required samples.

Sampling shall normally be instructed by the Engineer for every stored 200 cubic meter of concrete production with the concerned cement type or if the source of cement has been changed.

Testing outside the scope of the site or LGED laboratory shall be carried out in testing laboratory approved by the Engineer.

Aggregate

Tests to assess the suitability of the aggregates proposed for use in concrete to be placed in the permanent works shall be as follows:

- Grading
- Magnesium sulphate soundness
- Specific gravity and water absorption
- Clay, silt and dust content
- Organic impurities
- Sulphate and chloride content
- Elongation and flakiness
- Potential alkali reactivity
- Los Angeles Abrasion Test
- Aggregate drying shrinkage.

These tests are to be carried out in accordance with the appropriate ASTM standards and the results shall comply with the limits given therein or as otherwise stated in this Specification. Grading shall be carried out at least at weekly interval when concrete is being produced on a regular basis or before the start of production when irregular.

The Contractor shall supply samples of the aggregate materials proposed to be used for testing of Elongation and Flakiness Index and Los Angeles Abrasion Value (coarse aggregate) and Fineness Modulus (fine aggregate) and grading and other tests as required by the Engineer.

From the aggregate materials proposed by the Contractor, samples shall be selected according to STP Section 1 and 2 in the presence of the Engineer. The samples shall be brought to the site laboratory and tested for proving their conformance with the relevant Sub-section on 'Material Testing' of this Specification and of this Sub-section.

The quality control of the aggregate shall be as directed by the Engineer. Grading shall normally be checked daily.

Moisture content of the aggregate shall be determined daily and at any time when a change in the moisture content is expected.

If the Contractor proposes to change the source of supply of aggregate, samples from the new source shall similarly be supplied and tested.

Grading of mixed coarse aggregate shall be checked at site.

Water

The water used in mixing or curing concrete shall be tested by methods described in AASHTO Test Method T 260.

In sampling water for testing, care shall be taken that the containers are clean and that samples are representative.

When comparative tests are made with a water of known satisfactory quality, any indication of unsoundness, marked change in time of setting, or a reduction of more than 10 percent in mortar strength, shall be sufficient cause for rejection of the water under test.

The water shall be tested at a recognized laboratory approved by the Engineer when it falls outside the scope of the LGED Laboratory. The test results shall be signed by the laboratory-in-charge. The water shall be tested before commencement of work or any time required by the Engineer, or if the source is changed.

Admixtures

The Contractor shall submit to the Engineer specifications and samples of any admixture or additive that he proposes to use at least 28 days before the commencement of construction or manufacture of the particular structure on which he intends to use the admixture.

Any tests the Engineer may require on concrete mixes on account of the Contractor's proposal to use additives, shall be carried out at the expenses of the Contractor.

16.4 Composition of Concrete

Concrete classes

The class of concrete and properties applicable to the concrete in various parts of structures shall be as specified in the following table.

Each mix shall be designed to ensure optimum workability, prevent segregation and produce a dense, durable concrete by adjusting the fine and coarse aggregate proportions following procedures as stated under the section of 'Design of Concrete Mix' of this Sub-section.

Concrete Class	Minimum cement content kg/m³	Maximum water/cement Ratio Percent	28 day Cylinder Strength in kg/cm²
A-1	440	0.43	350
A-2	400	0.45	300
A-3	365	0.49	250
A-4	400 ^a	0.58	250
A-5	350	0.52	210
B-1	363 ^a	0.58	210
B-2	240	0.43	100

Denotation of a:

Minimum cement content specified includes 10% extra cement for concrete placed under water. The strength specified is for concrete mix designed for dry condition and without the 10% extra cement for under water concrete placement.

Size of coarse aggregate shall be 20mm unless otherwise specified.

Unless otherwise specified or directed by the Engineer, the requirement of air content in concrete shall be as per guidelines of standard specifications for Highway Bridges, AASHTO, 1996.

Location of concrete by class

The various classes of concrete shall be placed in the locations specified below and elsewhere as directed.

➤ Class A-1	➤ Pre-stressed Concrete for post tensioned and pre-tensioned members.
➤ Class A-2	➤ RCC pier column and cap monolithic to pre-stressed concrete superstructures.
➤ Class A-3	➤ RCC for superstructures generally not in contact with water, such as railing, rail post, wheel guard, deck slab, girder, cross-girder, fillet, ribs, double and single face new jersey concrete barriers, side walk, RCC pre-cast piles.
➤ Class A-4	➤ RCC cast-in-situ bored pile
➤ Class A-5	➤ All vertical members of sub-structures such as RCC pier cap, pier column, retaining wall, wing wall, abutment wall, approach slab, top and bottom slab of RCC box culvert including fillets, vertical member of RCC box culvert, top plugging of well/caisson, well cap, well steining and curb, adjacent/related fillets and ribs.
➤ Class B-1	➤ Plain Cement Concrete (Structural use – well bottom plug)
➤ Class B-2	➤ Plain cement concrete (Non-structural use - leveling/blinding concrete).

Regulation of water content

The amount of water used in the concrete for volume batching shall be regulated to adjust for any variation of the moisture content or grading of the aggregates as they enter the mixer as follows:

The batched volume of damp fine aggregate shall be corrected to the equivalent volume of dry aggregate. The volume of moisture in the aggregates shall be deducted from the free water to be added to the mix. To expedite correction to fine aggregate a “bulking curve” showing the relation between moisture content and increase over dry volume shall be prepared in advance by tests on the fine aggregate used. The Engineer may direct the use of a slump less than that specified whenever concrete of such lesser slump can be consolidated into place by means of vibration specified herein. Addition of water to overcome stiffening of the concrete before placing will not be permitted. Concrete shall have uniform consistency from batch to batch. Aggregate shall not be batched for concrete when free water is dripping from the aggregate.

Concrete mix proportions shall be such that the concrete is of adequate workability and can properly be compacted. Suggested ranges of values of workability of concrete for some placing conditions are given in the Table given below.

Degree of Workability	Placing conditions	Nominal maximum aggregate (mm)	Compacting factor	Slump mm
Very low	Small sections (i.e. pre-cast or > 300mm thick) subjected to intensive vibration and large sections to normal vibration	20	0.78	0 – 10
		40	0.78	0 – 25
Low	Simple reinforced sections with	20	0.85	10 – 25

Degree of Workability	Placing conditions	Nominal maximum aggregate (mm)	Compacting factor	Slump mm
	vibration and large sections without vibration	40	0.85	25 – 50
Medium	Simple reinforced sections without vibration and heavily reinforced sections with vibration	20	0.92	25 – 50
		40	0.92	50 – 100
High	Heavily reinforced sections without vibration	20	0.95	50 – 125
		40	0.95	100-175

Durability of concrete

Special exposures

For concrete intended to have low permeability when exposed to water, the water cement ratio shall not exceed 0.50.

For corrosion protection of reinforced concrete exposed to brackish water, sea water or spray from these sources, the water cement ratio shall not exceed 0.40.

If minimum requirement of concrete cover as given under the Section on 'Reinforcing Steel' is increased by 12mm, water cement ratio may be increased to 0.45.

The requirement of water cement ratio as stated above and the Table given below on Normal Weight Aggregate Concrete exposed to Sulphate containing solutions shall be calculated using the weight of cement meeting the requirements of ASTM C 150 or C 595, plus the weight of fly ash or pozzolan satisfying ASTM C 618 and/or slag satisfying ASTM C 989, if any.

Sulphate exposures

Concrete to be exposed to sulphate containing solutions or soils shall conform to the requirements of the Table given below or be made with a cement that provides sulphate resistance with the maximum water cement ratio provided in the Table.

Calcium chloride shall not be used as an admixture in concrete exposed to severe or very severe sulphate containing solutions, as defined in the Table given below.

Requirements for Normal Weight Aggregate Concrete Exposed to Sulphate Containing Solutions

Sulphate Exposure	Water Soluble Sulphate (SO ₄) in Soil, percent by Weight	Sulphate (SO ₄) in Water (ppm)	Cement Type ¹	Maximum Water Cement Ratio, by Weight
Negligible	0.00-0.10	0-150		
Moderate ²	0.10-0.20	150-1500	II, IP(MS), IS(MS), P(MS), I(PM) (MS) I(SM) (MS)	0.50
Severe	0.20-2.00	1500-10,000	V	0.45

Very severe	Over 2.00	Over 10,000	V plus pozzolan ³	0.45
Note :	4. For types of cement see ASTM C150 and C595. 5. Sea water 6. Pozzolan that has been determined by test or service record to improve sulphate resistance when used in concrete containing Type V cement.			

Corrosion of reinforcement

For corrosion protection, maximum water soluble chloride ion concentrations in hardened concrete at ages from 28 to 42 days contributed from the ingredients including water, aggregates, cementitious materials, and admixtures, shall not exceed the limits specified in the Table given below. When testing is performed to determine water soluble chloride ion content, test procedure shall conform to AASHTO T 260, "Methods of Sampling and Testing for Total Chloride Ion in Concrete and Concrete Raw Materials".

Maximum Chloride Ion Content for Corrosion Protection

Type of Member	Maximum Water Soluble Chloride Ion (C1) in Concrete, Percent by Weight of Cement
Prestressed concrete	0.06
Reinforced concrete exposed to chloride in service	0.15
Reinforced concrete that will be dry or protected from moisture in service	1.00
Other reinforced concrete construction	0.30

When reinforced concrete will be exposed to brackish water, sea water, or spray from these sources, the above requirements for water cement ratio, or concrete strength and minimum cover requirements (shown under the Sub-section on 'Concrete Cover to Reinforcement' of 'Reinforcing Steel') shall be satisfied.

Minimum concrete strength

Minimum concrete strength for structural use of reinforced concrete shall be 20 N/mm².

Design of concrete mix

When designing the concrete mix the following conditions shall be considered:

Strength	:	The class of the concerned concrete is to be as shown on the Drawings. The class is the specified cylinder strength of 28 days and shall be determined as indicated above in the Table under section on 'Concrete Classes' of this Sub-section.
Water/Cement Ratio	:	The ratio of free water to cement when using saturated surface dry aggregate shall be as low as possible and not to exceed 0.50 by weight for all concrete. For concrete in concrete barriers, edge beams and bridge deck directly exposed to traffic or concrete in pile caps or abutments in contact with the ground, the water cement ratio shall not exceed 0.45.
Cement Type and	:	Type-I Cement shall be used for all classes for "Concrete" and the minimum cement content shall be as indicated above in the

Minimum Content		Table under section on 'Concrete Classes' of this Sub-section.
Minimum Filler Content	:	Filler is defined as fine concrete aggregates including cement with a grain diameter less than 0.25mm. It shall not be less than (except mass concrete) 435 Kg per cubic meter Concrete for maximum 20mm size Coarse Aggregate. The same for maximum 40mm size Coarse Aggregate shall not be less than 350 kg per cubic meter of Concrete.
Coarse Aggregate	:	The maximum size of the coarse aggregate shall be either 40mm or 20mm and the grading and quality shall be as indicated in the portion of 'Coarse Aggregate' under the Sub-section on 'Construction Materials' of this Specification.
Fine Aggregate	:	The grading and quality is to be as indicated in the portion on 'Fine Aggregate' under the Sub-section on 'Construction Materials' of this Specification
Workability	:	The concrete shall be of suitable workability to obtain full compaction. Slumps measured by STP T8.1.1 shall be in accordance with the values shown unless otherwise required or approved by the Engineer. The designed concrete mix shall be approved by the Engineer to meet the requirements for each structural component as shown under the section on 'Concrete Classes' of this Sub-section.

Prior to the commencement of concrete operations, the Contractor shall design a mix for the concrete and prepare and test concrete samples of this mix under laboratory conditions. Preliminary mixes shall be repeated and adjusted as necessary to produce a concrete mix meeting the requirements stated under "Composition of Concrete" of this Sub-section. The details of the mix and test results shall be submitted to the Engineer for his approval.

Following the Engineer's approval of the mix design, the Contractor shall prepare a trial mix in the presence of the Engineer. The trial mix shall be batched, mixed and handled using the same methods and plant, the Contractor proposes to use. The mix shall comprise not less than half a cubic meter of concrete. The proportions of cement, aggregates and water shall be carefully determined by weight in accordance with the Contractor's approved mix design and sieve analysis shall be made of the fine and coarse aggregates.

Twelve concrete cylinder samples shall be made from the trial mix in the presence of the Engineer. The concrete cylinders shall be made, cured, stored and tested in accordance with BS 1881. Six cylinders shall be tested at 7 days and six cylinders shall be tested at 28 days. If the strength of any of the cylinders tested at 28 days is recorded below the characteristic strength, the Contractor shall redesign the mix, make further preliminary mixes for the Engineer's approval. He shall then undertake additional trial mixes and test the resultant samples until a satisfactory mix is obtained and approved by the Engineer.

From the same mix as that from which the test specimens are made, the workability of the concrete shall be determined by the slump test in accordance with STP T8.1.1. The remainder of the mix shall be cast in a wooden mould and compacted. After 24 hours, the sides of the mould shall be struck off and the surface examined in order to satisfy the Engineer that an acceptable surface can be obtained with the mix.

When a proposed mix has been approved, no variation shall be made in the mix proportions, or in the type, size, grading zone or source of any of the constituents without the consent of the Engineer. He may require further trial mixes to be made before any such variation is approved.

Until the results of trial mixes for a particular class have been approved by the Engineer, no concrete of the relevant class shall be placed in the works.

During production, the Engineer may require additional trial mixes before a substantial change is made in the materials or in the proportions of the materials to be used. However, it will not need to be

carried out when adjustments are made to the mix proportions during production in order to minimize the variability of strength and to approach more closely the target mean strength.

Trial mixes for mass concrete are not requested provided the Contractor is able to submit test results from mixes carried out before, which prove that the demanded quality of the mass concrete is according to the specifications.

When the Contractor intends to purchase factory-made pre-cast concrete units, trial mixes may be dispensed with provided that evidence is given to satisfy the Engineer that the factory regularly produces concrete, which complies with the Specification. The evidence shall include details of mix proportions, water-cement ratios, slump tests and strengths obtained at 28 days.

Selection of the trial mix is the ultimate responsibility of the Contractor irrespective of the fact that the Engineer has accorded approval.

Proportioning of mix

Proportions of materials for concrete shall be such that:

- a) Workability and consistency are achieved for proper placement into forms and around reinforcement, without segregation or excessive bleeding.
- b) Resistance to special exposures to meet the durability requirements are provided, and
- c) Conformance with strength test requirements is ensured.

The approved mix shall be proportioned by weight or, except cement by volume, if volume batching is approved by the Engineer. Allowance shall be made for the moisture content of the aggregates.

Fine and coarse aggregates and water may only be measured by volume in boxes or containers approved by the Engineer. Cement shall be added to Concrete Mixer by whole number of bags only.

16.5 Concrete in Blinding Layers

The blinding concrete/lean concrete (Mix 1:3:6) shall be mixed in proportion by volume wherever specified on the Drawings. Ordinary Portland Cement and well-graded aggregate of maximum nominal size, not exceeding 40mm, shall be used unless otherwise specified.

16.6 Batching

The Contractor shall provide and maintain suitable measuring equipment and devices of good order required to determine and control accurately the relative amount of various materials entering the mix.

All measurements shall be by weight/volume and shall be accurate within a tolerance of 1% for each batch. Besides, the deviation from the average amount of filler (materials including cement less than 0.25mm) from ten samples of different batches of fresh concrete should not be more than 6%.

Satisfactory methods of handling materials shall be employed.

A batching plant shall be used for measuring materials but alternative methods proposed by the Contractor may be considered subject to the approval of the Engineer. The batching plant shall include bins, weighing hoppers and scales for the fine aggregate and for each separated size of coarse aggregate. If cement is used in bulk, a bin, hopper and scales for the cement shall be included. The container shall be water-tight.

Provisions satisfactory to the Engineer shall be made for batching other components of the mix at the batching plant or at the mixer, as may be necessary. The batching plant may be either of stationary or of mobile type. It shall always be properly leveled within the accuracy required for the proper operation of the weighing mechanisms.

Bins and hoppers

Bins with adequate separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that as the quantity desired in the weighing hopper is being approached the material may be added slowly and shut off with precision. A port or other opening for removing an overload of the several materials from the hopper shall be provided.

Weighing hoppers shall be constructed so as to discharge fully.

Scales

The scales for weighing aggregates and cement shall be of either the beam type or the dial type without spring. They shall be accurate within one-half of 1% under operating conditions throughout the range of use. Ten 25 kg weights shall be available for checking the accuracy. All exposed fulcrums, clevises and similar working parts of scales shall be kept clean. When beam-type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 100 kg of load and upto 25 kg over-load. All weighing and indicating devices shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls.

Cement may be measured by weight, or in standard bags weighing 50 kg net each. When measured by weight, a separate satisfactory scale and hopper shall be provided together with a boot or other approved device to transfer the cement from the weighing hopper.

The amount of water shall be measured by weight separately on an individual scale or may be measured by volume.

Any solid admixture, to be added, shall be measured by weight; but liquid or pest admixtures may be measured by volume or weight.

16.7 Quality Control of Concrete

General

The Contractor shall assume the full responsibility that the quality of the concrete conforms to the specifications and this responsibility shall not be waived by the tests carried out and approved by the Engineer. The Contractor shall thus at his own discretion establish additional testing procedures as necessary.

The Contractor shall be responsible for providing samples of concrete and its constituent materials either for testing by himself or for testing at the Engineer's laboratory or laboratory designated by the Engineer. For this purpose, concrete test cylinders which shall be made in accordance with BS 1881/AASHTO T 23 (ASTM C 31) shall be deemed to be 'samples'. All sampling of constituent materials shall be carried out in accordance with the provisions of the appropriate British/American Standard and all sampling of fresh and of hardened concrete shall be carried out in accordance with the provisions of BS 1881/AASHTO T 23 (ASTM C 31) unless such provision is at variance with the Specification.

The tests, which the Contractor is required to undertake on behalf of the Engineer are those to be carried out on fresh concrete at the place of final deposit, or elsewhere at the site as directed by the Engineer.

Adjustment of water/cement ratio

The Contractor shall test aggregates for moisture content and so determine the water- cement ratio of

the fresh concrete. Determination of water-cement ratio shall be carried out as required by the Engineer and the results and calculations shall be submitted to him.

Slump tests

Slump testing of concrete shall be carried out as required by the Engineer. The minimum is one test at the commencement of each casting, one per hour of casting and one each time a strength test specimen is taken.

A slump cone shall be made available at site by the Engineer and testing shall be as per STP T 8.1.

The slump of concrete to be used in the works shall not exceed the slump of the trial mix by more than 10% and shall in any case not be more than the maximum specified.

Compressive strength

The Contractor shall, in the presence of the Engineer, sample concrete for testing from the batching and mixing plant at the time of pouring of concrete into the forms or elsewhere. Samples shall be obtained at uniform intervals throughout the production or delivery of concrete for a given placement.

Cylinder or cube testing of concrete strength shall be carried out as required by the Engineer. A minimum of three test cylinders or cubes shall be taken for each day's casting or for every 15 cubic meters of concrete cast in larger pours.

After stripping, each cylinder shall be indelibly marked with the date of taking cylinder or cubes, location in the structure and prescribed number.

2 sets of three test moulds (cylinder or cube) shall be made available at site by the Engineer. Samples for testing shall be taken in the presence of the Engineer and shall be dated.

Test cylinders or cubes shall be tested for 7 days and 28 days compressive strength as per STP T 8.2.

The average strength of the cylinders or cubes, tested at 28 days, shall exceed the specified strength. One out of the three cylinders or cubes tested may have a value less than the specified strength provided that it is not less than 85% of the specified strength, except that not more than one test result per element may be below the specified strength.

Failure to pass tests

If cylinders taken at site during the progress of the works fail to reach the specified strength, no further pouring of concrete shall take place until the cause of the failure has been established and corrective measures have been taken to the satisfaction of the Engineer.

The Engineer may require that core samples are taken and tested in accordance with ASTM C 42 or a similar standard or other tests be performed on sections of the works made from the suspect concrete. If such tests fail to demonstrate the integrity of the sections of the works, all sections made with the suspected concrete shall be removed from the site. Costs of all such tests shall be borne by the Contractor.

Testing hardened concrete

Entire operation shall be carried out as per approval of the Engineer with due precaution so that the structural integrity is no way affected. The Contractor shall remain responsible for any negligence. If approved by the Engineer, on each specific occasion, hardened concrete liable to rejection shall be tested for compressive strength in accordance with ASTM C 42 at the Contractor's expenses. Unless otherwise directed, cores shall be 150mm in diameter. At least three specimens shall be cored and tested from the locations as directed by the Engineer.

If the average compressive strength of the core specimens, so obtained, is equal to or greater than 85% of the specified 28-days cylinder, compressive strength for that section of the work, the concrete represented by the core specimen, shall be considered to be structurally satisfactory.

If the concrete is considered to be structurally satisfactory, the holes left by the removal of the test cores shall be appropriately repaired or as directed by the Engineer. Unless otherwise directed, concrete, which fails to meet the requirements of this Section shall be removed and replaced in an approved manner without any extra cost to the Employer.

16.8 Concrete Construction

General

The Contractor shall, in due time and as soon as possible, submit his proposed construction methods and work programme along with Shop Drawings to the Engineer and shall obtain his approval before commencement of any works.

The Contractor shall maintain an adequate number of trained and experienced supervisors and foremen at the site to supervise and control the works.

All construction, other than concrete, shall conform to the requirements prescribed in other Sections and Sub-sections for the several items of work entering into the complete structure.

Mixing concrete

General

All concrete shall be mixed in batch mixers. It may be mixed at the site of construction, at a central plant, or in transit. Each mixer shall have attached to it, in a prominent place, a manufacturer's plate showing the capacity of the drum in terms of mixed concrete and the speed of rotation of the mixing drum.

Mixers at local site of construction

Mixers at local sites shall be approved drum-type capable of combining the aggregate, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. The mixer shall be equipped with a suitable charging hopper, water storage and a water-measuring device, accurate within 1%. Controls shall be so arranged that the water can be applied only while the mixer is being charged. Suitable equipment for discharging the concrete shall be provided. The mixer shall be cleaned at suitable intervals. The pickup and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

The mixer shall be operated at a drum speed of not less than 15 nor more than 20 revolutions per minute at the recommended speed of the manufacturer. The batched materials shall be so charged into the drum that a portion of the water shall enter in advance of the cement and aggregates and the water shall continue to flow into the drum for a minimum time of 5 seconds after all the cement and aggregates are in the drum. Mixing time shall be measured from the time all materials, except water, are in the drum and shall, in the case of mixers, having a capacity of 1 cubic meter or less, not be less than 50 seconds nor more than 70 seconds. Mixing shall be continued for at least 90 seconds after all materials are in the drum, unless a shorter time is shown to be satisfactory by the mixing uniformity tests of 'Specification for Ready Mixed Concrete' (ASTM C 94). In the case of dual drum mixers, the mixing time shall not include transfer time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein. Any concrete mixed less than the specified minimum time shall be discarded and disposed of by the Contractor at his own expenses.

The volume of concrete, mixed per batch, shall not exceed the mixer's nominal capacity in cubic meters as shown on the manufacturer's guaranteed capacity standard rating plate on the mixer. However, an overload upto 20% of the mixers nominal capacity may be permitted provided concrete test data for strength, segregation and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

Re-tempering concrete by adding water or by other means shall not be permitted. Concrete, which is not of the required consistency at the time of placement, shall not be used.

Central plant mixers

These mixers shall be of approved drum type capable of combining the aggregate, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Central plant mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. The water system for a central mixer shall be either a calibrated measuring tank or a meter and shall not necessarily be an integral part of the mixer.

The mixer shall be cleaned at suitable intervals. It shall be examined daily for changes in interior condition. The pick-up and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

Central plant mixers, which have a capacity of 2-5 cubic meters and greater than 5 cubic meters, may permit a minimum mixing time of 90 seconds and 120 seconds respectively provided a mixing analysis and tests of the job materials indicate such produced concrete is equivalent to strength and uniformity to that attained as stated in the preceding paragraphs.

Conveying concrete

Concrete shall be conveyed from the mixer/batching plant to the place of final deposit as rapidly as possible by methods that will prevent segregation or loss of materials. Conveying equipment shall be capable of providing a supply of concrete to the place of deposit without segregation of ingredients and without interruptions sufficient to permit loss of plasticity between successive increments. Re-mixing of concrete shall not be allowed. Concrete, which does not reach its final position in the forms within the stipulated time, shall not be used.

Mixed concrete shall be transported from the central mixing plant to the work site in agitator trucks or upon written permission by the Engineer in non-agitator trucks. Delivery of concrete shall be so regulated that placing is at a continuous rate unless delayed by the placing operations. The intervals between delivery of batches shall not be so great as to allow the concrete in place to harden partially, and in no case such an interval shall exceed 30 minutes.

Agitator trucks

Unless otherwise permitted in writing by the Engineer, agitator trucks may be used for transportation of central plant mixed concrete. Agitator trucks shall have watertight revolving drums suitably mounted and shall be capable of transporting and discharging the concrete without segregation. The agitating speed of the drum shall not be less than 2 or more than 6 revolutions per minute. The volume of the mixed concrete permitted in the drum shall not exceed the manufacturer's rating nor exceed 80% the gross volume of the drum.

Upon approval by the Engineer, open-top revolving-blade truck mixers may be used in lieu of agitating trucks for transportation of central plant mixed concrete.

The interval between introduction of water into the mixer drum and final discharge of the concrete from the agitator shall not exceed 45 minutes. During this interval the mix shall be agitated continuously.

Non-agitator-trucks

Bodies of non-agitating equipment shall be smooth, watertight metal containers equipped with gates that will permit control of the discharge of the concrete. Covers shall be provided when needed for protection against weather.

The non-agitating equipment shall permit delivery of the concrete to the work site in a thoroughly mixed and uniform mass with a satisfactory degree of discharge.

Uniformity shall be satisfactory, if samples from the one-quarter and three-quarter points of the load do not differ by more than 30mm in slump. Discharge of concrete shall be completed within 30 minutes after the introduction of the mixing water to the cement and aggregate.

Truck or transit mixers

These shall be equipped with electrically actuated counters by which the number of revolutions of the drum or blades may readily be verified and the counters shall be actuated at the commencement of mixing operations at designated mixing speeds. The mixer when loaded shall not be filled to more than 60% of the drum gross volume. The mixer shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

Except when intended for use exclusively as agitators, truck mixers shall be provided with a water-measuring device to measure accurately the quantity of water for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount.

Truck mixers may be used for complete mixing at the batch plant and as truck agitators for delivery of concrete to job site or they may be used for complete mixing of the concrete at the job site. They shall either be a closed watertight revolving drum or an open top revolving blade or paddle type.

The amount of mixing shall be designated in number of revolutions of the mixer drum. When a truck mixer is used for complete mixing, each batch of concrete shall be mixed for not less than 70 nor more than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as the "mixing speed". Such designation shall appear on a metal plate attached to the mixer. If the batch is at least 0.5 cubic meter less than guaranteed capacity, the number of revolutions at mixing speed may be reduced to not less than 50. Mixing in excess of 100 revolutions shall be at the agitating speed. All materials, including the mixing water, shall be in the mixer drum before actuating the revolution counter, which will indicate the number of revolutions of the drum or blades.

When wash water (flush water) is used as a portion of the mixing water for the succeeding batch, it shall be accurately measured and taken into account in determining the amount of additional mixing water required. When wash water is carried on the truck mixer, it shall be carried in a compartment separate from the one used for carrying or measuring the mixing water. The Engineer will specify the amount of wash or flush water and may specify a "dry" drum, if wash water is used without measurement or without supervision.

When a truck is used for complete mixing at the batch plant, mixing operations shall begin within 30 minutes after the cement has been added to the aggregate. After mixing, the truck mixer shall be used as an agitator, when transporting concrete, at the speed designated as agitating speed by the manufacturer of the equipment. Concrete discharge shall be completed within 45 minutes after the addition of cement to the aggregates. Each batch of concrete, delivered at the job site, shall be accompanied by a time slip issued at the batching plant, bearing the time of departure therefrom. When the truck mixer is used for the complete mixing of the concrete at the job site, the mixing operation shall begin within 30 minutes after cement has been added to the aggregates.

The rate of discharge of the plastic concrete from the mixer drum shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully opened.

Handling and placing of concrete

Concrete placing shall not be commenced without the written approval of the Engineer or his representative. This approval shall be in the form of a standard checklist approved by the Engineer prior to the commencement of the Work. The checklist shall be filled in and approved by the Engineer or his representative during his inspection and acceptance of materials, plant and equipment, concrete pouring arrangements, the positioning, fixing and condition of reinforcement and any other items to be embedded including the cleanliness, alignment and suitability of the containing surfaces or formwork.

The temperature of concrete at the time of placing shall not exceed 35°C.

In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from the interior of forms. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their

service unnecessary. These temporary members shall entirely be removed from the forms and not be buried in the concrete.

The concrete shall be placed in the position and sequences indicated on the Drawings, and Specifications or as directed by the Engineer. The concrete shall be placed in clean, oiled formwork and compacted before initial set has occurred. In any event concrete shall not be placed later than 30 minutes from the time of mixing.

Concrete shall be placed in horizontal layers and each layer shall not be more than 600mm thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the batches. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer that has not taken the initial set.

The concrete shall be deposited as far as possible in its final position without re-handling or segregation and in such a manner so as to avoid displacement of the reinforcement and other embedded items or formwork.

Open troughs and chutes shall be of metal or metal line. The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall be permitted only on written authorization of the Engineer. Where chutes are used to convey the concrete, their slopes shall not be such as to cause segregation. Where long steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement. In case an inferior quality of concrete is produced by the use of such conveyors, the Engineer may order discontinuation of their use and the installation of a satisfactory method of placing.

Pneumatic placing of concrete shall be permitted only if authorized by the Engineer. The equipment shall be so arranged that a vibration does not damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 3m from the point of deposit. The discharge lines shall be horizontal or inclined upwards from the machine. At the conclusion of placement, the entire equipment shall be thoroughly cleaned.

Placement of concrete by pumping shall be permitted only if authorized by the Engineer. The equipment shall be so arranged that vibrations do not damage freshly placed concrete. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there is no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

For simple spans, concrete shall preferably be deposited by beginning at the centre of the span and working from the centre towards the ends. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers. For continuous spans, the concrete placing sequence shall be as shown on the plans or agreed by the Engineer.

Concrete in slab and girder haunches less than 1m in height shall be placed at the same time as that in the girder stem.

Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise provided.

Concrete in T-beam or deck girder spans may be placed in one continuous operations, if permitted by the Engineer.

Concrete in columns and pier shafts shall be placed in one continuous operations unless otherwise directed.

Unless otherwise permitted by the Engineer, no concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be applied to the supporting structures until they have been in place at least 14 days unless otherwise permitted by the Engineer.

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable materials to a sufficient depth to expose sound concrete. To avoid visible joints as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a "feather edge" might be produced at a construction joint, an inset form shall be used to produce a blocked out portion in the preceding layer which shall produce an edge thickness of not less than 150mm in the succeeding layer. Work shall not be discontinued within 450mm of the top of any face unless provision has been made for a coping less than 450mm thick, in which case, if permitted by the Engineer, a construction joint may be made at the under side of the coping.

Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon the reinforcement steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete while cleaning the reinforcement steels.

Where concrete is required to be placed against undisturbed ground, the entire space between the finished concrete surface and the ground, including any over-break, is to be completely filled with concrete of the specified class. The concrete shall be well rammed and compacted to ensure that all cavities are filled and the concrete is everywhere in contact with the ground. Where permitted by the Engineer, any extensive patches of over break may first be filled with concrete belonging to the Class for "Mass Concrete in Structure and CC Blocks" as directed by the Engineer.

Where concrete is required to be placed against a metal surface to which it is required to adhere, care shall be taken to work the concrete well into the re-entrant angles and to ensure contact by hammering the metal part on its free side provided that this is done without damaging the metal or its protective coating, if any.

Concrete shall not be dropped through a height greater than 1200mm except with the approval of the Engineer who may order the use of bankers and the turning over of the deposited concrete by hand before being placed.

When placing operations would involve dropping the concrete more than 1200mm, it shall be deposited through sheet metal or other approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcement bars, which are projected.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clean.

The laying of concrete shall be carried out in such a way that the exposed faces of concrete shall be plain, smooth, sound and solid, free from honeycomb and excrescences. After compaction the exposed concrete surface shall be struck off smooth with hand held steel floats. No plastering of imperfect concrete faces will be allowed. Any concrete that is defective in any way shall, if so ordered by the Engineer, be cut out and replaced to such depth or be made good in such manner as the Engineer may direct.

Construction joints shall be formed in the work where indicated on the Drawings or as previously approved by the Engineer. Where necessary, the Contractor shall allow for working beyond ordinary working hours to allow each section of concrete to be completed in a continuous pour with the placing of concrete carried up to each construction joint.

Compaction of concrete

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration subject to the following provisions:

- The vibration shall be internal unless special authorization of other methods are given by the Engineer or as provided herein.
- Mechanical vibrators of the capacity as approved by the Engineer shall be used in conjunction with or without hand rammers, pokers or any other means as directed by the Engineer.
- Vibrators shall be of a type and design as approved by the Engineer. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 4,500 impulses per minute.
- The intensity of vibration shall be such as to visibly affect a mass of concrete of 20mm slump over a radius of at least 450mm.
- Vibrators must be operated by skilled workmen engaged/appointed by the Contractor mainly for this job.
- Surface vibrators of the type of Pan-vibrators, or vibrating screens shall be used for compacting castings of shallow depth as directed by the Engineer.
- The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. Spare vibrators shall be readily on hand in case of breakdown.
- Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into the corners and angles of the forms.
- Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point, to the extent that localized areas of grout are formed.
- While using immersion vibrators in walls, these should be lowered to the bottom of the wall before concreting is started and pulled up as concreting proceeds. When using vibrators, concrete can be placed from bottom to top of wall in one process, provided it is laid in regular layers. Care should be taken to ensure that vibrators are not trapped under a great depth of concrete.
- Application of vibrators shall be at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.
- Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete, which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms.
- Vibration shall be supplemented by such spading as is necessary to ensure smooth surface and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.
- In columns, deep beams and walls mild striking by mallets at the outer faces of the form works should also be done simultaneously during use of vibrator for compaction.

The provisions of this Sub-section shall also apply to pre-cast piling, concrete cribbing and other pre-cast members except that the manufacturer's methods of vibration may be used if approved by the Engineer.

16.9 Depositing Concrete under Water

Concrete shall not be deposited in water except with the approval of the Engineer and under his immediate supervision and in this case the method of placing shall be as defined in this portion.

Concrete deposited in water shall be with 10 percent excess cement. It shall be carefully placed in a compact mass in its final position by means of Tremie, a bottom opening bucket or other approved methods and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces. The forms under water shall be watertight.

The discharge end of the Tremie shall be closed at the start of work so as to prevent water entering the tube and shall be entirely sealed at all times. The Tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped in to the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow shall be continuous until the work is completed. Concrete slump shall be in between 100mm and 150mm.

Depositing of concrete by the opening bucket method shall conform to the following specifications. The top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited. When discharged it, shall be withdrawn slowly until it goes well above the concrete.

16.10 Protection of Concrete from Adverse Conditions**General**

Concrete shall be protected from damage from the effects of sunshine, dry wind, rain, running water or mechanical damage for a continuous period, until the concrete has reached at least three quarters of its 28-days strength, but for not less than 10-days. Temperature of the concrete mixture shall require to be maintained between 10°C and 32°C unless otherwise provided herein. The Contractor shall submit his proposals to achieve this protection for the Engineer's approval.

Damaged concrete shall either be repaired to an acceptable condition or be removed and replaced.

Protection from rain

During rainy weather, proper protection shall be given to ingredients, production methods, handling and placing of concrete. If required, in the opinion of the Engineer, the concrete depositing operation shall be postponed and newly placed concrete shall be protected from rain after forming proper construction joint for future continuation.

Protection from hot weather

During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation that could impair required strength or serviceability of the member or structure.

Under a temperature above 32°C surfaces of forms, reinforcing steel, steel beam flanges etc. in contact with the mix shall be cooled down below this temperature by means of water spray or by any other appropriate methods.

Protection from cold weather

Under a cold weather condition, temperature of the concrete shall be maintained not below 7°C during the curing period for the first six days on placement of concrete unless pozzolan cement or fly ash cement is used. Periods to be followed in the later case has been shown in the table given below:

% of cement replaced by weight with pozzolans	Required period of controlled temperature
10%	8 days
11-15%	9 days
16-20%	10 days

However, this requirement may be waived in the case the compressive strength of 65% of the specified 28-days design strength is achieved in 6-days.

In maintaining the requisite temperature if external heating is used, it shall be applied and withdrawn gradually and uniformly so that the concrete surface is not heated more than 32°C.

Temperature of concrete at the time of placement in sections less than 300mm in thickness shall not be less than 16°C when the air temperature is below 2°C.

Special requirements for bridge decks

Prior to the application or curing, concrete being placed and finished for bridge decks shall be protected from damage due to rapid evaporation when the weather is low humid, windy or having high temperature. Such protection shall be adequate to prevent premature crusting of the surface or an increase in dry cracking. In providing such protection the humidity of the surrounding air shall be raised with fog sprayers operated upwind of the deck.

Concrete exposed to salt water

Unless otherwise, specifically provided, concrete for structures exposed to salt water shall be mixed for a period of not less than 2 minutes and water content of the mixture shall be carefully controlled and regulated so as to produce concrete of maximum impermeability. The concrete shall be thoroughly consolidated as necessary to produce maximum density and a complete lack of rock pockets. Unless otherwise shown on the Drawings, the clear distance from the face of the concrete to the reinforcing steel shall not be less than 100mm. No construction joints shall be formed between levels of extreme low water and extreme high water or the upper limit of wave action as determined by the Engineer. Between these levels the forms shall not be removed, or other means provided, to prevent salt water from coming in direct contact with the concrete for a period of not less than 30 days after placement. Except for the repair of any rock pockets and the plugging of form tie holes, the original surface, as the concrete comes from the forms, shall be left undisturbed. Special handling shall be provided for pre-cast members to avoid even slight deformation cracks.

16.11 Perforations and Embedding of Special Devices

The Contractor is responsible for determining in advance of making any concrete pour, all requirements for perforation of concrete sections or embedding therein of special devices of other trades, such as conduits, pipes, weep holes, drainage pipes, fastenings, etc. Any concrete, poured without prior provision having been made, shall be subject to correction at the Contractor's expenses.

Special devices to be embedded:

- Expansion joints
- Drain outlets including down pipes and bolts herefor
- Bolts and inserts for sign posts
- Bolts and inserts for various purposes regarding inspection and maintenance as directed by the Engineer.

Other devices not mentioned above shall be shown on the Drawings or directed by the Engineer.

16.12 Curing of Concrete

In order to prevent loss of water, all newly placed concrete shall be cured by use of one or more of the methods specified herein. Curing shall commence immediately after the free water has left the surface and finishing operations are complete. In the case the concrete surface begins to dry before the selected cure method is applied, the surface of the concrete shall be kept moist by a fog spray application so as to prevent any damages to the surfaces.

Curing by other than steam or radiant heat methods shall continue uninterrupted for 7 days except that when pozzolans in excess of 10 percent, by weight, of the Portland cement are used in the mix. When such pozzolans are used, the curing period shall be 10 days. For other than top slabs of structures serving as finished pavements, the above curing periods may be reduced and curing terminated when test cylinders cured under the same conditions as the structure indicate that concrete strengths of at least 70 percent of that specified have been reached.

During periods of hot weather, if considered necessary by the Engineer, water shall be applied to the concrete surfaces being cured by the liquid membrane method or by the forms-in-place method. The process shall continue for a period that the Engineer determines a cooling effect is no longer required.

Materials

Water

Water used in curing of concrete shall be subject to approval and shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other injurious substances. Water shall be tested in accordance with and shall meet the suggested requirements of AASHTO T 26. Water known to be of potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

Liquid membranes

Liquid membrane forming compounds for curing concrete shall conform to the requirements of AASHTO M 148 (ASTM C 309).

Waterproof sheet materials

Waterproof paper, polyethylene film, and white burlap polyethylene sheet shall conform to the requirements of AASHTO M 171 (ASTM C 171).

Methods

Forms-In-place method

Formed surfaces of concrete may be cured by retaining the forms in place for the required time.

Water method

Concrete surface shall be kept continuously wet by ponding, spraying or covering with materials that are kept continuously and thoroughly wet. Such materials may consist of cotton mats, multiple layers of burlap or other approved materials, which do not discolor or otherwise damage the concrete.

Liquid membrane curing compound method

The liquid membrane method shall not be used on surfaces where a rubbed finish is required or on surfaces of construction joints unless it is removed by sand blasting prior to placement of concrete against the joint. Type 2, white pigmented, liquid membranes may be used only on the surfaces of bridge decks, on surfaces that will not be exposed to view in the completed work or on surfaces where their use has been approved by the Engineer.

When membrane curing is used, the exposed concrete shall be thoroughly sealed immediately after the free water has left the surface. Form surfaces shall be sealed immediately after the forms are removed and necessary finishing has been done. The solution shall be applied by power-operated atomizing spray equipment in one or two separate applications. Hand-operated sprayers may be used for coating small areas. Membrane solutions containing pigments shall be thoroughly mixed prior to use and agitated during application. If the solution is applied in two increments, the second application shall follow the first application within 30 minutes. Satisfactory equipment shall be provided, together with means to properly control and assure the direct application of the curing solution on the concrete surface so as to result in a uniform coverage at the rate of 4.5 liters for each 14 square meter of area.

If the film is damaged by inclement weather condition or in any other manner during the curing period and before the film has dried sufficiently, a new coat of the solution shall be applied to the affected portions equal in curing value to that specified above.

Waterproof cover method

This method shall consist of covering the surface with a waterproof sheet material so as to prevent moisture loss from the concrete. This method may be used only when the covering can be secured adequately to prevent moisture loss.

The concrete shall be wet at the time the cover is installed. The sheets shall be of the widest practicable width and adjacent sheets shall overlap a minimum of 150mm and shall be tightly sealed with pressure sensitive tape, mastic, glue, or other approved methods to form a complete waterproof cover of the entire concrete surface. The paper shall be secured so that wind will not displace it. Should any portion of the sheets be broken or damaged before expiration of the curing period, the broken or damaged portions shall be immediately repaired. Sections that have lost their waterproofing qualities shall not be used.

Accelerated curing

Curing by high-pressure steam, steam at atmospheric pressure, heat and moisture or other accepted processes, shall be permitted to accelerate strength gaining and reduce time of curing.

Accelerated curing shall provide a compressive strength of the concrete at the load stage, considered at least equal to the required design strength at that load stage.

Curing process shall be such as to produce concrete with a durability at least equivalent to that obtained for concrete cured by the above methods.

The use of accelerated curing method for concrete containing other types of cement or any admixture shall be subject to the Engineer's acceptance.

Field cured specimens

The Engineer may require strength tests of cylinders cured under field conditions to check adequacy of curing and protection of concrete in the structure.

Field cured cylinders shall be cured under field conditions in accordance with "Practice for Making and Curing Concrete Test Specimens in the Field" (ASTM C 31).

Field cured test cylinders shall be moulded at the same time and from the same samples as laboratory cured test cylinders.

Procedures for protecting and curing concrete shall be improved when the strength of field cured cylinders at the test age designated for determination of f'_c is less than 85% of that of companion laboratory cured cylinders. The 85% limitation shall not apply, if field cured strength exceeds f'_c by more than 3.5 N/mm^2 .

16.13 Finish and Finishing

Surface irregularities shall be classified as "abrupt" or "gradual". Offsets caused by displaced or misplaced form sheathing or lining of form sections, or loose knots in forms or otherwise defective formwork, will be considered as "abrupt" irregularities. All other irregularities will be considered as gradual irregularities.

Where a surface is partly below and partly above the final ground level, the finish for the exposed surface shall extend for 0.15m below the ground level.

The formed surfaces, which will be permanently buried under earth, will require no treatment for abrupt or gradual irregularities. However, repair of defective concrete and filling of holes left by the removal of fasteners from the ends of tie rods shall be undertaken.

All abrupt and gradual irregularities on all exposed surfaces shall be removed by sack rubbing or sand blasting or grinding or by all these methods or any other method approved by the Engineer, which is not harmful to the concrete. The permissible surface irregularities shall not exceed 6mm for abrupt irregularities and 13mm for gradual irregularities. The permissible irregularities may be reduced at places of the surface where, in the opinion of the Engineer, the formed finish does not provide the desired effect and no extra payment shall be permissible for such work.

Holes, honeycombs, or other defects left by forms shall be promptly repaired in accordance with the relevant Sub-section of this Specification.

All surfaces such as blinding concrete, opening for second stage concrete etc. on which concrete is to be placed subsequently, shall not be finished for abrupt or gradual irregularities.

Generally, concrete surface shall remain as cast and no plastering work will be performed on it. The formwork shall be lined with a material approved by the Engineer to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one-structure. The Contractor shall repair any imperfections in the resulting finish as required by the Engineer. Internal ties and embedded metal parts will be allowed only with the Engineer's specific approval.

Concrete surface finishing

Skilled workmen shall perform finishing of concrete surfaces to the satisfaction of the Engineer. Exposed flat concrete surfaces shall be screed to produce an even and uniform surface and then they shall be given a trowel finish unless otherwise specified on the Drawings. All exposed and unprotected edges shall be given 20mm x 20mm chamfers.

The Concrete surface finish on upward facing, horizontal or sloping faces shall be, except for blinding concrete or otherwise stated on the Drawings, a "fair" surface. A 'fair' surface shall be obtained by screeding and trowelling with a wood float.

Screeding shall be carried out following compaction of the concrete by the slicing and tamping action of a screed board running on the top edges of the formwork or screeding guides to give a dense concrete skin true to line and level.

Wood float trowelling shall be carried out after the concrete has stiffened and the film moisture has disappeared. Working should be kept to the minimum compatible with a good finish and the surface shall be true to the required profile to fine tolerance. Whenever necessary, the Contractor shall provide and erect overhead covers to prevent the finished surfaces from being marred by rain drops or dripping water.

The surface of blinding concrete shall be that obtained by screeding as described above.

Where a "fine" surface is indicated on the Drawings, this shall be obtained in a similar manner to "fair" surface save that a steel float shall be used in lieu of the wood float.

Formed surface for painting exposed to view shall be smooth and free from projections and shall be rubbed smooth immediately after the forms are removed. Formed surfaces shall be classified as follows:

- Unexposed concrete surfaces upon or against which backfill or concrete is to be placed, require no treatment except the removal and repair of defective concrete.
- Exposed surfaces shall have a very smooth, sound surface by control of formwork, concrete placement and repair of abrupt surface irregularities by grinding or rubbing of high spots and filling of voids.

Concrete decks

Immediately after placing concrete, concrete decks shall be struck off using templates to provide proper crowns and shall be finished smooth to the correct levels. Finish shall be slightly but uniformly roughened by brooming. The finished surface shall not vary more than 10mm from a 3.0m straight

edge placed in any direction on the roadway. Deviation from the grade line shall not be more than +30mm in any 20m length.

Curb and sidewalk surface

Exposed faces of curbs and sidewalks shall be finished to true lines and grades. The curb surface shall be wood floated to a smooth but not slippery finish. Sidewalk surfaces shall be slightly but uniformly roughened by brooming.

Ordinary finish

An ordinary finish is defined as the finish left on a surface after the removal of the forms when all holes left by form ties have been filled and all irregular projections and any other minor surface defects have been repaired. The surface shall be true and even, free from depressions fins or projections.

The concrete shall be struck off with a straight edge and floated to true grade. Under no circumstance shall the use of mortar topping for concrete surfaces be permitted.

Grout cleaning

Grout cleaning may be called for on the Drawings or required by the Engineer because of unsatisfactory appearance. The operation requires that the surface is wetted and uniformly covered with a grout consisting of 1 part cement to 1.5 parts fine sand. White cement shall be used for all or part of the cement in the grout to give the colour required to match the concrete. The grout shall be uniformly applied with brushes or a spray gun and all air bubbles and holes shall be completely filled. Immediately after the application of the grout, the surface shall be vigorously scoured with a cork or other suitable float. While the grout is still plastic, the surface shall be finished with a sponge rubber or other suitable float removing all excess grout. This finishing shall be done at the time when grout will not be pulled from the holes or depressions. After being allowed to be thoroughly dry, the surface shall be vigorously rubbed with a dry burlap to completely remove any dried grout. There shall be no visible film of grout remaining on the surface after this rubbing and the entire cleaning operation of any area must be completed on the day it is started. If any dark spot or steak remains after this operation, they shall be removed with a fine grained silicon carTendere stone, but the rubbing shall not be as much to change the texture of the surface. Unless it is required by the Drawings or directed by the Engineer, grout cleaning should be delayed until the final clean up of the project.

Rubbed finish

On removal of forms the rubbing of concrete shall be started as soon as its condition permits. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall elapse before wetting down to allow the mortar used in patching to have thoroughly set. A medium coarse carborundum stone shall be used for rubbing a small amount of mortar on the face. The mortar used shall be composed of cement and fine aggregate mixed in the same proportions as that used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time. The final finish shall be obtained by rubbing with a fine carborundum stone and water until the entire surface is of a smooth texture and uniform colour.

After the final rubbing has been completed and the surface has dried up, burlap shall be used to remove loose powder. The final surface shall be free from unsound patches, paste, powder and objectionable marks.

Any surface that has been given a rubbed finish, shall be protected from subsequent construction operations. Any surfaces not protected, shall be cleaned and again rubbed if necessary, to secure a uniform and satisfactory surface.

After completion of initial rubbing curing shall be continued.

Tooled finish

Tooled finishing shall be carried out by treating the surface with an approved heavy duty power hammer fitted with a multi-point tool which shall be operated over the surface to remove 5mm to 6mm of concrete and expose maximum areas of coarse aggregate.

Aggregate left embedded shall not be fractured or loose. 25mm wide bands at all corners and arises shall be left as cast. The finish surface shall have even and of uniform appearance and shall be washed with water upon completion.

No tooling shall be done until the concrete has set for at least 14 days and as much longer as may be necessary to prevent the aggregate particles from being 'picked' out of the surface.

Sandblasted finish

Sandblasted finishing will be carried out on a thoroughly cured concrete surface with hard, sharp sand to produce an even fine-grained surface in which the mortar has been cut away, leaving the aggregate exposed.

Wire brushed or scrubbed finish

Wire brushed or scrubbed finish will be performed as soon as the forms are removed and while the concrete is yet comparatively green. The surface shall be thoroughly and evenly scrubbed with stiff wire or fiber brushes, using a solution of muriatic acid. The proportion of the solution shall constitute of one part acid to four parts water. This shall be continued until the cement film or surface is completely removed and the aggregate particles are exposed, leaving an even-pebbled texture presenting an appearance grading from that of fine granite to coarse conglomerate, depending upon the size and grading of aggregate used. When the scrubbing has progressed sufficiently to produce the texture desired, the entire surface shall be thoroughly washed with water to which a small amount of ammonia has been added in order to remove all traces of acid.

Inspection and making good

Concrete surface shall be inspected for defects and for conformity with the Specifications and where appropriate, for comparison with approved sample finishes. Subject to the strength and durability of the concrete being unimpaired, the making good of surface defects may be permitted but the standard of acceptance shall be appropriate to the type and quality of the finish specified and ensure satisfactory performance and durability. On permanently exposed surfaces, great care is essential in selecting the materials and the mix proportions to ensure that the final colour of the faced area blends with the parent concrete in the finished structure.

Voids can be filled with fine mortar, preferably incorporating Styrene Butadiene Rubber (SBR) or Polyvinyl Acetate (PVA), while the concrete is still green or when it has hardened. Fine cracks can be filled by wiping a cement grout, a SBR, PVA or latex emulsion, a cement/SBR or a cement/ PVA slurry across them. Fins and other projections shall be rubbed down.

16.14 Second Stage Concrete

Unless shown on the Drawings or otherwise instructed by the Engineer, second stage concrete shall be of class for major RCC structures.

Block-outs for second stage concrete and the specifications and locations of the embedded parts shall be in accordance with the Drawings.

The surface against which the second stage concrete are to be placed shall be thoroughly cleaned to make the surface free from all loose particles, organic substances, oil, grease, rust, plastic materials, wood and defective concrete.

The projected parts of the embedded items or the parts, which will remain embedded shall be thoroughly cleaned of oil, grease and rust. All such parts shall remain true to dimensions, plumb and levels as shown on the Drawings and directed by the Engineer.

16.15 Factory Made Pre-cast Concrete Elements

The Engineer shall approve in writing any suppliers of pre-cast concrete elements. The Engineer, if he so desires, may withdraw the approval later on.

All concrete works of such elements shall fully conform all requirements of this Specification.

The supplier shall maintain standard laboratory facilities.

Concrete members, specified to be fabricated as pre-cast concrete units, shall be fabricated with concrete of the specified class placed in to a grout tight mould. If so required, the mould shall be laid on a vibrating table and vibration should be applied while concrete is placed.

Members, structurally dependent on a rigid fixing with the adjoining structures, should not in general be permitted to be pre-cast.

Unless otherwise approved by the Engineer, pre-cast concrete members shall neither be moved from the casting position until the concrete has attained a compressive strength of 80% of the specified 28-days strength, nor transported until it has gained a strength of 90% of the specified 28-days strength.

Extreme cares shall be taken in handling and moving pre-cast concrete members. Pre-cast girders and slabs shall be transported in an upright position. Shock shall be avoided and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as and when the member would be in its final position. If the Contractor finds it expedient to transport or store pre-cast units in other than this position, it shall be done at his own risks after notifying the Engineer of his intention to do so. Any unit rejected shall be replaced at the Contractor's own expenses by an acceptable unit.

All details on the handling and transportation of pre-cast members shall be submitted in writing to the Engineer for his approval.

Each pre-cast member is to be uniquely and permanently marked so as to show its type, date of casting and reinforcement.

Handling and stacking of pre-cast units

The Contractor shall give the Engineer full details of his proposed methods of handling, transportation and stacking of pre-cast concrete units. The Engineer will examine these in details and will either approve the methods or order modifications to ensure that the units are not subject to excessive stresses. The finally approved methods are to be adhered to at all times and the Contractor shall be deemed to have included in his rates for all measures required to handle, transport and stack the units safely and without undue stressing.

16.16 Placing concrete in pre-stressed concrete work

Concrete in one pre-cast unit shall be placed in one operation continuously without interruption. The Contractor shall provide such protective cover as and when necessary to avoid stoppage due to sudden rain. No unit shall be removed from the mould or erected until sufficiently matured to ensure that no damage is done to the unit.

For post-tensioned construction, temporary openings shall be provided in the formwork where necessary, so as to enable placing and adequate compaction of concrete especially around and underneath sheathing and anchorage. Cares shall be taken to avoid damaging the sheath.

Vibrators shall not come into direct contact with the sheath in the case of post-tensioned work. If the sheath is damaged during concrete casting, the Engineer may reject the whole or a portion of the concrete cast. Sheath shall be cleaned out within half an hour of completion of each concrete casting operation by blowing oil-free compressed air through the length of the sheath.

16.17 Concreting of Anchorage recesses

For post-tensioned work, the tendons shall be cut back to give a minimum of 30mm cover after concreting of the recesses.

The interior surfaces of anchorage recesses shall be roughened.

Concrete conforming to the requirements of this Specification shall be cast in the recesses to the shapes designed. Prior to pouring concrete, the surface of the anchorage recesses shall be coated with an approved epoxy resin-bonding agent.

16.18 Grouting of Ducts for Pre-stressing Tendons

General

The time of commencement of grouting shall be approved by the Engineer. The Contractor shall give notice to the Engineer on time for the commencement of the grouting.

The purpose of grouting is to provide permanent protection to the post tensioning steel and to develop bond between the pre-stressing steel and the concrete.

Definition of terms

Admixture	As previously stated a chemical(s) added to the grout other than Portland cement and water to retard setting time or to achieve better fluidity, workability, and to minimize bleeding.
Duct	The hole or void provided in the concrete for the tendon used in post tensioning formed by sheathing.
Grout	A mixture of cement and water with or without admixtures.
Grout opening/vent	An inlet, outlet, or vent in the duct for grout, water or air.

Grout openings or vents

All ducts shall have grout openings at both ends. For draped cables, all high points should have a grout vent except where cable curvature is small, such as in continuous slabs. All grout openings or vents shall include provisions for preventing grout leakage.

Equipment

The grouting equipment shall include a mixer capable of continuous mechanical mixing which will produce a grout free of lumps and un-dispersed cement. The equipment shall be able to pump the mixed grout in a manner, which will comply with all provisions of the recommended practice.

Accessories for accurate solid and liquid measures shall be provided to batch all materials.

The pump shall be a positive displacement type and be able to produce an outlet pressure of at least 10.5 kg/cm². The pump should have seals adequate to prevent introduction of oil, air or other foreign substance in to the grout and to prevent loss of grout or water.

A pressure gauge having a full scale reading of no greater than 21 kg/cm² shall be placed at some point in the grout line between the pump outlet and the duct inlet.

The grouting equipment shall contain a screen having a clear opening of 3.2mm to screen the grout prior to its introduction in to the grout pump. If a grout with a Thixotropic additive is used, a screen opening of 4.8mm is satisfactory. This screen shall be easily accessible for inspection and cleaning.

The grouting equipment shall utilize gravity feed to the pump inlet from a hopper attached to and directly over it. The hopper must be kept at least partially full of grout at all times during the pumping operation in order to prevent air from being drawn into the post-tensioning duct.

Under normal conditions, the grouting equipment shall be capable of continuously grouting the largest tendon in no more than 20 minutes.

Materials

Portland cement

Specifications same as have been described previously.

Cement used for grouting shall be fresh and shall not contain any lump or other indication of hydration or "pack set".

Water

Specifications same as have been described previously.

The water used in the grout shall be potable, clean and free of injurious quantities of substances like oil, salt, acid, alkali, sugar, vegetable, etc. known to be harmful to Portland cement, or pre-stressing steel.

Admixtures

Admixtures, if used, shall impart the properties of low water content, good flowing, minimum bleed and moderate expansion. Its formulation shall contain no chemical in quantities that may have harmful effect on the pre-stressing steel or cement. Admixtures containing chlorides, fluorides, sulphites and nitrates shall not be used.

Aluminum powder of the proper fineness and quantity or other approved gas evolving material which is well dispersed through the other admixture may be used to obtain 5 to 10 percent unrestrained expansion of the grout.

All admixtures shall be approved by the Engineer and used in accordance with the instructions of the manufacturer.

Mixing grout

Water shall be added to the mixer first, followed by Portland cement and admixture as are prescribed by the admixture manufacturer.

Mixing shall be of such duration as to obtain a uniform thoroughly blended grout without excessive temperature increase or loss of expansive properties of the admixture. The grout shall be continuously agitated until it is pumped.

Water shall not be added to increase grout flow when it has been decreased by delay in use of the grout.

Proportion of materials shall be based on tests made on the grout before grouting begun, or may be selected based on prior documented experience with similar materials and equipment and under comparable field conditions (weather, temperature, etc.). The water content shall be the minimum necessary for proper placement, and when Type 1 or 2 cement is used shall not exceed a water-cement ratio of 0.45.

The water content required for Type 3 cement shall be established for a particular brand based on tests.

The intensity of pumping of the grout may be determined by the Engineer in accordance with the U.S. Corps of Engineers Method is CRD-C79. When this method is used, the efflux time of the grout sample, immediately after mixing, shall not be less than 11 seconds. The flow cone test does not apply to grout which incorporates a thixotropic additive.

Trial mixes shall be carried out on Site with the selected constituents to demonstrate the physical properties of the grout.

Injection of grout

In injecting grout, the pertinent considerations are as follows:

- Flushing of metal ducts shall be optional.
- The pumping pressure at the tendon inlet shall not exceed the value which may develop the crack in surrounding concrete.

- If the actual grouting pressure exceeds the maximum recommended pump pressure, grout may be injected in to any vent that has been or is ready to be capped as long as a one-way flow of grout is maintained. In following this procedure, the vent being used for injection, shall be fitted with a positive shutoff.
- When one-way flow of grout cannot be maintained, the grout shall be immediately flushed out of the duct with water.
- Grout shall be pumped through the duct and continuously wasted at the outlet pipe until no visible slugs of water or air are ejected and the efflux time of the ejected grout shall not be less than the injected grout. To ensure that the tendon remains filled with grout, the outlet and/or inlet shall be closed. Plugs, caps or valves thus required shall not be removed or opened until the grout has set.

Temperature considerations

The temperature of concrete shall require to be controlled and shall not be lower than 20°C or higher from the time of grouting until job cured 50mm cubes of grout reach a minimum compressive strength of 57 kg/cm².

Temperature shall not go beyond 32°C while mixing or pumping the grout. If necessary, the mixing water shall be cooled.

16.19 Loading

No superstructure load shall be placed upon finished bents, piers, or abutments until the Engineer so directs; but incase shall any load of any kind be placed until the concrete has completed curing.

The Contractor shall not place any temporary loads on deck slabs unless allowed by the Engineer in writing. Bridge deck slabs shall be opened to traffic only when so directed by the Engineer and generally no sooner than 28 days on placing of concrete.

16.20 Control of Heat in Structures

The Contractor shall establish measures to control the heat deriving from the hydration of the concrete in structures of major dimensions i.e. pile caps, etc. Temperature gradients introducing risks of cracking shall not occur and the temperature shall not exceed 70°C.

The Contractor shall also establish measures to avoid harmful excessive heat generation in massive structures, such as cooling down aggregates before mixing.

The Contractor shall submit in due time a proposal for the establishment of the aforementioned measures to the Engineer for his approval. The measures shall immediately be changed, if requested by the Engineer even later.

16.21 Backfill to Structures

All spaces which have been excavated and the volumes of which are not occupied by the concrete structure shall be back-filled and compacted with acceptable materials and as directed by the Engineer.

16.22 Cleaning Up

Upon completion of structure and before final acceptance, the Contractor shall remove all forms and scaffolding etc. down to 0.5m below the finished ground line. Excavated, or garbage materials, rubbish etc. shall be removed from the Site which shall be left in a neat condition satisfactory to the Engineer.

16.23 Measurement

The concrete of the several different grades and types completed in place and accepted shall be measured by either the cubic meter for each class of concrete included in the BOQ or by the unit for each type of pre-cast concrete member listed in the BOQ. In computing quantities, the dimensions used shall be those shown on the Drawings or ordered by the Engineer; but the measurement shall not include any concrete used for the construction of temporary works or which is included in other billed items. No deduction from the measured quantity shall be made for drainage openings and pipes of less than 300mm in diameter, conduits, chamfers, reinforcement bars, pre-stressing tendons, expansion joints and water-stops. However, deduction will be made for the volume of concrete displaced by piles embedded in the concrete.

The quantities of reinforcing steel, pre-stressing steel and other related items as shown in the Contract Documents, which are included in the completed and accepted structure shall be separately measured for payment as per the provisions made under the Section on 'Reinforcing Steel' of this Specification.

Formwork and false work shall not be measured separately but shall be deemed to be an integral part of the concrete items.

Surface finishes shall not be measured separately but shall be deemed to be an integral part of the concrete items.

Joints including fillers and expansion joints shall not be measured separately unless they are specified as separate items in the BOQ.

The number of pre-cast concrete members of each type listed in the BOQ will be the number of acceptable members of each type furnished and installed in the work.

16.24 Payment

The cubic meters of concrete and the number of pre-cast concrete members, measured as provided above will be paid for at the Contract unit prices per cubic meter or the Contract unit prices per each member for each type or class as would be applicable as per the BOQ.

Payment for concrete of the various classes and for pre-cast concrete members of the various types shall be considered to be the full compensation for the costs of furnishing all labour, materials, equipment and incidentals and for doing all works involved in constructing the concrete work complete in place as shown on the Drawings and as specified. Such payment shall also include the full compensation for furnishing and placing expansion joint fillers, sealed joints, water-stops, drains, vents, miscellaneous metal devices and the drilling of holes for dowels and the grouting of dowels in drilled holes, unless payment for such works would be specified under another item of the BOQ.

Payment for all types of concrete work shall be considered to be the full compensation for the costs of furnishing and installing and removal of all temporary works like staging, formwork, working platforms, cranes, transporting, placing, compaction, finishing, curing and rendering of the concrete as specified till the concrete work becomes self-supporting and can perform its intended functions.

The Contractor's rates shall be fully inclusive of all costs of all laboratory tests to be carried out as specified under different sub-items unless any payment is separately specified under the BOQ.

The payment shall be the full compensation of all incidentals necessary to complete the Work.

Payment for pre-cast units shall include all concrete, formwork, transport and erection and where applicable any bolts or other devices and bedding necessary to fix them in their permanent positions.

Item of payment

	Unit
Concrete Class as detailed on the Drawings and as specified in the Bill of Quantities	Cubic Meter
Pre-cast concrete elements as detailed on the Drawings and as specified in the Bill of Quantities	Numbers

17. FALSE WORK AND FORMS

17.1 Scaffolding (False work)

Scaffolding is defined to be any temporary structure required to support structural elements of concrete, steel, masonry, or other materials at the time of their construction or erection.

Plans, Drawings and structural calculations in details shall be submitted to the Engineer for approval, but in no case shall the Contractor be relieved of his responsibilities for results obtained by using this Document.

All scaffolding shall be designed and constructed to provide the necessary rigidity and strength to safely support all loads imposed and produced in the finished structure, the lines and grades indicated on the Drawings. The supports shall be designed to withstand the worst combination of self-weight, formwork weight, formwork forces, reinforcement weight, wet concrete weight, construction and wind loads, together with all incidental dynamic effects caused by placing, vibrating and compacting the concrete. No harmful cracking may occur in the placed concrete. The Engineer may require the Contractor to employ screw jacks or hardwood wedges to take up any settlement in the formwork either before or during the placing of concrete.

Scaffolding shall be founded on a solid base, which is safe against undermining, protected from softening and capable of supporting the loads imposed on it. Scaffolding which cannot be founded on a satisfactory footing shall be supported on piling, which shall be spaced, driven and removed in a manner approved by the Engineer.

Horizontal and inclined bracings shall be provided for posts higher than 3m. Spans of beam bottoms shall be supported by posts with maximum 1m apart when steel is used and instructions from the manufacturer/supplier shall be strictly followed. Spacing of the props under beams shall consider the increased load and shall be posted closer than those under the floor slab.

Scaffolding can in certain cases be supported on structures already constructed. In that case, the Contractor shall in due time submit to the Engineer in writing all information on the loading from the scaffolding as requested. The Engineer shall consider the loading and submit his approval in writing.

Scaffolding shall be set to give the finished structure the camber shown on the Drawings or specified by the Engineer. If during construction any weakness develops or the scaffolding shows undue settlement or distortion, the work shall be stopped and any structure affected thereby shall be removed and the scaffolding shall be further strengthened before work is resumed. Suitable screw jacks, pairs of wages or other devices shall be used at each post to adjust scaffolding to grade.

All materials used in the construction of the scaffolding shall conform to the corresponding ASTM or BS Standards. Material tests and certificates may be required by the Engineer. Examinations of welding may also be requested. Test loading of the scaffoldings may be requested for the determination of the flexibility and the strength. All expenses of the tests and examinations of scaffoldings shall be borne by the Contractor.

Scaffolds shall be made from strong bamboo poles, wooden posts, steel pipes or any other suitable materials. They shall be adequately tied to vertical members resting on firm floor. Strong ropes shall be used to tie up bamboo poles. In addition, cross-bracing with bamboo or wooden posts shall be provided along with ties or guys of steel wire or rod not less than 6mm in dia meter.

Good, sound and uniform bamboo shall be collected in sufficient quantities for providing scaffolding, propping, temporary staging, ramp etc. The bamboos shall be free from any defects, firmly ties to each other and joints made smooth. Joining members only with nails shall be prohibited. Bamboos for vertical support shall not be less than 75mm in diameter and shall be straight as far as possible.

Bamboos may be used as vertical support for up to a height of 4m, if horizontal bracings are provided at the centre. Splicing shall be avoided.

After stripping the formwork, the bamboo posts shall be cleaned and stacked vertically in shade protected from rain and sun. Defective or damaged bamboo posts shall be removed from the Site.

Timber posts may be used in supporting formwork upto a height of 6m. The posts shall not be less than 80mm in diameter at any place and shall spread to at least 150mm in diameter at the top. The timber posts shall be supported on timber planks at the bottom. Either the bottom or the top of the posts shall be wedged with a piece of triangular wood peg for easy removal. Adequate horizontal and inclined braces shall be used for all timber centering. All timber posts shall be carefully inspected before use and members with cracks and excessive knots and crookedness shall be discarded. The joints shall normally be made with bolts and nuts. No rusted or spoilt threaded bolts and nuts shall be used.

When steel scaffoldings are used, it shall be painted in a manner that no mark of corrosion shall appear on the permanent concrete structures.

The Engineer shall only select the type of scaffolding. Bamboo scaffolding will only be used, if agreed and allowed by the Engineer. All scaffoldings shall remain in place for a period, which shall be determined by the Engineer.

Scaffold shall be dismantled after use piece by piece. Holes in the wall shall be filled up with the same materials as that of the wall. Filled up holes shall have uniformity in texture and colour with the surrounding surface. Crash striking shall not be allowed.

Triangular wooden wedges shall be put under the posts for easy dismantling of the members. Timber planks or steel sheets covering several posts at a time shall be placed below the vertical or inclined posts.

Materials and joints in scaffolding shall be inspected from time to time both before and after erection for the soundness, strength, damage due to weathering etc. Inspections shall be made for spillage of material or liquids, loose material lying on the gangways and proper access to the platform.

The scaffold shall be secured at enough places; no ties shall be removed. Warning sign prohibiting the use of any defective or incomplete scaffold and working in bad weather and high wind shall be posted in a prominent place. Inspections shall be made for the observance of these requirements.

17.2 Formwork

Definition

Formwork is defined to be an enclosure or panel, which contain the fluid concrete and withstand the forces due to its placement and consolidation. Forms in turn be supported on scaffolding.

General

The work to be performed under this Sub-section includes the furnishing and installing and removing of forms for all cast-in-places concrete work as shown and noted on the Drawings and as specified herein or as directed by the Engineer.

Forms shall be substantial and sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied together to maintain position and shape. Forms and their supports shall be designed so as not to damage previously placed structure.

Relevant provisions of the American Concrete Institute (ACI) issue of ACI 347 on 'Recommended Practice for Concrete Formwork' or some other generally accepted Standards shall apply for the structural designing of the formwork, except as they may be modified herein.

Design factors

The following factors shall be considered while designing formwork.

- Rate and method of placing concrete.
- Construction loads including vertical, horizontal and impact loads.
- Forms for pre-stressed concrete members shall be designed and constructed to permit movement of the member without damage during application of pre-stressing force.

Materials

Formwork shall be constructed from sound materials of sufficient strength, properly braced, strutted and shored as to ensure rigidity throughout the placing and compaction of the concrete without visible deflection. The materials used be of wood, steel or other approved materials and shall be mortar-tight. Formwork shall be so constructed that it can be removed without shock or vibration to the concrete.

Formwork for concrete, permanently exposed to public inspection, shall be faced with plain 28/26 gauge steel sheet fitted over 38mm thick wooden plank panels suitably braced or steel framing faced with minimum 12/14 BWG mild steel sheet. Formwork for cement concrete blocks shall be fabricated from M.S. sheet of sufficient thickness to prevent any distortion.

Where metal forms are used, all bolts and rivets shall be countersunk and well grounded to provide a smooth plane surface.

Where timber is used it shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may mark the surface of concrete.

Form ties shall be prefabricated rod, flat band, or wire type, or threaded internal disconnected type, of sufficient tensile capacity to resist all imposed load of freshly placed concrete and having external holding devices of adequate bearing area. Ties shall permit tightening and spreading of forms and shall leave no metal closer than 25mm from surface. Ties shall fit tight to prevent mortar leakage at holes in forms. Removable ties shall be coated with non-staining bond breaker. All ties shall be protected from rusting at all times. No wire ties or wood spreaders shall be permitted. Cutting ties back from concrete face will not be permitted.

Construction method

The Contractor shall submit for the approval of the Engineer details of the methods and materials proposed for formwork to each section of the Work. Details of all proposed wrought formwork and formwork to produce special finishes are to be submitted for approval in writing to the Engineer before any material is hauled at Site. If the Engineer so requires, samples of formwork shall be constructed and concrete be placed so that the proposed methods and finish effect can be demonstrated.

All joints shall be close fitting to prevent leakage of grout. At construction joints the formwork shall be tightly secured against previously cast or hardened concrete in order to prevent stepping or ridges to exposed surfaces.

Where the Contractor proposes to make the formwork from standard sized manufactured formwork panels, the size of such panel shall be approved by the Engineer before they are used in the construction of the Work. The finished appearance of the entire elevation of the structure and the adjoining structures shall be considered when planning the patterns of joint lines caused by formwork and by construction joints to ensure continuity of horizontal and vertical lines.

Formwork shall be constructed to provide the correct shape, lines and dimensions of the concrete shown on the Drawings. Due allowance shall be made for any deflection which will occur during the placing of concrete within the formwork. Panels shall have true edges to permit accurate alignment and provide a neat line with adjacent panels and at all construction joints. All panels shall be fixed with their joints either vertical or horizontal, unless otherwise specified or approved.

Formwork shall be provided for the top surfaces of sloping work where the slope exceeds 15° with the horizontal and shall be anchored to enable the concrete to be properly compacted and prevent floating. Care shall be taken to prevent air being entrapped. Openings for inspection of the inside of

the formwork and for the removal of water used for washing shall be provided and so formed as to be easily closed before placing concrete.

Formwork for exposed concrete surfaces

All exposed concrete surfaces are to be 'form finish' and shall be cast in any approved formwork and shall be free from honeycomb, fins, projections and air holes. All external angles to form finish concrete surfaces shall be chamfered as directed.

Forms for concrete surfaces exposed to view shall produce a smooth surface of uniform texture and colour substantially equal to that which would be obtained with the use of plywood conforming to the National Institute of Standards and Technology Product Standard PSI for Exterior B-B Class I Plywood. Panels lining such forms shall be arranged so that the joint lines form a symmetrical pattern conforming to the general lines of the structure. The same type of form lining material shall be used throughout each element of a structure. Such forms shall be sufficiently rigid so that the undulation of the concrete surface shall not exceed 3mm when checked with a 1.5m long straight edge or template. All sharp corners shall be filleted with approximately 19mm chamfer strips.

The Contractor shall submit shuttering Drawings and details of pattern and the method of forming joints in the exposed (form finish) concrete to the Engineer for his approval. All changes and modification made by the later shall be appropriately incorporated by the former and final approval whereof be obtained from the Engineer.

Unless otherwise stated on the Drawings, wrought formwork shall be used for all permanently visible concrete surfaces. Wrought formwork shall be such as to produce a smooth and even surface free from perceptible irregularities. Tongues and grooved paneled boards, plywood or steel forms shall have their joints flushed with the surface. The formwork shall be formed with approved standard size panels. The panels shall be arranged in a uniform approved pattern, free from defects likely to be detected in the resulting concrete surface.

In all types of formwork to form finished exposed concrete, only non-steining mould oil supplied by an approved manufacturer shall be used.

The respective usage of the same formwork to cast form-finished exposed concrete shall be as decided by the Engineer and in no case the formwork, not guaranteed to produce the required form-finish to the satisfaction of the Engineer, shall be used.

The exposed concrete shall have a uniform finish. The finish of the concrete when shuttering and formwork are removed will generally be without any blemish and will be such as will not require touch up. Slight touch up for a small spot or two, if necessary shall be carried out skillfully so as to be synonymous with the entire surfaces.

The finished surfaces shall be within the specified tolerances and full cover to the reinforcement steel shall be maintained.

Formwork for non-exposed concrete surfaces

Unless otherwise stated on the Drawings, rough formwork may be used for all surfaces, which are not permanently exposed. Rough formwork may be constructed of plain butt-joined sawn timber. But the Contractor shall ensure that all joints between boards shall be grout-tight.

The finished surfaces shall be within the specified tolerances and full cover to the reinforcement steel shall be maintained.

Formed surfaces and finish

The formwork shall be lined with a material approved by the Engineer so as to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and so joined and fixed to its backing as not to impart any blemish. It shall be of the same type and obtained from only one source throughout the construction of any individual structure. The Contractor shall make good any imperfection in the finish as required by the Engineer. Internal ties and embedded metal parts will be allowed only with the specific approval of the Engineer.

Sizes of timber and other sections for formwork

Scaffolds, formwork and components thereof shall be capable of supporting without failure, at least two times the maximum intended load. The following loads shall be used in designing the formwork:

- a) Weight of wet concrete: 20 kN/m³.
- b) Live load due to workmen and impact of ramming or vibrating : 15-40 kPa (light duty for carpenter and stone setters, medium duty for brick layers and plasterers, heavy duty for stone masons).
- c) Allowable bending stress (flexural tensile stress) in soft timbers : 8,000 kPa.

The sizes for formwork elements specified in the Table given below are applicable for spans of upto 5m and height of upto 4m. In case of longer span and height, formwork and support sizes shall be determined by calculating the load and approved by the Engineer before use.

Sizes of Timber and other Sections for Formwork	
Types of Formwork	Members Size in mm
Flat sheetings for slab bottoms, columns and beam sides	25 to 50
Beam bottoms	75x100 to 150x150
Vertical posts	75x100 to 150x150
Bamboo posts	Minimum 75 dia
Ballies	Not less than 100 dia at mid-length and 80 dia at thin end
Joist and ledgers supporting sheetings of slab	50x100 to 75x200
Studs for supporting vertical wall sheetings	50x100 to 150x150
Columns yokes-horizontal cross, pieces supporting vertical sheetings	50x100 to 100x100

Quality of shuttering

The shuttering shall have smooth and even surface and its joints shall not permit leakage of cement grout.

Ply-board shuttering material used shall be well seasoned free from projecting nails, splits or other defects that may mark the surface of concrete. It shall not be so dry as to absorb water from concrete and swell and budge, nor so green or wet as to shrink after erection.

The timber shall be accurately sawn and plain on the sides and the surface coming in contact with concrete.

Wooden formwork with metal sheet lining or steel plates stiffened by steel angles shall also be permitted. Where metal forms are used, all bolts and nuts shall be countersunk and well grounded to provide a smooth plain surface.

The chamfers, leveled edges and mouldings shall be made in the formwork itself. Opening for fixture and other fittings connected with the services shall be provided in the shuttering as directed by the Engineer.

Clamps shall be used, to its practicality, to hold the forms together. Where use of nails is unavoidable, it shall be kept to minimum number and these shall be left projected so that they can easily be withdrawn. Use of double-headed nails shall be preferred.

Tolerances

The formwork shall be made so as to produce a finished concrete true to shape, lines, levels, plumb and dimensions as shown on the Drawings subject to the following tolerances unless otherwise specified in this document or Drawings or as directed by the Engineer.

- Sectional dimension + 5mm
- Plumb + 1 in 1000 of height

- Levels + 3mm before any deflection has been taken place

Tolerances given above are specified for local aberrations in the finished concrete surface and should not be taken as tolerance for the entire structure taken as a whole or for the setting and alignment of formwork which should be as accurate as possible to the entire satisfaction of the Engineer. Errors, if noticed in any lift/tilt of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

Preparation of formwork

The formwork shall be arranged in a manner as to readily be dismantled and removed from the cast concrete without shock, disturbance or damage. Where necessary, the formwork shall be so arranged that the soffit form, properly supported on props only, can be retained in position for such period as may be required by maturing conditions or Specification. If the component is to be pre-stressed whilst still resting on the soffit form, provision shall be made to allow for elastic deformation and any variation in weight distribution.

The surfaces of formwork shall be free from foreign matters, projecting nails and the like, splits or other defects, and all formwork shall be cleaned and made free from standing water, dirt, shavings, chippings or other foreign matter before concrete is placed,

Before placing concrete, all built-in reinforcement bars, anchoring, steel beams, cables, fixing truss, bolts, pipes or conduits or any other fixtures shall be fixed in their correct positions. The cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without the approval of the Engineer.

All exterior and interior angles on the finished concrete of 90° or less shall be given 20mm x 20mm chamfers unless otherwise shown on the Drawings or directed by the Engineer. When chamfers are to be formed, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer.

No ties or bolts or other devices shall be built in to the concrete for the purpose of supporting formwork without the prior approval of the Engineer. The whole or part of any such support embedded in the Reinforced Concrete shall be capable of removal so that no part remaining embedded in the concrete, shall be nearer than 75mm from the surface. Holes left after removal of such supports shall be neatly filled with well reamed dry-pack mortar following the procedures described in the relevant Sub-section of this Specification.

All rubbish shall be removed from the interior of the forms before the concrete is placed. After cleaning, the formwork in contact with the concrete shall be treated with a suitable non-staining mould oil or suitable approved release agent to prevent sticking of the concrete. Care shall be taken to prevent the oil from coming in contact with the reinforcement or mixing with the concrete. At construction joints, surface retarding agents shall be used only where ordered by the Engineer.

All formwork shall be inspected and approved by the Engineer before concrete is placed in it. However, this shall not relieve the Contractor from the requirements as to soundness, finish and tolerances of the concrete specified in this Specification or elsewhere acknowledged as Standard.

Removal of forms

Forms shall not be removed without the approval of the Engineer. In the determination of the time for the removal of forms, consideration shall be given to the location and character of the structure, the weather, the materials used in the mix and other conditions influencing the early strength of the concrete. Extreme cares shall be taken to ensure that the method of removal shall not cause overstressing of the concrete or damage to its surface.

Forms shall be removed in such a manner as not to impair safety and serviceability of the structure. All concrete to be exposed by form removal shall have sufficient strength not to be damaged thereby.

Forms supporting pre-stressed concrete members shall not be removed until sufficient pre-stressing has been applied to enable pre-stressed members to carry their dead load and anticipated construction loads.

Forms shall not be removed in the cases of footing forms where the removal would endanger the safety of the cofferdams, forms from enclosed cells where access is not provided, deck forms in the cells that do not interfere with the future installation of utilities shown on the Drawings, or other works.

Except for concrete being post-tensioned, no concrete shall be subjected to loading which will induce a compressive stress in it exceeding one-third of its compressive strength at the time of loading, or one-third of the specified characteristic strength whichever is less. It may be possible to use shorter periods before striking forms by determining the strength of the concrete in the structural element.

Forms supporting cast-in-situ concrete in flexure may be struck when the strength of the concrete in the element is 10 N/mm² or twice the stress to which it will be subjected, whichever is greater provided that striking at this time will not result in an unacceptable deflection. This strength may be assessed by test on cylinder/cube cured under the same conditions as the concrete in the element as far as possible.

When forms to vertical surfaces such as beam sides, walls and columns are removed in less than 24 hours, care shall be taken to avoid damage to the concrete. The provision for suitable curing methods shall immediately follow the removal of the vertical forms at such early ages and the concrete shall be protected from high temperatures by means of suitable insulation.

Forms on upper sloping faces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any repair or treatment required on such sloping surfaces shall be performed at once.

If the floor is to be used to support construction loads, props should be retained for 28 days unless the Contractor can prove the requisite concrete strength by tests.

The form shall be removed slowly, as the sudden removal of wedges is equivalent to a shock load on the partly hardened concrete.

Materials and plants shall not be stacked on any newly constructed floor unless sufficient support is maintained to withstand such loads without damaging the floor.

The following table is a guide to the minimum periods that must elapse between the completion of the concreting operations and the removal of formwork. No formwork shall be removed without the permission of the Engineer and such permission shall not relieve the Contractor of his responsibilities regarding the safety of the structure.

Type and Position of Formwork	Approximate Period (days)
Side of beams, walls and columns (unloaded)	5
Slab soffits (props supporting)	14
Removal of props to slabs	21
Beam soffits (props supporting)	21
Removal of props to beams	28

Notwithstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

Jacks, wedges, chamfer strips

Formwork for the support of a bridge superstructure shall contain suitable jacks, wedges or chamfer strips to set the form to the required grade and to take up any settlement in the framework either before or during the placing of concrete.

Openings

Temporary and permanent openings in concrete shall be framed neatly with provisions for keys or reinforcing steel as shown on the Drawings or as directed by the Engineer.

Defects in formed surfaces

Workmanship in formwork alongwith concrete placing shall be such that concrete shall normally require no repair to surfaces being perfectly compacted and smooth.

If any blemish is revealed after removal of formwork, the Contractor shall obtain immediately the Engineer's decision concerning remedial measures to be undertaken. Notwithstanding the specifications and provisions stated under the Sub-section on 'Finish and Finishing' of this Specification such measures may include, but shall not be limited to the following:

- Fins, pinholes, bubbles, surface discolouring and mirror defects may be rubbed down with sacking immediately on removal of the form.
- Abrupt and gradual irregularities may be rubbed down with carborundum stone and water after the concrete has been fully cured.
- Deep honeycombed concrete shall be repaired within 24 hours of striking the formwork by cutting back to sound concrete. The concrete shall be cut back at least 50mm behind face reinforcement. Cut edges shall be regular and not feathered. Recasting shall be with the same concrete as the original casting. The formwork and its method of placing in this case also, shall be approved by the Engineer.
- Under some circumstances, abrupt and gradual irregularities of shallow honey- combed concrete may be repaired by cutting back and reforming with an approved epoxy resin or mortar in accordance with the manufacturer's instructions.

Regardless of the above repairing measures, any structure containing excessive honeycomb, as would be termed by the Engineer, shall be subjected to rejection by the Engineer. The Contractor, on receipt of written orders from the Engineer, shall remove and rebuild such portions of the structure at his own expenses.

Holes to be filled

Holes on the concrete surfaces formed by formwork supports or the like shall be filled with dry pack mortar made from one part by weight of ordinary Portland cement and three parts of specified fine aggregate approved by the Engineer. The mortar shall be mixed with sufficient water only to make the materials stick together when being moulded in the hands. All construction materials shall conform to the requirements as described previously and under the relevant Sub-sections on 'Construction Materials' of this Specification.

The Contractor shall thoroughly clean any hole that is to be filled and break out any loose, broken or cracked concrete or aggregate and remove any dry cement from the hole. The surrounding concrete shall be soaked until the whole surface that will come in to contact with the dry pack mortar has been covered and darkened by absorption of the free water by the cement. The surface shall then be dried so as to leave a small amount of free water on it.

The dry pack material shall then be placed and packed in layers having a compacted thickness not greater than 10mm. Compaction shall be carried out by using a hardwood stick and a hammer and shall extend over the full area of the layer. Special cares be taken to compact the dry pack against the sides of the holes.

After compaction, the surface of each layer shall be scratched before further loose material is added. The holes shall be slightly overfilled. The surface shall be finished by laying a hardwood block against the dry pack fill and striking the block several times.

Approval of scaffoldings and form

Plans, Drawings and structural calculations shall be submitted to the Engineer on time so that no construction of such scaffoldings and forms shall take place before the Engineer's approval is

accorded in writing. Such approval shall not relieve the Contractor of his responsibilities for the involved structure.

The Engineer shall have reasonable time for his examination of the Contractor's plans and calculations, if scaffoldings are introducing temporary loading on new structures in particular. For this purpose, the Contractor shall not be allowed any extension of time beyond the stipulated period of the Contract.

Before concrete is placed, the Engineer shall inspect all formworks and scaffoldings. No concrete shall be placed until inspection is made and approval is given by the Engineer. Such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion and the soundness of the structure.

17.3 Measurement

Formwork and false work shall not be measured separately but shall be deemed to be an integral part of the concrete items.

17.4 Payment

The Contractor's rates for concrete work, inter-alia, shall be inclusive of all costs of all formwork, falsework and centering and for their subsequent removal. No additional payment will be made to the Contractor for these works.

18. JOINTS IN CONCRETE

18.1 Construction Joints

General

Construction joints are defined as concrete surfaces upon or against which concrete is to be placed and to which new concrete is to be placed, that have become so rigid that the new concrete cannot be incorporated integrally with that previously placed. Construction joints shall be formed wherever there is a discontinuity in placing concrete in external elements of concrete structures. Formed vertical or inclined, construction joints as well as unformed joints which are, due to interruption of concrete placement, only be permitted where shown on the Drawings or directed by the Engineer. All exposed faces of construction joints shall be made absolutely straight, leveled or plumbed and normal to the finished surface.

Spacing of construction joints shall be in accordance with good concreting practice as defined in BS 8110 or equivalent and enabling adequate precautions to be taken against shrinkage cracking. Placing of concrete shall be carried out continuously. The joints shall be at right angle to the general direction of the member and shall take due account of shear and other stresses.

All planned reinforcing steel shall extend uninterrupted through joints. Additional reinforcing steel dowels shall be placed across the joints, if and when directed by the Engineer. Such additional steel shall be furnished and placed at the Contractor's expenses.

Bonding

Unless otherwise shown on the Drawing, horizontal joints may be made without keys and vertical joints shall be constructed with shear keys. Surfaces of fresh concrete at horizontal construction joints shall be rough floated sufficiently to thoroughly consolidate the surface and intentionally left in a rough condition. Shear keys shall consist of formed depressions in the surface covering approximately one-third of the contact surface. The forms for keys shall be beveled so that removal will not damage the concrete.

Surfaces of construction joints shall be prepared as early as possible after casting. The preparation shall consist of the removal of all laitance, loose or defective concrete coatings, sand and other deleterious materials. Preparation shall be carried out preferably when the concrete has set but not hardened by jetting with a fine spray of water or brushing with a stiff brush, just sufficient to remove the outer mortar skin and to expose the larger aggregate without it is being disturbed. Where this

treatment is impracticable and work is resumed on a surface, which has set, the whole surface shall be thoroughly roughened or scrapped with suitable tools so that no smooth skin of concrete that may be left from the previous work is visible.

The prepared joint face shall be thoroughly cleaned by compressed air and water jets or other approved means and brushed and watered immediately before depositing concrete. The cleaned and saturated surfaces, including vertical and inclined surfaces, shall first be thoroughly covered with a thin coating of mortar or neat cement grout against which the new concrete shall be placed before the grout has attained its initial set.

The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints, which are exposed to view, shall be carefully finished true to line and elevation.

Bonding and doweling to existing structures

When reinforcing dowels grouted in to holes drilled in the existing concrete is required at such construction joints, the holes shall be drilled by methods that will not damage the concrete around the holes. The diameters of the holes shall be 6mm larger than the nominal diameter of the dowels unless shown otherwise on the Drawings. The dowel bars shall be round mild steel bar of the diameter and length as indicated on the Drawings and/or as per the directions of the Engineer. The grout shall be a neat cement paste of Portland cement and water or an epoxy. Immediately prior to placing the dowel bars, the holes shall be cleaned off dust and other deleterious materials, shall be thoroughly saturated with water, have all free water removed and shall be dried to a saturated surface dry condition. Sufficient grout or an epoxy shall be placed inside the holes so as not to remain any void after the dowels are inserted. Grout shall be cured for a period of at least 3 (three) days or until dowel bars are encased in concrete. When an epoxy is used, the mixing and placing shall conform to the manufacturer's recommendations.

Forms at construction joints

When forms at construction joints overlap previously placed concrete, they shall be re-tightened before depositing new concrete. Exposed face edges of all joints shall be neatly formed with straight bulk heads or grade strips, or otherwise properly finished true to line and elevation.

18.2 Expansion and Contraction Joints

18.2.1 Expansion Joints

General

Expansion joints are intended to accommodate relative movement between adjoining parts of a structure.

Compressible filler shall be placed between the joint faces to provide freedom for expansion for the two adjacent concrete masses. Care shall be taken to ensure that the material fills the joint completely and that no concrete or hard material is left in the joint after the second face of the joint has been cast.

Material

One of the following specifications shall be used as pre-mould fillers:

- ① Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction, ASTM 1751.
- ① Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction ASTM D 1752. Type-II (cork) shall not be used when resiliency is required.
- ① Specification for Preformed Expansion Joint Filler for Concrete, ASTM D 994.

The bitumen sheet, laid on the horizontal top surface of the expansion joint keys, shall be a 10mm thick material approved by the Engineer.

Metal armour

Expansion joint armour assemblies shall be fabricated from steel with the following materials:

- ① Steel bars, plates and shapes shall conform to the requirements of ASTM A 36.
- ① Bolts and nuts shall conform to the requirements of ASTM A 307.
- ① High strength bolts, nuts and washers shall conform to the requirements of ASTM A 325.
- ① Steel castings shall conform to the requirements of ASTM A 486 or ASTM A 27.
- ① Grey iron castings shall conform to the requirements of ASTM A 48.
- ① Sheet metal shall be of commercial quality.

Armour assemblies

All assemblies shall be accurately fabricated and straightened at the workshop, as necessary to conform to the concrete section. The assemblies shall be installed so that their top surface matches the plane of the adjacent finished concrete surface throughout the length of the assembly. Appropriate methods shall be followed in placing the assemblies to keep them in correct position during the placing of concrete. The opening at expansion joints shall be that designated on the Drawings at normal temperature or as directed by the Engineer for other temperatures. Cares shall be taken to avoid impairment of the clearance in any manner.

18.2.2 Contraction Joints**General**

Joints placed in structures or slabs to provide for volumetric shrinkage of monolithic unit or movement between monolithic units are defined as contraction joints. The joints shall be constructed so that there will be no bond between the concrete surface forming the joints.

Material

Material placed in contraction joints shall consist of asphalt saturated felt paper or other approved bond-breaking material.

18.2.3 Pourable Joint Sealants

Pourable sealants shall be placed along the top edges of contraction or filled expansion joints. It shall conform to the following considerations:

- ① Unless otherwise shown on the Drawings or ordered by the Engineer, joint sealants shall be a hot poured rubber bitumen compound for horizontal joints and either a bituminous compound or an elastomeric two part polysulphide sealant for sloping, vertical and soffit joints.
- ① Bituminous compounds shall comply with BS 2499 for horizontal joints and BS 2499 Type A1 for sloping or vertical joints. Polysulphide compound shall comply with BS 4254.
- ① Joint sealants and the requisite priming materials shall be obtained from manufacturers approved by the Engineer. The application of joint sealant shall not be commenced without the Contractor obtains its approval by the Engineer.

18.2.4 Compressive Filler

Unless otherwise specified, the joint filler shall be of resin or bituminous bonded corks such as 'Hydrocor' manufactured by Expandite Ltd. The filler shall be obtained from a manufacturer approved by the Engineer and shall be stored and fixed in accordance with the manufacturer's instructions.

18.2.5 Water stops

General

Water stops shall be of the type, size and shape shown on the Drawings. They shall be dense, homogeneous and without holes or other defects.

Types

Water stops to be used may be of the following types:

❶ Polym vinyl chloride (PVC) water stops

Where shown on the Drawings, construction (as required and approved by the Engineer), contraction and expansion joints shall be made watertight by the provision of a continuous Water Stop strip of Poly Vinyl Chloride (PVC) manufactured by the extrusion process from an elastomeric plastic compound, the basic resin of which shall be Poly Vinyl Chloride. Unless otherwise specified or ordered, a two bulb dumbbell section PVC. Water Stop shall be used in construction joints and a three bulb section PVC Water Stop shall be used in expansion joints.

Water Stops shall be of high grade PVC, containing no filler or reclaimed or scrap material. PVC shall comply with the requirements of BS 2571 for PVC Type A, Class 1. The quality of Water Stops shall comply with the following major requirements:

- Specific gravity 1.30 (maximum)
- Hardness 80 (minimum)
- Tensile strength 138 kg/cm² (minimum)
- Elongation 225% (minimum)

❷ Rubber water stops

Rubber Water Stops shall be manufactured with synthetic rubber made exclusively from neoprene, reinforcing carbon black, zinc oxide, polymerization agents and softeners. The quality shall conform the following major requirements:

- Neoprene content 70% by volume (minimum)
- Hardness 50-60
- Tensile strength 193 kg/cm² (minimum)
- Elongation 600% (minimum)

Rubber Water Stops shall be formed with an integral cross section in suitable moulds, so as to produce a uniform section with a permissible variation in dimension of 0.8mm plus or minus. No splices will be permitted in straight strips. Strips and special connection pieces shall be well cured in a manner such that any cross section shall be dense, homogeneous, and free from all porosity. Junctions in the special connection pieces shall be full moulded. During the vulcanizing period, the joints shall be securely held by suitable clamps. The material at the splices shall be dense and homogeneous throughout the cross-section.

18.2.6 Installation

Open joints

Open joints shall be constructed by the insertion and subsequent removal of a wood strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. When not protected by metal armour, open joints in slabs shall be finished with an edging tool. Upon completion of concrete finishing work, all mortars and other debris shall be removed from the open joints.

Filled joints

When filled joints are shown on the Drawings, pre-moulded type fillers shall be used unless Poly Styrene board is specifically called for. Filler for each joint shall consist of as few pieces of material as possible. Abutting edges of filler material shall be accurately held in alignment with each other and tightly fit or taped as necessary to prevent the intrusion of grout. Joint filler material shall be anchored to one side of the joint by waterproof adhesive or other methods so as to prevent it from working out of the joint but not interfere with the compression of the material.

Sealed joints

Prior to installation of the pourable joint sealants, all foreign materials shall be removed from the joint. The filler material shall be cut back to the depth shown or approved and the surface of the concrete, in contact with the sealant, be cleaned by light sand blasting. When required, a Poly Ethylene foam strip shall be placed in the joint to retain the sealant and isolate it from the filler material. The sealant materials shall then be mixed and installed in accordance with the manufacturer's directions. Any material that fails to bond the sides of the joint within 24 hours after placement shall be removed and replaced.

Water stops

Water Stops shall be obtained from a manufacturer approved by the Engineer, and shall be fixed and joined according to the manufacturer's instructions. All strips shall be stored in a place as cool as practicable and shall in no case be exposed to the direct sun light.

Water Stops shall be installed with approximately half of the width of the material embedded in the concrete on either side of the joint. It shall be firmly supported by split stop-end shuttering and in no case shall Water Stop be pierced to assist in fixing. Special care shall be taken to ensure that the concrete is well worked against the embedded parts of the strips and is free from honeycomb. Precautions are to be taken to protect any projected portions of the strips from damage during the progress of the works and from sunlight and heat.

If, after placing concrete, Water Stops are moved out of position or shape, the surrounding concrete shall be removed, the Water Stop reset, and the concrete replaced at the Contractor's own expenses. Two 9mm diameter reinforcing bars shall be provided to support the Water Stops and shall be securely held in position by the use of spacers, supporting wires, or other approved devices.

Flexible Water Stops shall be fully supported in the formwork, free from nails and clear of reinforcement and other fixtures. Damaged Water Stops shall be replaced and care shall be taken to place the concrete so that Water Stops do not bend or distort.

Splicing of Poly Vinyl Chloride Water Stop shall be performed in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt but not to char the plastic. Splices shall develop at least 90% of the tensile strength of un-spliced materials and shall withstand bending 180° around a 50mm diameter pin without cracking or separating.

The Contractor shall submit to the Engineer for his approval, at least before the commencement of concrete works, details of the Contractor's proposals for the installation of Water Stops. These shall show where joints in the Water Stops are to be located and details of the intersections and changes of direction to a scale that shows the position of any joint or shape of any moulded section.

As far as possible, jointing of PVC Water Stops on Site shall be confined to the making butt joints in straight runs of Water Stops. Where it is agreed with the Engineer that it is necessary to make an intersection or change of direction of any joint other than a butt joint in a straight run, a preliminary joint, intersection or change of direction piece shall be made and subjected to such tests as the Engineer may require.

Precautions shall be taken so that the Water Stops shall neither be displaced nor damaged by construction operations or other means. All surfaces of the Water Stops shall be kept free from oil, grease, dried mortar or any other foreign matter while the Water Stop is being embedded in concrete.

Means shall be used to ensure that all portions of the Water Stop designed for embedding shall be tightly enclosed by dense concrete.

18.3 Measurement

Construction Joints shall not be measured. Expansion and Contraction joints shall be measured in linear meter of the joints. There will be no additional measurement for joint fillers, sealed joints, Water Stops, miscellaneous metal devices etc.

18.4 Payment

Payment for construction joints shall be deemed included in the items of concrete and there will be no extra payment for it. For expansion and Contraction joints the amount of completed and accepted work measured as provided above shall be paid at the Contract Unit Price per linear meter and the payment shall constitute the full compensation for furnishing and placing joint fillers, sealed joints, Water Stops, drains, vents, miscellaneous metal devices including all labour and incidentals for full completion of the Work as per Specifications.

Item of payment

	Unit
Expansion joints	Linear meter
Contraction joints	Linear meter

19. WEARING COURSE

19.1 Description

This work shall include cement concrete wearing course prepared with durable and impervious material on the bridge deck in conformity with details shown on the Drawings and these specifications or as approved by the Engineer.

19.2 General

Prior approval by the Engineer shall be required in respect of preparation of the surface, mix, placing and finishing the concrete and all other activities related to this Work. However, such approval by the Engineer shall not relieve the Contractor of any responsibility under the Contract for the satisfactory completion of the work in accordance with the Specifications.

Minimum thickness of the Wearing Course shall be 50mm, if not shown otherwise on the Drawings.

19.3 Material

Cement

Cement shall be Portland cement Type-1 conforming the requirement of ASTM C-150. All other properties of cement shall be the same as have been described under the relevant Sub-sections of the Section on 'Construction Materials' of these Specifications.

Sand

Sand shall be non-saline, hard, dense and free from deleterious materials and shall have a minimum F.M. 1.8. It should conform to the requirements of AASHTO Standard Specifications M 6. All other requirements shall be the same as have been described under the relevant Sub-sections of the Section on 'Construction Materials' of these Specifications.

Coarse aggregate

Except otherwise stated, coarse aggregate shall consist of 6mm down graded chips obtained from boulders conforming all specifications described under the relevant Sub-section of the Section on 'Building Materials' and 'Concrete for Structures' of these Specifications.

Water

Water for mixing concrete shall conform to the requirements specified under the relevant Sub-section of the Section on 'Concrete for Structures' of these Specifications.

Concrete mix

Concrete mix use for this work shall be a workable mixture conforming the following requirements.

Material/Property	Concrete
Cement (Parts by weight)	1
Sand of minimum F.M. 1.8 (Parts by weight)	1.5
Coarse Aggregate (Parts by weight)	3
Air content (In percentage)	3-6
Slump (in mm)	25-50

The dry weight ratios are approximate and should produce good workability.

19.4 Construction Method

The surfaces of new decks upon which a wearing surface overlay is to be placed shall be finished to a rough texture by coarse brooming or by other appropriate and approved method. After curing of the deck concrete is complete and before placing the overlay, the entire area of the deck surface and vertical faces of curbs, concrete parapets, barrier walls etc. upto height of 25mm above the top elevation of the overlay shall be blast cleaned to a bright clean appearance which is free from laitance, curing compound, dust, dirt, oil, grease and all other foreign materials. The blast cleaning of an area of the deck shall normally be performed within 24 hours period preceding placement of the overlay on the area. Just prior to placement of the overlay, all dust and other debris shall be removed by flushing with water or blowing with compressed air. The prepared surface shall then be soaked with clean water for not less than 1 hour prior to the placement of the overlay. Before the overlay is applied, all free water shall be blown out and off, and this procedure shall be continued until the surface appears dry or barely damp.

The surfaces of the existing deck that have become weared from prolong traffic usage or from other reasons shall be scarified to a depth shown on the Drawings or specified. If no depth is shown or specified, a minimum of 6mm of material shall be removed by scarifying. Prior to scarification begins and until operations are completed, all deck drains, expansion joints and other openings where damage could result, as determined by the Engineer, shall be temporarily covered or plugged to prevent entry of debris. No scarifying or chipping will be allowed within 2m of a new overlay until 48 hours elapse on its placement. In areas where deteriorated or unsound concrete is encountered, as determined by the Engineer, the concrete shall be removed to a depth of 20mm below the top mat of reinforcing steel. A minimum of 20mm clearance shall be required around the reinforcing steel except where lower bar mats make this impractical. Care shall be exercised to prevent damage of the exposed reinforcing steel. All reinforcing steel shall be blast cleaned. The repair areas are to be filled during the overlay operation. After scarification and removal of unsound concrete has been completed, the deck surface shall be blast cleaned and prepared as specified for new decks.

The Contractor shall submit to the Engineer for approval, 14 calendar days prior to date of placement, the proposed mix design in writing and samples of all mix materials in sufficient quantity to produce a minimum of 0.085 cubic meter of concrete for laboratory mix design testing.

All procedures and specifications with regard to proportioning, mixing, placing, finishing, curing and testing of concrete shall be similar to those illustrated under the relevant Sub-sections of the Section 'Concrete for Structures' of these Specifications.

19.5 Measurement

The wearing course shall be measured by the number of cubic meters completed in place and accepted. In computing quantities, the dimensions used shall be those shown on the Drawings or ordered by the Engineer.

19.6 Payment

Payment for wearing course shall be the full compensation for the cost of furnishing all labours, materials, equipment and incidentals and for doing all other works involved in constructing the wearing course complete in place as shown on the Drawings and specified.

Item of payment

	Unit
Cement concrete wearing course	Cubic Meter

20. REPAIR OF EXISTING CONCRETE STRUCTURES**20.1 Description**

This work shall consist of re-construction of the existing localized defective concrete (including that associated with small extensions of existing concrete structures), rehabilitation of existing concrete facing, repair of minor cracks in structural concrete and anchoring and tying of existing structural members.

The work shall be carried out in accordance with these Specifications and to the locations, lines and dimensions shown on the Drawings or as required by the Engineer.

Any extension work associated with repair of existing localized defective concrete is covered under the Sub-section titled 'Concrete for Structures' and the Section titled 'Reinforcing Steel' of this Specification and the extension work shall be measured and paid for under those Sections.

20.2 Materials

Concrete shall conform to the specifications contained in the Sub-section on 'Concrete for Structures' of this Specification.

Cement mortar shall comply with the specifications contained in the Sub-section on 'Brick Masonry Works' of this Specification except that the mix may vary as shown on the Drawings.

20.3 Construction Methods**General**

The Contractor and the Engineer shall jointly survey structures to be repaired and the location of all repairs shall be permanently marked in paint on each structure. The repair works shall be carried out by skilled and experienced personnel well conversant with this work.

Repair of existing localized defective concrete

Where existing defective concrete is to be repaired or extended, the existing concrete shall be carefully broken to ensure that all defective materials are removed and that, where necessary, sufficient reinforcement is exposed.

All loose concrete shall be removed, the exposed reinforcement shall be carefully cleaned and the exposed concrete shall be cleaned of all dusts. A construction joint shall be prepared on the exposed face to ensure a good feature between the existing section and the repair/extension works.

The prepared faces shall be inspected and approved by the Engineer before new work commences.

Repair to concrete surfaces

Defective concrete on the face of substructure walls, in soffits to beams, slabs and other superstructure and on the web faces of main beams and other superstructures shall be carefully removed in a sequence and in accordance with the strict instructions of the Engineer. Such works shall be permanently supervised by a representative of the Engineer and the Contractor shall ensure that technical staff are permanently available at the Site to receive instructions. The structural integrity of the existing members shall not be impaired and the Contractor shall be fully responsible to ensure that strict procedures are followed. Defective concrete shall be carefully and cleanly removed by manual methods using hammers and chisels. The concrete exposed shall be cleaned of all dust and loose materials. Any reinforcement shall be carefully cleaned using wire brushes unless and otherwise instructed by the Engineer.

The removed concrete shall be replaced by a method proposed by the Contractor and approved by the Engineer after inspection of the exposed work. The Contractor shall demonstrate that the method he proposes to adopt is capable of giving a face equivalent to the workmanship standard that would be accepted in new works.

Repair of minor cracks in concrete

Minor cracks shall be cleaned to remove all loose materials to expose a sound surface. On approval by the Engineer of the cleared crack, it shall be grouted to full depth with cement mortar and trimmed flush with the face of the concrete.

Anchoring and tying

Structural concrete members that exhibit cracking and relative movement may be anchored or tied as instructed by the Engineer. Prior to commencing work, the Contractor shall obtain the approval of the Engineer of the methods to be followed. This shall cover the provision of temporary stages, the drilling methods, safety measures, anchoring methods and subsequent testing for ground anchors to ensure tie bars capable of carrying twice the working load, stressing methods and ultimate grouting of anchor bars. The Contractor shall take instructions from the Engineer on the precise requirements for the provision, installation and anchoring of all tie bars incorporated in the Work.

20.4 Measurement

Repair of defective concrete shall be measured as the volume in cubic meters marked up, replaced to original lines and accepted by the Engineer.

Concrete surface repairs shall be measured as the area in square meters marked up, repaired and accepted by the Engineer.

Repair of minor cracks shall be measured as the length in linear meters marked up, grouted and accepted by the Engineer.

Anchoring and tying shall be measured as the weight in Kg of anchors and tie bars ordered, installed and accepted by the Engineer.

20.5 Payment

The works measured as provided above shall be paid at the relevant Contract unit prices per cubic meter, per square meter, per linear meter and per Kg as applicable. The payment shall constitute the full compensation for all works including all materials, preparatory work and removal of defective materials, temporary works, all labour, equipment, tools and incidentals necessary to complete the Work. For anchoring and tying, the payment shall also be the full compensation for fixing or drilling, installation, grouting in stages and stressing.

Item of payment

	Unit
Repair of existing defective concrete	Cubic Meter

Repair of existing concrete surfaces	Square meter
Repair of minor cracks in existing concrete	Linear meter
Supplying and fixing anchors and tie bars	Kg.

21. BEARINGS

21.1 General

This section provides the technical requirements associated with the design, manufacture, testing and delivery to site and installation of the permanent confined elastomer bearings.

The term “Elastomeric bearing” in this specification shall refer to bearing consisting of one or more elastomer slabs bonded to metal plates during manufacture so as to form a sandwich arrangement and caters for translation and/or rotation of superstructure by elastic deformation of elastomer. “Neoprene bearing pads” shall denote single un-reinforced elastomer slabs.

Unless otherwise specified all bearings shall be designed, manufactured and installed in accordance with the requirements of Part 9 of BS 5400 and BS 6177.

All bearings shall be warranted against all defects and any malfunctioning for a minimum period of 10 (ten) years from the date of completion of the whole of the Works and all defects occurring during this period are to be made good by the Contractor at his expenses. The Warranty is to be provided jointly and severally by the Contractor and the Manufacturer and shall be in the format shown in the Particular Specification.

All bearings used in the Contract shall be preferably from one supplier only, unless otherwise agreed by the Engineer.

21.2 Description

This work shall consist of furnishing and fixing in position of bearing in accordance with the details shown on the Drawings to the requirements of these specifications.

21.3 Materials

All material to be used for bearings of the bridge, shall correspond to all specifications as have been stated under the Sub-section ‘Construction Materials’ of this Specification.

Specifications for fabrication

- Mild steel used for plate reinforcement shall comply with ASTM A570, Grade 36 or ASTM A611, Grade D. The steel plates shall be free from sharp edges and burrs and shall be completely encased in the bearing rubber.
- Bearing with steel laminates shall be cast as a single unit in a mould and vulcanized under heat and pressure. Casting elements in separate units and subsequent bending will not be permitted, nor shall cutting from larger size cast be also permitted.
- Bearings of similar size to be used shall be produced by identical process and in a lot as far as practicable. Phased production may only be resorted to when the total number of bearings is significantly large enough.
- The moulds used shall have standard surface finish adequate to produce bearings free from any surface blemishes.
- Steel plates for laminates shall be sand blasted clean of all mill scale and shall be free from all contaminants prior to bending by vulcanization. Rusted plates with pitting shall not be used. All edges of plates shall be rounded.
- Spacers used in mould to ensure uniform vulcanizing condition and homogeneity of elastomer through the surface and body of the bearing.
- Bearings shall be fabricated with tolerances specified below:

1.	Overall Height	

	Design Thickness 32mm or less Design Thickness over 32mm	-0, +3mm -0, +6mm
2.	Overall Horizontal Dimensions 0.914m or less Over 0.914m	-0, +6mm -0, +12mm
3.	Thickness of Individual Layers of Elastomer (Laminated Bearings only) At any point within the bearings	+20% of design value but no more than +3mm.
4.	Parallelism with Opposite Face Top and bottom sides	0.005 radians 0.02 radians
5.	Position of Exposed Connection Members Holes, slots, or inserts	+3mm
6.	Edge Cover Embedded laminates or connection members	-0, +3mm
7.	Thickness Top and bottom cover layer (if required)	-0, the smaller of 1.5mm and +20% of the nominal cover layer thickness.
8.	Size Holes, slots, or inserts	+3mm

21.4 Drawings

The Contractor shall have to supply, fix in position and maintain the bearings strictly in accordance with the Drawings and Designs of this Contract.

21.5 Acceptance of Specification

- The manufacturer shall have all test facilities required for process and acceptance control tests installed at his plant to the complete satisfaction of the Engineer. The test facilities and their operation shall be open to inspection by the Engineer on demand.
- All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipments and labour shall be borne by the manufacturer unless otherwise specified herein or specially agreed to between the manufacturer and the Engineer.
- Acceptance testing shall be commenced with the prior submittal of testing programme by the manufacturer to the Engineer and after obtaining his approval.
- Any acceptance testing delayed beyond 60 days of production shall require special approval of the Engineer and modified acceptance testing, if considered necessary by him.
- All acceptance testing shall be conducted by the inspector assisted by the personnel having adequate expertise and experiences in rubber testing provided by the manufacturer, working under the supervision of the inspector and to his complete satisfaction.

Quality control certificate

A lot under acceptance shall comprise all bearings, including a pair of extra test bearings of equal or nearly equal size produced under identical conditions of manufacture to be supplied for a particular project.

The size and composition of acceptance lot shall get approved by the Engineer.

The manufacturer shall certify for each lot of bearing under acceptance:

- that an adequate system of continuous quality control was maintained in his plant.

- that process remained in control during the production of the lot of bearings under acceptance as verified from the quality control records/charts which shall be open to inspection of the Engineer on demand.
- a certified copy of results of process control testing done on samples of elastomer used in the production of the lot shall be appended and shall include at least the following information:
 - composition of the compound – raw elastomer and ash content the grade of raw elastomer used (including name, source, age on shelf)
 - test results of hardness
 - tensile strength
 - elongation at break
 - compression test
 - accelerated ageing etc.

Certificate and markings

Bearings shall be transported to the bridge site on final acceptance by the Engineer and shall be accompanied by an authenticated copy of the certificate to that effect.

An information card giving the following details for the bearings, duly certified by the manufacturer shall also be appended.

Date of manufacturing

Elastomer grade used

Bearing dimensions

Production batch No.

Specific bridge location, if any

Explanation of markings used on the bearing.

All bearings shall have suitable index markings identifying the information as given above. The markings shall be made in indelible ink or flexible paint and if practicable, should be visible after installation. The top of the bearing and direction of installation shall be indicated.

In addition to above, test shall be carried out for selected samples which shall be sent to the authorized laboratory (preferably BUET) in sealed condition with a view to verify the results in accordance with the requirements specified in the Table given under 'Elastomeric Bearings' in the Sub-section of 'Construction Materials' of this Specification. The Contractor shall supply all the requisite number of bearings required for a bridge to the respective Office of the Executive Engineer. Samples for inspection and testing shall be selected from within the lot at random. A minimum of 1 (one) bearing shall be taken from the lot when the requirement of bearings remains within 12 (twelve), 2 (two) bearings shall be taken for testing when the number of required bearings is more than 12 (twelve) but not exceeding 30 (thirty). When it exceeds 30 (thirty), then additional testing requirement shall be 1 (one) for each additional 30 (thirty), or part thereof.

21.6 Installation

Care shall be taken in packing, transportation, storage and handling to avoid any mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather.

Installation of multiple bearings one behind the other on a single line of support, shall not be permitted.

All bearings installed along a single line of support shall be of identical dimensions.

Bearings shall be placed on surfaces that are plane to within 1.5mm and unless the bearings are placed in opposing pairs, horizontal to within 0.01 radians. Any lack of parallelism between the top of the bearing and the underside of the girder that exceeds 0.01 radians shall be corrected by grouting or as otherwise directed by the Engineer.

For case in place concrete construction of superstructure, where bearings are installed prior to its concreting, the forms around the bearings shall be soft enough for easy removal. Forms shall also fit

the bearings snugly and prevent any leakage of mortar grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.

For pre-cast concrete or steel superstructure elements, fixing of bearing to them may be done by application of epoxy resin adhesive to interface after specified surface preparation. The specifications for adhesive material, workmanship and control shall be approved by the Engineer. Care shall be taken to guard against faulty application and consequent behavior of the adhesive layer as a lubricant. The bedding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearing against displacement for the purpose of design.

21.7 Maintenance

The bearings shall be subject to planned maintenance care.

The exposed bearing surfaces shall be maintained clean and free from contamination with grease, oil, etc.

After installation, routine maintenance inspection of all bearings shall be made till the expiry of the maintenance period to check for any surface cracking or signs of damage, deterioration or distress.

Damaged bearings shall be replaced immediately. To avoid difference in stiffness, all adjacent bearings on the same line of support shall also be replaced.

21.8 Measurement

The quantity of elastomer bearings shall be measured in set of given dimension as installed and accepted.

21.9 Payment

The completed and accepted work measured as provided above shall be paid at the contract unit price per set, which payment shall constitute the full compensation for furnishing all materials, equipment, appliances and labour including transport, storage, installation as well as all incidentals necessary to complete the work fully as per the Specifications prescribed in this Sub-section.

Item of payment

	Unit
Steel laminated Elastomeric Bearings	Set

22. INSERTS AND FITTINGS

22.1 Description

This Work shall consist of furnishing and embedding of inserts, fitting and other incidental parts into bridgework necessary to provide for further support for utility pipes and cables and the like in accordance with these Specifications. The type, size and location will be indicated on the Drawings or instructed by the Engineer.

22.2 Materials

Unless otherwise indicated on the Drawings or as approved by the Engineer, all inserts and fittings shall be made of galvanized malleable iron or galvanized steel. This shall conform to the requirements of AASHTO Standard Specification M 183 (ASTM A 36).

Samples of the inserts and fittings to be used shall be submitted to and approved by the Engineer before they are installed.

22.3 Construction Methods

The inserts and fittings shall be embedded at the locations indicated on the Drawings or as instructed by the Engineer. During pouring of concrete in structures, the inserts and fittings shall be secured at the correct positions by appropriate means acceptable to the Engineer.

The inserts and fittings shall be plugged or pressed against the formwork in a way that no mortar from the concrete shall enter the thread of the inserts or fittings.

The location, placing, securing and plugging of inserts and fittings shall be approved by the Engineer before placing of concrete.

On removing the formwork, the Contractor shall properly clean the surfaces of all the inserts and fittings to the satisfaction of the Engineer.

22.4 Measurement

The work shall be measured in terms of Weight (Kg) of inserts and fittings installed complete and accepted.

22.5 Payment

The work measured shall be paid for at the Contract unit prices for the different types of inserts and fitting as shown in the Bill of Quantities. The payment shall be the full compensation for supply and installation of the inserts and fittings including all labour, equipment, tools and incidentals necessary to complete the work in accordance with the specifications of this Sub-section.

Item of payment

	Unit
Supply and Installation of Inserts and Fittings	Kg

23. DRAINAGE OF STRUCTURES

23.1 Description

This item of work shall consist of furnishing and erection of drain outlets on bridgework and drainage structures including PVC piping, cleaning boxes, catch basins, concrete drains, erosion protection, inserts, fittings and other incidentals necessary to provide for further supports of drain pipes in accordance with the lines, levels, grades, sizes, dimensions and types shown on the Drawings.

23.2 Materials

Bridge cullies

The size and strength of bridge gullies shall be as indicated on the Drawings.

Cast iron piping

Cast Iron Piping shall comply with AASHTO M 129 or other approved Standards.

PVC pipes

All PVC pipes shall comply with ISO R 161 "Pipes of Plastic Materials for the Transport of Fluids", with BS 3505 "Un-plasticized PVC Pipes for Cold Water Services".

Cleaning boxes

The Contractor shall submit to the Engineer for his approval the details of boxes with cleaning lids made of approved material to be installed at the locations indicated on the Drawings.

Inserts shall be carried out of steel conforming to AASHTO M 183 (ASTM A 36).

Fittings and other incidentals

Materials to be as indicated on the Drawings or as approved by the Engineer.

23.3 Construction Methods**Storage and handling of materials**

The steel and PVC parts shall be carefully handled and stored on blocks, racks or platforms so as not to be in contact with the ground and the steel parts shall be protected from corrosion. Materials shall be kept free from dirt, oil, grease and other foreign matter.

Bridge gullies

Bridge gullies are to be cast in to the structure at the location as indicated on the Drawings. Special care must be taken to avoid displacement of gullies during concreting operations.

Cast iron pipes

Special jointing instructions relevant to the purchased types of pipe will be issued by the Engineer. The pipes shall be embedded at the locations as indicated on the Drawings. During casting of concrete the pipes shall be kept in the correct position by appropriate means approved by the Engineer.

PVC pipes

The jointing shall be of a type recommended by the manufacturer of the pipes. Bends shall be of long sweep, free from kinks.

Embedded pipes shall be cast in to the structure at the locations as indicated on the Drawings. During casting of concrete the pipes shall be kept in the correct position by appropriate means approved by the Engineer.

Exposed pipes shall be parallel to or at right angles to walls, slabs and girders. All exposed pipes shall be attached to concrete, steel, masonry or timber by galvanized malleable iron or galvanized steel straps, clamps or hangers of an approved type, held at not less than two pints by galvanized steel bolts or lag screws. The runs shall be supported at no greater than 1m centres on horizontal or near horizontal runs, unless an otherwise specified and not less than 50mm clear of the supporting members.

All ends of pipes installed during construction shall be closed against the intrusion of foreign material.

Cleaning boxes

To be installed by methods proposed by the Contractor and approved by the Engineer.

Inserts

To comply with the Sub-section on 'Inserts and Fittings' of this Specification.

23.4 Measurement

The work of Rain Water Down Pipes shall be measured in linear meter of such pipes.

23.5 Payment

The work measured as provided above shall be paid for at the Contract unit price per linear meter of pipe. The payment shall constitute the full compensation for furnishing all materials as indicated on the Drawings including delivery, erection, treatment and finishing and for all labour, equipment, tools and incidentals necessary for completion of the Work.

Item of payment

	Unit
Rain water down pipe	Linear meter

24. REINFORCING STEEL**24.1 Reinforcement for RCC****24.1.1 Description**

Works covered by this item shall consist of supplying and placing of steel reinforcement in different types of concrete structures including board cast-in-situ piles and pre-cast concrete piles but not includes reinforcement for pre-stressed concrete. The works shall conform to the specifications, the types, sizes and positions of reinforcement requirements shown on the Drawings and this specification.

24.1.2 Materials**Reinforcement**

Reinforcing bars discussed under this Section shall be made of Mild Steel or High yield Steel, plain or deformed, for all Reinforced Concrete Works but excluding Pre-stressing Concrete.

Bars shall be rolled and produced from steel in the form of new and clean billets directly reduced from ingot of properly identified heats of open hearth, basic oxygen or electric arc furnace steel or lots of acid besmear steel.

Reference standards**Deformed reinforcement**

Steel Bars and Wires for the Reinforcement of Concrete	BDS 1313
Rolled Deformed Steel Bars (intermediate grade) for Concrete Reinforcement	BDS 580
Deformed and Plain Billet Steel Bars for Concrete Reinforcement	ASTM A 615
Rail Steel Deformed and Plain Bars for Concrete Reinforcement	ASTM A 616
Axle Steel Deformed and Plain Bars for Concrete Reinforcement	ASTM A 617
Low Alloy Steel Deformed Bars for Concrete Reinforcement	ASTM A 706
Deformed Steel Wire	ASTM A 496
Welded Deformed Steel Wire Fabric	ASTM A 497
Zinc Coated (Galvanized) Steel Bars	ASTM A 767
Epoxy – Coated Reinforcing Steel	ASTM A 775

Plain reinforcement

BDS 1313, ASTM A 615 M, ASTM A 616 M, ASTM A 617 M, ASTM A 185

Smooth steel wire

Cold – Drawn Steel Wire - ASTM A 82

Cold – worked steel reinforcement

IS 1786 : 1985, BS 4461 : 1978

Mild steel plain round bar

This is a type of bar plain and round in shape of a structural or intermediate grade with a yield strength of not less than 280 MPa (N/mm²) i.e. 40 grade.

Deformed bars

Reinforcing steel under this type comprises Mild Steel Grade 40 and High Strength Grade 60 Deformed re-bars with yield strength of not less than 280 MPa (N/mm²) in case of Grade 40 and with yield strength of not less than 410 MPa (N/mm²) in case of Grade 60.

Other bars

Steel welded wire, fabric plain reinforcement conforming to ASTM A 185 may be used, except that for wire with specified yield strength f_y exceeding 410 MPa (N/mm²), f_y shall be the stress corresponding to a strain of 0.35 percent.

Smooth steel wire conforming to ASTM A 82 may be used in concrete except that for a wire with a specified yield strength f_y exceeding 410 MPa (N/mm²), f_y shall be the stress corresponding to a strain of 0.35 percent.

Fabricated deformed steel bar mats conforming to ASTM A 184 and deformed steel wire complying with ASTM A 496 may be used. Deformed wire for concrete reinforcement shall not be smaller than a nominal diameter of 5.72mm, and for a wire with specified yield strength (f_y) exceeding 410 MPa (N/mm²), f_y shall be the stress corresponding to a strain of 0.35 percent.

Welded deformed steel wire fabric conforming ASTM A 497 may be used for a wire with specified yield strength exceeding (f_y) 410 MPa (N/mm²), f_y shall be the stress corresponding to a strain of 0.35 percent.

24.1.3 Chemical Composition

The structural grade shall be made from billets. The ends of the bar shall be machine sheared perpendicular to the axis of the bar. The bars shall be free from injurious defects and shall have a workman like finish.

The chemical composition should conform to the requirements of ASTM 706-82.

24.1.4 Process

The steel shall have been made by one or more of the following processes:

- open-hearth
- basic oxygen
- electric furnace
- acid besmear

24.1.5 Dimensional Requirements

The nominal diameter, perimeter and cross sectional areas of a deformed bar is equivalent to that of a plain bar having the same standard weight per unit length. Dimensional requirements of such bars have been shown in the Table given below:

Bar Designation n No.*	Nominal Dimensions**			Nominal weight, lb/ft [Nominal mass, kg/m]
	Diameter, in. [mm]	Cross Sectional Area, in. ² [mm ²]	Perimeter, in. [mm]	
3 [10]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.376 [0.560]
4 [13]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.668 [0.994]
5 [16]	0.625 [15.9]	0.31 [199]	1.963 [49.9]	1.043 [1.552]

Bar Designation No.*	Nominal Dimensions**			Nominal weight, lb/ft [Nominal mass, kg/m]
	Diameter, in. [mm]	Cross Sectional Area, in. ² [mm ²]	Perimeter, in. [mm]	
6 [19]	0.750 [19.1]	0.44 [284]	2.356 [59.8]	1.502 [2.235]
7 [22]	0.875 [22.2]	0.60 [387]	2.749 [69.8]	2.044 [3.042]
8 [25]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	2.670 [3.973]
9 [29]	1.128 [28.7]	1.00 [645]	3.544 [90.0]	3.400 [5.060]
10 [32]	1.270 [32.3]	1.27 [819]	3.990 [101.3]	4.303 [6.404]
11 [36]	1.410 [35.8]	1.56 [1006]	4.430 [112.5]	5.313 [7.907]
14 [43]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	7.65 [11.38]
18 [57]	2.257 [57.3]	4.00 [2581]	7.09 [180.1]	13.60 [20.24]

* Bar numbers are based on the number of eighths of an inch including in the nominal diameter of the bars [bar numbers approximate the number of millimeters of the nominal diameter of the bar].

** The nominal dimension of a deformed bar are equivalent to those of a plain round bar having the same weight [mass] per foot [metre] as the deformed bar.

24.1.6 Tensile Properties

The tensile properties of the Grade 40 and Grade 60 steel have been shown in the Table given below:

Item	Requirements	
	Grade 40 [300]*	Grade 60 [420]
Tensile strength, min, psi [MPa]	70,000 [500]	90,000 [620]
Yield strength, min, psi [MPa]	40,000 [300]	60,000 [420]
Elongation in 8 in. [203.2 mm], min, %		
Bar Designation No.		
3 [10]	11	9
4, 5 [13, 16]	12	9
6 [19]	12	9
7, 8 [22, 25]	-	8
9, 10, 11 [29, 32, 36]	-	7
14, 18 [43, 57]	-	7

* Grade 40 [300] bars are furnished only in sizes 3 through 6 [10 through 19].

24.1.7 Bend Test Requirement

The pin diameter required for performing bend tests shall conform to ASTM A 615. The following table contains such requirements:

Bar Designation No.	Pin Diameter for Bend Tests *	
	Grade 40 [300]	Grade 60 [420]
3, 4, 5 [10, 13, 16]	3.5d	3.5d
6 [19]	5d	5d
7, 8 [22, 25]	-	5d
9, 10, 11 [29, 32, 36]	-	7d
14, 18 [43, 57] (90°)	-	9d

* Test bends 180° unless noted otherwise.

d = Nominal diameter of specimen

Permissible variation

For lots from standard weights.	+ 5% for 6mm dia + 3.5% for 10mm dia and above
Individual	+ 6% for all sizes

Length

Length of the bar shall be maximum possible, but each bar shall not be less than 12m in length or 45.36 kg in weight whichever is greater.

24.1.8 ASTM Code Requirements for Deformations

Deformations shall be spaced along the bar at substantially uniform distances. The deformations on the opposite sides of the bar shall be similar in size and shape.

The deformations shall be placed with respect to the axis of the bar so that the included angle is not less than 45°. Where the line of deformation forms an included angle with the axis of the bar from 45° to 70° inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the line of deformation is over 70°, a reversal in direction is not required.

Average spacing or distance between deformations on each side of the bar shall not exceed 17 (seventeen) times of the nominal diameter of the bar.

Overall length of deformations shall be such that the gap between the ends of the deformations on the opposite sides of the bar shall not exceed 12.5% of the nominal perimeter of the bar. Where the ends terminate in a longitudinal rib, the width of the longitudinal rib shall be considered as the gap. Where more than two longitudinal ribs are involved, the total width of all longitudinal ribs shall not exceed 25% of the nominal perimeter of the bar. Furthermore, the summation of gaps shall not exceed 25% of the nominal perimeter of the bar. Nominal perimeter of the bar shall be 3.14 times the nominal diameter (d_b).

Spacing, height and gap of deformations as to be conformed have been shown in the following table:

Deformation requirements, in. [mm]

Bar designation	Maximum average spacing	Minimum average height	Maximum gap (Chord of 12.5% of Nominal Perimeter)
3 [10]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
5 [16]	0.437 [11.1]	0.028 [0.71]	0.239 [6.1]
6 [19]	0.525 [13.3]	0.038 [0.97]	0.286 [7.3]
7 [22]	0.612 [15.5]	0.044 [1.12]	0.334 [8.5]
8 [25]	0.700 [17.8]	0.050 [1.27]	0.383 [9.7]
9 [29]	0.790 [20.1]	0.056 [1.42]	0.431 [10.9]
10 [32]	0.889 [22.6]	0.064 [1.63]	0.487 [12.4]
11 [36]	0.987 [25.1]	0.071 [1.80]	0.540 [13.7]
14 [43]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	1.58 [40.1]	0.102 [2.59]	0.864 [21.9]

Note: *Any bar that fails to satisfy the aforementioned all requirements is to be treated as plain reinforcement.*

24.1.9 Binding Wire

Reinforcement binding wire shall be the best black annealed mild steel wire and not less than approximately 1.6mm in diameter/24 BWG or 26 BWG galvanized iron wire.

24.1.10 Wire Mesh

Wire mesh shall conform to the requirements of AASHTO Standard Specification M 55 Welded Steel Wire Fabric for Concrete Reinforcement.

24.1.11 Ordering Material

The name of the proposed supplier of the reinforcement shall be submitted as soon possible to the Engineer for his approval. The Contractor shall submit necessary information concerning the supplier as requested by the Engineer.

Copies of orders placed shall be submitted to the Engineer.

The manufacturer shall submit all requested relevant data on the steel, i.e. breaking strength, yield strength, characteristics on elongation, chemical composition etc., to the Engineer for his approval.

No steel shall be delivered without a certificate guaranteeing the yield stress.

The steel shall be stored and marked in a way that it enables identification of the steel corresponding to each certificate later on.

24.1.12 Tests

Test results in addition to those to be submitted by the Contractor and specified above shall be required.

The Contractor shall cut out samples as directed by the Engineer.

The samples shall be tested according to the Engineer's instructions by an approved Testing Institution, provided that the testing facilities are not available in the LGED Laboratories. Approximately three samples shall be tested from each 10 tons of reinforcement delivered at the Site. Expenses incurred in connection with cutting, carrying and testing the samples shall be borne by the Contractor at his own costs.

24.1.13 Construction Methods of Reinforcing Bar

Storage and care

All reinforcing steel when received at the Site, prior to its use, shall be stacked off the ground on platforms, skids or any other support and shall be kept free from dirt, oil and grease. All cares shall be taken to prevent the steel reinforcement from any mechanical injury and surface loss resulting from its exposition to weather conditions that produce rust. It shall be clean and kept free from loose rust and loose mill scale at the time of fixing in position and subsequent pouring of concrete. However, reinforcement steel may not be rejected on the ground of bonded rust, surface seams, surface irregularities and mill scale so long minimum dimensions, cross-sectional area and tensile properties of a hand wire brushed specimen meet the specified physical requirements for the size and grade of steel.

Reinforcement shall be handled and stored in a manner that will prevent bending out of the desired shape and any accumulation of dirt, oil and paint. When placed in the works, it shall be free from dirt, oil, grease, paint, mill scale and loose or thick rust.

Bar reinforcement shall be shipped in standard bundles, tagged and marked in accordance with the Codes of Practice of the Concrete Reinforcing Steel Institute.

Fabrication

All bars shall be fabricated following Specifications, methods and procedures stated below. Fabrication tolerances shall be in accordance with ACI 315.

Cutting and bending

All reinforcement bars shall be cut and bent cold to the specified shape and pertinent dimensions shown on the Drawings using a proper bar bender, operated by hand or power to attain proper radii of bends. The equipment used and methods followed for this purpose shall get the approval of the Engineer.

Bars shall not be bent or straightened in a manner that will injure the material.

Bars partially embedded in concrete shall not be field bent unless otherwise shown on the Drawings or directed by the Engineer.

Errors in alignment of reinforcement partially embedded in hardened concrete shall not be corrected by bending in place, except as permitted by the Engineer.

Bars bent during transportation or handling shall be straightened before being used in work. It shall not be heated to facilitate bending.

Fabrication tolerances shall be in accordance with ACI 315.

All bars shall have standard hooks at the end, which shall meet the following requirements unless otherwise specified on the Drawings. When the dimensions of hooks or the diameter of bends are not prescribed, they shall be in accordance with ACI 318 'Building Code requirements for Reinforced Concrete'. Some of the standard requirements have been specified below:

- ① 180° turn plus an extension of at least 4 bar diameters but not less than 60mm at the free end of the bar.
- ① 90° turn plus an extension of at least 12 bar diameters at the free end of the bar.
- ① For stirrup and the anchorage only:

➤ For 16mm ϕ bar and smaller	:	90° bend plus an extension of at least 6 bar diameters or 75mm whichever is greater at the free end of the bar.
➤ For 19mm ϕ , 22mm ϕ and 25mm ϕ bar	:	90° bend plus an extension of at least 12 bar diameters or 150mm whichever is greater at the free end of the bar.
➤ For 25mm ϕ bar and smaller	:	135° bend plus an extension of at least 6 bar diameters at the free end of the bar.
➤ For closed ties and continuously wound ties	:	135° bend plus an extension of at least 6 bar diameters, but not less than 75mm.

The minimum diameter of bend measured on the inside of the bar, for standard hooks other than for stirrups and ties in sizes 10mm ϕ thorough 16mm ϕ , shall not be less than the values shown in the table given below.

Minimum diameters of Bend

Bar size	Minimum diameter of bend
10mm < d_b < 25mm	6 d_b
25mm < d_b < 40mm	8 d_b
40mm < d_b < 55mm	10 d_b

* d_b is the nominal diameter of bar, mm

For stirrups and tie hooks, inside diameter of bend shall not be less than 4 bar diameters for 16mm ϕ bar and smaller. For bars larger than 16mm ϕ , diameter of bend shall be in accordance with the specifications shown in the above table.

Bends for other bars, where full tension in the bar may occur, shall be made around a pin having a diameter not less than 20 bar diameters. Hooks shall conform to American Concrete Institute Standard Building Code Requirements for reinforced concrete ACI 316-89, or as shown on the Drawings.

Placing, supporting and fastening

All bar reinforcement shall be accurately placed, supported and secured in position as shown on the Drawings using approved spacer blocks and chairs prior to any concrete pouring. Displacement tolerance may be allowed within the permissible tolerance limit as shown in the table given below unless otherwise specified by the Engineer. The reinforcement shall be checked and approved by the Engineer before pouring of concrete.

Tolerances for Placing Reinforcement

	Tolerance for depth (d)	Tolerance for Minimum Concrete Cover
d < 200mm	+ 10mm	- 10mm
d > 200mm	+ 12mm	- 12mm

Notwithstanding the above provisions, tolerance for the clear distance to formed soffits shall be minus 6mm and tolerance for cover shall not exceed minus one-third the minimum concrete cover required in the design Drawings or specifications.

Tolerance for longitudinal location of bends and ends of reinforcement shall be + 50mm, except at discontinuous ends of members where tolerance shall be + 12mm.

Welding of crossing bars shall not be permitted for assembly of reinforcement unless authorized by the Engineer.

The Contractor shall be responsible for the accuracy of cutting, bending and placing of the reinforcement. Reinforcement will be inspected for compliance with the requirements as to grade, size, shape, length, splicing locations, overlapping length and position after it has been placed.

Before the reinforcement is placed, the surfaces of the bars and the surfaces of any metal bar supports shall be cleaned of heavy rust, loose mill scale, dirt, grease and other objectionable foreign substances. Heavy flaky rust, which can be removed in firm rubbing with hessian or equivalent treatment, shall be considered objectionable. After being placed, the reinforcing bars shall be maintained in a clean condition until they are completely embedded in the concrete.

Reinforcement shall be accurately placed in the position shown on the Drawings and/or as directed by the Engineer and shall be securely held by blocking against the forms, by supporting on concrete or approved metal or plastic chairs or by using metal hangers and by wiring together at intersections using annealed wire of specified diameter with the ends turned in to the main body of concrete. Bars shall be tied at all intersections except where spacing is less than 300mm in any direction when alternate intersections shall be tied. Wire ties shall be securely tied and folded so that they do not project beyond the planes formed by the reinforcing bars. The adequacy of the supports and ties to secure the reinforcement properly shall be subject to the approval of the Engineer.

Reinforcement supports shall be strong enough to withstand the imposed loads without movement of the reinforcement. They shall be positively attached to the reinforcement and of such size and number as to maintain the specified cover.

There shall be a clear distance of at least 25mm between the bars and any adjacent embedded metal works. The Contractor shall ensure that there is no disturbance of the reinforcing bars in concrete that has already been placed.

Reinforcement binding wire shall be best black annealed mild steel wire and not less than approximately 1.6mm in diameter/24 BWG or 26 BWG galvanized iron wire.

Cover blocks required for ensuring that the reinforcement is correctly positioned shall be as small as possible, consistent with their purpose, or a shape and material acceptable to the Engineer and designated so that they will not overturn when the concrete is placed. The concrete cover blocks or space blocks shall be made of concrete having 1 part cement, 1 part sand and 2 part coarse aggregate. The coarse aggregate would be 6mm down graded. The blocks would be cast in mould and continuously cured for 21 days before use. Wire shall be cast in the block for the purpose of tying

it to the reinforcement. The wire must not be closer than 30mm from the concrete surface. The use of small stones or wood blocks shall not be permitted.

If concrete cylinder blocks are used for proper spacing of vertical bars in column, the height shall be 2.54cm and radius shall be equal to the distance of the centre line of the bar from column face.

Top reinforcement in slabs shall be maintained in position by means of chairs made out of ferrous metal and shall conform to industry practice as described in the Manual on 'Standard Practice of the Concrete Reinforcing Steel Institute'. The diameter and quantity being sufficient to ensure security of the reinforcement shall be used to support access ways, working platforms, or the placing equipment or for conducting of an electric current.

Platforms for the support of workers and equipment and machines shall be placed directly on the forms without any disturbance of the reinforcing steel during concrete placement.

Before any steel reinforcement is embedded in the concrete, any loose mill scale, loose rust and any oil, grease or other deleterious matter shall be removed. Partially set concrete, which may adhere to the exposed bars during concrete placing operations, shall also be removed.

24.1.14 Lateral Reinforcement for Pier/Columns

Spirals

Spiral reinforcement for columns shall conform to the following:

- a) Spirals shall consist of evenly spaced continuous bar or wire of such size and so assembled as to permit handling and placing without distortion from designed dimensions.
- b) Size of spirals shall not be less than 10mm diameter for cast-in-place construction.
- c) The minimum and maximum clear spacing between spirals shall be 25mm and 75mm respectively.
- d) Anchorage of spiral reinforcement shall be provided by 1.5 extra turns of spiral bar or wire at each end of a spiral unit.
- e) Splices in spiral reinforcement shall be lap splices of 48 spiral diameter, but not less than 300mm.
- f) Spirals shall extend from the top of footing or slab in any story to the level of the lowest horizontal reinforcement in members supported above.
- g) Spirals shall extend above termination of spiral to bottom of slab or drop panel, where beams or brackets do not frame into all sides of a column.
- h) Spirals shall extend to a level at which the diameter or width of capital is 2 times that of the column, in case of columns with capitals.
- i) Spirals shall be held firmly in place and true to line.

Ties

Tie reinforcement for compression members shall conform to the following:

- a) All bars shall be enclosed by lateral ties, at least 10mm diameter in size for longitudinal bars 30mm diameter or smaller, and at least 12mm diameter in size for 35mm diameter to 55mm diameter and bundled longitudinal bars
- b) Vertical spacing of ties shall not exceed 16 longitudinal bar diameters or 48 tie diameters, or the least dimension of the compression members.

- c) Ties shall be arranged such that every corner and alternate longitudinal bar shall have lateral support provided by the corner of a tie with an included angle of not more than 135° . No vertical bar shall be farther than 150mm clear on each side along the tie from such a laterally supported bar. Where longitudinal bars are located around the perimeter of a circle, a complete circular tie is allowed.
- d) The lowest tie in any storey shall be placed within one-half the required tie spacing from the top most horizontal reinforcement in the slab or footing below. The uppermost tie in any storey shall be within one-half the required tie spacing from the lowest horizontal reinforcement in the slab or drop panel above.
- e) Where beams or brackets provide concrete confinement at the top of the column on all (four) sides, the top tie shall be within 75mm of the lowest horizontal reinforcement in the shallowest of such beams or brackets.

Lateral reinforcement for beams

Compression reinforcement in beams shall be enclosed by ties or stirrups satisfying the size and spacing limitations as stated above. Such ties or stirrups shall be provided throughout the distance where compression reinforcement is required.

Lateral reinforcement for flexural framing members subject to stress reversals or to torsion at supports shall consist of closed ties, closed stirrups, or spirals extending around the flexural reinforcement.

Closed ties or stirrups shall be formed in one piece by overlapping standard stirrup or tie end hooks around a longitudinal bar, or formed in one or two pieces lap spliced with a lap of development length.

24.1.15 Spacing of Reinforcement

The minimum clear spacing between parallel bars in a layers shall be equal to one bar diameter, but not less than 25mm.

Where parallel reinforcement is placed in two or more layers, bars in the upper layers shall be placed directly above those in the bottom layer with clear distance between layers not less than 25mm.

For compression members, the clear distance between longitudinal bars shall be not less than 1.5 bar diameters or 40mm.

Clear distance limitation between bars shall apply also to the clear distance between a contact lap splice and adjacent splices or bars.

In walls and one-way slabs, the maximum bar spacing shall be three times the wall or slab thickness (h) but not more than 450mm.

For two-way slabs, maximum spacing of bars shall be 2h but not more than 450mm.

For temperature steel only, maximum spacing shall be 5h but not more than 450mm.

24.1.16 Splicing

General

All reinforcement shall be furnished in the full lengths indicated on the Drawings unless otherwise permitted. Except for splices shown on the Drawings and splices for No. 5 [16mm ϕ], or smaller bars, splicing of bars will not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible.

Where the Drawings do not detail laps that will be necessary, the Contractor shall furnish working Drawings to the Engineer for his approval.

If such additional lap splices are approved, the extra weight occasioned by such lap splices shall not be included in the measurement of reinforcement for payment unless provided for in these Specifications.

Lapped splices

All splices for high yield strength steel bars shall have a lap length as shown on the Drawings or if not shown therein shall be in accordance with the American Concrete Institute Building Code Requirements for Reinforced Concrete (ACI 318-89).

All splices for mild steel shall have a lap length as shown on the Drawings or if not shown therein, of not less than 40 diameters of the smaller bar when hooks are used and 50 diameters for bars without hooks.

Lap splices shall not be used for 35mm diameter bars and larger, except when bars of different diameters are lap spliced in compression, the splice length shall be the larger development length of the larger bar, or the splice length of the smaller bar.

Lap splices of bundled bars shall be based on the lap splice length required for individual bars within the bundle, increased in accordance with development of bundled bars. Individual bar splices within a bundle shall not overlap. Entire bundles shall not be lap spliced.

Bars spliced by non-contact lap splices in flexural members shall not be spaced transversely farther apart than one-fifth the required lap splice length, nor 150mm.

Lap splices shall generally be located at points of minimum tension in bars. Except where otherwise shown on the Drawings, lap splices shall be made with the bars placed in contact and securely wired together.

Welded splices

Welding on site shall be avoided wherever possible, but where suitable safeguards and techniques are employed and provided that the types of steel including high-yield steels to SS 2 have the required welding properties, it may be undertaken with the acceptance of the Engineer. Before welding any reinforcement, the Contractor shall supply to the Engineer a Welding Procedure Specification (WPS) and an example of the weld for the type of steel, connection and weld being proposed. If such evidence is not available, the Contractor shall demonstrate satisfactory performance by means of testing as agreed by the Engineer. Unless satisfactory performance of the proposed welded connection is established by either of the two methods described above, approval for use of the welded connection shall not be given.

In addition and as required by the Engineer, the competence of the operators shall be demonstrated prior to and periodically during welding operations by submission of independent Welder Qualification Records (WQR) for each welder to be used on site.

Welding may be used in fixing reinforcement in position, for example, by welding between crossing or lapping reinforcement, or between bars and other steel members.

Welded intersections shall not be spaced farther apart than 300mm in the direction of calculated stress, except for wire fabric used as stirrups.

Structural welding shall not be carried out unless specifically shown on the Drawings.

Notwithstanding the above, the Engineer will not permit tack welding of bars, which will be subject to fluctuating stresses in the completed structure.

Welding shall conform to the Structural Welding Code, Reinforcing Steel, AWS D 1.4 of the American Welding Society and applicable special provisions.

Welded splices shall be butted and welded to develop in tension at least 125 percent of specified yield strength f_y of the bar. A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of specified yield strength f_y of the bar. Welded splices and mechanical connections not meeting the above requirements are allowed where area of reinforcement is at least twice that required by analysis shall meet the following:

- Splices shall be staggered at least 600mm and in such manner as to develop at every section at least twice the calculated tensile force at the section but not less than 140 N/mm² for total area of reinforcement provided.
- Spliced reinforcement may be rated at the specified splice strength, in computing tensile force developed at each section. Un-spliced reinforcement shall be rated at that fraction of f_y defined by the ratio of the shorter actual development required to develop the specified yield strength (f_y).

Splices of deformed bars in tension

The minimum length of lap for tension splices shall be as required for Class A or B splice, but not less than 300mm, where the classification shall be as follows:

Class A splice	$1.0l_d$
Class B splice	$1.30l_d$

* l_d is the development length

Lap splices of deformed bars in tension shall be Class B splices except that Class A splices are allowed when the area of reinforcement provided is at least twice that required by analysis over the entire length of the splice, and one-half or less of the total reinforcement is spliced within the required lap length.

Where area of reinforcement provided is less than twice that required by analysis, welded splices or mechanical connections used shall meet the following requirements. This is also applicable in case of splices in tension tie members those shall be made with a full welded splice or full mechanical connection.

- Welded splices shall be butted and welded to develop in tension at least 125 percent of specified yield strength f_y of the bar.
- A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of specified yield strength f_y of the bar.

Welded splices or mechanical connections used where area of reinforcement provided is at least twice that required by analysis shall meet the following:

- a) Splices shall be staggered at least 600mm and in such manner as to develop at every section at least twice the calculated tensile force at the section but not less than 140 N/mm² for total area of reinforcement provided.
- b) Spliced reinforcement may be rated at the specified splice strength, in computing tensile force developed at each section. Unspliced reinforcement shall be rated at that fraction of f_y defined by the ratio of the shorter actual development length to l_d required to develop the specified yield strength f_y .

Splices in adjacent bars shall be staggered at least 750mm.

Splices of deformed bars in compression

The minimum length of lap for compression splice shall be $0.07 f_y d_b$ for f_y equal to 410 N/mm² or less or $(0.13 f_y - 24) d_b$ for f_y greater than 410 N/mm², but not less than 300mm. For f'_c (specified compressive strength of concrete, N/mm²) less than 20 N/mm², length of lap shall be increased by one-third.

When bars of different diameters are lap spliced in compression, the splice length shall be the larger of the development length of the larger bar, or the splice length of the smaller bar.

Welded splices or mechanical connections used in compression shall also satisfy the following requirements :

- Welded splices shall be butted and welded to develop in tension at least 125 percent of the specified yield strength f_y of the bar.
- A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of the specified yield strength f_y of the bar.

End bearing splices

- a) Compression splices for bars required to transmit compressive stress only, may consist of end bearing of square cut ends held in concentric contact by a suitable device.
- b) Bar ends shall terminate in flat surfaces within 1.5° of a right angle to the axis of the bars, and shall be fitted within 3° of full bearing after assembly.
- c) End bearing splices shall be used only in members containing closed ties, closed stirrups or spirals.

Special splice requirements for columns

Lap splices, butt welded splices, mechanical connections, or end-bearing splices shall be used with the limitations as stated below. A splice shall satisfy the requirements for all load combinations for the column.

Lap splices in columns

- a) Lap splices shall conform to the first two requirements stated above under the Sub-section on 'Splices of Deformed Bars in Compression' and where applicable to (d) or (e) below where the bar stress due to factored loads is compressive.
- b) Where the bar stress due to factored loads is tensile and does not exceed $0.5f_y$ in tension, lap splices shall be Class B tension lap splices if more than one half of the bars are spliced at any section, or Class A tension lap splices if half or fewer of the bars are spliced at any section and alternate lap splices are staggered by l_d (development length).
- c) Where the bar stress due to factored loads is greater than $0.5f_y$ in tension, lap splices shall be Class B tension lap splices.
- d) If spiral reinforcement confines the splice, the lengths required may be multiplied by 0.75, but lap length shall not be less than 300mm.

Welded splices or mechanical connectors in columns

Welded splices or mechanical connectors in columns shall also meet the following requirements.

- Welded splices shall be butted and welded to develop in tension at least 125 percent of specified yield strength f_y of the bar.
- A full mechanical connection shall develop in tension or compression, as required, at least 125 percent of specified yield strength f_y of the bar.

End bearing splices in columns

End bearing splices complying with the requirements stated above under Sub-section on "End Bearing Splices" may be used for column bars stressed in compression provided that the splices are staggered or additional bars are provided at splice locations. The continuing bars in each face of the column shall have a tensile strength at least $0.25f_y$ times the area of the vertical reinforcement in that face.

Splices of plain bars

For plain bars, the minimum length of lap shall be twice that of deformed bars.

Mechanical anchorage

Any mechanical device capable of developing the strength of reinforcement without damage to concrete is allowed as anchorage.

Mechanical device may be used only when its adequacy can be proven by test results to the satisfaction of the Engineer.

Development of reinforcement may consist of a combination of mechanical anchorage plus additional embedded length of reinforcement between the point of maximum bar stress and the mechanical anchorage.

24.1.17 Substitutions

Substitutions of different size bars shall be permitted only with specific authorization by the Engineer and at no additional cost to the Employer. If bars are substituted, they shall have a cross sectional area equivalent to the design area or larger.

The Contractor shall also provide, also in the case of substitutions, at his own expenses and to the approval of the Engineer, such necessary detailing of the reinforcement as he require for the execution of the work to the Engineer's satisfaction.

24.1.18 Concrete Cover to Reinforcement

Unless specified on the Drawings, the clear concrete cover to reinforcement shall be as tabulated below:

Description of Concrete Element	Clear Cover (mm)	
	Normal Exposure	Saline Water
Wall and Floor Slab		
a) contact with earth	60	75
b) exposed to weather and water	50	60
Piles		
a) cast-in-place	75	100
b) pre-cast	40	50
Beam, Girder, Column	40	50
Floor Slab	25	25
Bridge Pier	50	60
Bridge Deck Slab	40	40
Railing	25	25

24.1.19 Protective Coating

All exposed reinforcing steel at construction joints shall be protected with a brush coat of neat cement mixed to a consistency of thick paint within one week after the placing of the initial concrete, unless it is definitely known that the steel will be embedded within 30 days. This coating shall be entirely removed, by light tapping with a hammer or other tools, not more than one week before the placing of the final pour.

24.1.20 Bundled Bars

- a) Groups of parallel reinforcing bars bundled in contact to act as a unit shall be limited to four in any one bundle.
- b) Bundled bars shall be enclosed within stirrups or ties.

- c) Bars larger than 35mm diameter shall not be bundled in beams.
- d) Individual bars within a bundle terminated within the span of flexural members shall terminate at different points with at least 40 times the nominal diameter of bar staggered.
- e) Where spacing limitations and minimum concrete cover are based on nominal bar diameter, a unit of bundled bars shall be treated as a single bar of a diameter derived from the equivalent total area.
- f) Minimum concrete cover shall be equal to the equivalent diameter of the bundle, but need not be greater than 50mm.

24.1.21 Inspection

The Contractor shall notify the Engineer when the steel has been placed in position and ready for concrete placing. No concrete shall be placed until the Engineer inspected the steel and given his approval in writing.

24.1.22 Measurement

The quantity of reinforcement to be measured under this section shall be the computed weight in metric tons of material used and accepted as shown on the Drawings provided that the quantity shall not include the reinforcement in any item of works. In computing the weight to be measured, the theoretical weights of bars of the cross section shown in this Specification shall be used.

The computed weight shall not include the extra materials incurred when bars larger than those specified are used or the extra materials necessary for splices, when bars shorter than those specified are used with the permission of the Engineer or the weight of any devices used to support or fasten the reinforcement in correct position.

24.1.23 Payment

This work measured as provided above, shall be paid for at the Contract unit price per metric ton of reinforcement for the particular Bill of Item. The payment shall be considered to be the full compensation for furnishing, fabricating, splicing and placing of the reinforcing steel, supports and binding wire, cutting and bending, all labours, equipment, tools and incidentals necessary to complete the works prescribed in this Section.

No separate payment shall be allowed for chair, lap, splice, separator etc. The costs of these shall be included in the unit rate.

Item of payment

	Unit
Mild steel reinforcing bars	Metric tons
High yield steel reinforcing bars	Metric tons

25. PRE-STRESSING REINFORCEMENT

25.1 General

Description

The works covered by this item shall consist of pre-stressing pre-cast or cast-in-situ concrete by furnishing, placing and pre-tensioning or post tensioning or by a combination of these methods of bars, strand or wires specified on the Drawings and these Specifications. This work shall further include any appurtenant items necessary for any particular pre-stressing system to be applied. This shall include but not limited to necessary joineries, providing spacers, stressing, ducts, anchorage assemblies and grout use for pressure grouting ducts.

When members are to be constructed with part of the reinforcement pre-tensioned and part post-tensioned, the applicable requirement of this Specification shall apply to each method.

Definitions

Post-tensioning is defined as any method of pre-stressing concrete in which the pre-stressing reinforcement is tensioned after the concrete is placed.

Pre-tensioning is defined as any method of pre-stressing concrete in which the pre-stressing reinforcement is tensioned before the concrete is placed.

Pre-stressing reinforcement is defined as any reinforcement which is pre-stressed by applying post tensioning or pre-tensioning.

Details of design

When the design for the pre-stressing work is not fully detailed on the plans, the Contractor shall determine the details conforming to these specifications as needed to satisfy the pre-stressing requirements stipulated on the plans. Unless otherwise shown on the plans, all design procedures, coefficient and allowable stresses, friction and pre-stress losses as well as tendon spacing and clearance shall be in accordance with the Division I, Design of the AASHTO Standard Specifications for Highway Bridges, 1992 unless modified subsequently.

The values assumed in the design for friction coefficient, wobble coefficient and draw-in shall be shown on the Drawings. The Contractor shall demonstrate the validity of these values by testing with a dead end anchorage assembly. The test shall be carried out to the required load in 6 increments and for each increment the gauge pressure, elongation and load cell force shall be recorded.

25.2 Supplementary Drawings**Working drawings**

Whenever the plans do not include complete details for a pre-stressing system and its method of installation, or when complete details are provided in the plans and the Contractor wishes to propose any change, the Contractor shall prepare and submit to the Engineer Working Drawings to the pre-stressing system proposed for use. Fabrication or installation of pre-stressing material shall not begin until the Engineer has approved the Drawings.

The Working Drawings of the pre-stressing system shall show complete details and substantiating calculations of the method, materials and equipment the Contractor proposing for use in the pre-stressing operations, including any addition or rearrangement of reinforcing steel and any revision in concrete dimensions from that shown on the plans. Such details shall outline the method and sequence of stressing anchoring devices, working stresses, anchoring stresses, tendon elongation, type of ducts and all other data pertaining to the pre-stressing operation, including the proposed arrangement of the pre-stressing steel in the members.

Composite placing drawings

In addition to all required Working Drawings, the Contractor shall prepare Composite Placing Drawings to scale and in sufficient detail to show the relative positions of all items those are to be embedded in the concrete and their embedded depth for the portions of the structure that are to be pre-stressed. Such embedded items include the pre-stressing ducts, vents, anchorage reinforcement and hardware, reinforcing steel and other such items. Such Drawings shall be adequate to ensure that there will be no conflict between the planned positions of any embedded items and that concrete cover will be adequate. If during the preparation of such Drawings conflicts are discovered, the Contractor shall revise his Working Drawing for one or more of the embedded items or propose changes in the dimensions of the work as necessary to eliminate the conflicts or provide proper cover.

Approval of the drawings

All Working Drawings and Composite Placing Drawings shall be submitted to the Engineer sufficiently ahead of starting work for review and approval by the Engineer. No work shall start until such approval is received by the Contractor.

Expenses for drawings

All costs involved with the preparation of such Drawings and with making the necessary modifications to the work resulting therefrom shall be borne by the Contractor.

25.3 Materials

Pre-stressing steel

Pre-stressing tendons shall comprise high strength strand, high strength steel wire or high strength alloy bars conforming grade and type as shown on the Drawings and shall conform to the requirements of the following standards.

- Steel wire conforming to BDS 240.
- Steel wire conforming to ASTM A 421.
- Low-relaxation wire conforming to ASTM A 421.
- High-strength steel bar conforming to ASTM A 722.
- Strand conforming to ASTM A 416.
- Low-relaxation strand conforming to ASTM A 416.

The Contractor may propose at his own costs any other internationally acknowledged system other than what has been described here subject to the approval of the Engineer. Wires, strands and bars, not specifically listed in the above Standards, shall conform to the minimum requirements of these Specifications and do not have properties that make them less satisfactory than those listed. Detailed drawings of the alternatives shall be submitted for approval, which must clearly demonstrate the proposed alternatives as a practical substitute.

All pre-stressing steel shall be clean and free from oil, dirt, scales, splits, harmful scratches, surface flaws, rough, jagged and imperfect edges and other defects likely to impair its use in pre-stressed concrete. Slight rust may be permitted provided there is no surface pitting visible to the naked eye.

Coupling units and other similar fixtures used in conjunction with the wires or bars shall have an ultimate tensile strength of not less than individual strengths of the wires or bars being joined.

Where it is not possible to ascertain the Modulus of Elasticity by test or from the manufacturer of steel, the following values may be adopted:

Type of Steel	Modulus of Elasticity E_s (kN/mm ²)
Plain cold-drawn wire	210
High tensile steel bars rolled or heat-treated	200
Strands	195

Reinforcement used as un-tensioned steel shall be anyone of those permitted in reinforced concrete.

No tendons shall be used in the construction before the testing has been carried out and approved by the Engineer.

Anchorage and couplers

The end anchorage and couplers (stressing anchorage and dead end anchorage) shall be especially designed for the actual type of tendon and must have been used on other similar works those have demonstrated proper functioning and durability for this purpose.

Allowance shall be made to test to destruction anchorage. The anchorage and couplers shall be capable of fixing the pre-stressing steel at a load of not less than 95% of the actual strength of the pre-stressing steel without overshooting the anticipated set under test in an un-bonded state.

Elongation at rupture below the requirements of the tendon shall not be reduced by the coupling of tendons. Couplers or their components shall be enclosed in an adequately long housing so as to allow necessary movements. Their use shall invariably exclude points of sharp curvature of tendon. The Engineer's approval shall be necessary for indicating locations for the coupler's use.

The manufacturer shall submit appropriate test certificate from an approved testing laboratory.

Information in all details of the design and the steel quality of the anchorage shall be submitted to the Engineer.

Bonded systems

Bond transfer lengths between anchorage and the zone, where full pre-stressing force is required under service and ultimate loads, shall normally be sufficient to develop the minimum specified ultimate strength of the pre-stressing steel. Ultimate strength required for the bonded tendons, tested in an un-bonded state, shall not overshoot the ultimate capacity of the tendon assembly, including the anchorage or coupler in the case the anchorage or couplers are located at critical sections under ultimate load.

Un-bonded systems

For un-bonded tendons, a representative anchorage and coupler specimen and the tendon shall withstand 500,000 cycles from 60% to 66% of its minimum specified ultimate strength and also 50 cycles from 40% to 80% of its minimum specified ultimate strength. This will require performing a dynamic test.

Anchorage for un-bonded tendons shall not cause a reduction in the total elongation under ultimate load of the tendon to less than 2% measured in a minimum gauge length of 3.05 meter.

All the coupling components shall be completely protected with a coating material prior to final encasement in concrete.

Anchorage devices with distribution plates

The average bearing stresses on the concrete created by the anchorage distribution plates shall not exceed the values allowed by the following equations:

At service Load -

$$f_{cp} = 0.6 f_c' (A_b'/A_b)^{0.5}$$

but not greater than $1.25f_c'$

At transfer Load -

$$f_{cp} = 0.8 f_c' (A_b'/A_b - 0.2)^{0.5}$$

but not greater than $1.25f_{ci}'$

Where,

f_{cp} = Permissible compressive concrete stress.

f_c' = Compressive strength of concrete.

f_{ci}' = Compressive strength of concrete at time of initial pre-stress.

A_b' = Maximum area of portion of the concrete anchorage surface that is geometrical Similar to and concentric with the area of the anchorage.

A_b = Bearing area of the anchorage.

Anchorage devices without distribution plates

Should the Contractor elect to furnish anchoring devices of a type that are sufficiently large and which are used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stress to the concrete, the steel distribution plates or assemblies may be omitted.

Anchorage devices without distribution plates, which have not been pre-approved by the Engineer shall not be used until the Contractor furnishes certified copies or pre-qualification tests which demonstrate satisfactory performance under conditions expected for the project. Pre-qualification tests for such anchorage devices shall be performed in accordance with the requirements for testing special anchorage devices in the AASHTO.

For such anchorage systems previously tested and approved on projects having the same tendon configuration, the Engineer may waive additional testing provided there is no change in the material,

design or details previously approved. The working drawings shall identify the project for which approval was obtained, otherwise testing will be necessary.

Supplemental reinforcement

Any supplementary reinforcement required in the local zone of the anchorage to resist bursting, splitting and spalling tensile stresses in the immediate vicinity of the anchorage which are dependent on the configuration of the anchor device, shall be considered to be a part of the anchorage device. Such reinforcement shall be designed by the anchorage supplier and shall be furnished and placed in addition to the general zone reinforcement, which is shown on the Designs.

Ducts

Ducts used to provide holes or voids in the concrete for the placement of post-tensioned bonded tendons may be either formed with removable cores or may consist of rigid or semi-rigid metal ducts which are cast into the concrete.

Ducts formed with removable cores shall be formed with no constriction, which would tend to block the passage of grout. All coring materials shall be removed.

Ducts formed by sheath left in place shall be a type that will not permit the intrusion of cement paste. They shall transfer bond stresses as required and shall retain shape under the weight of the concrete and shall have sufficient strength to maintain their correct alignment without visible wobble during placement of concrete.

The inside diameter of ducts shall be at least 6mm larger than the nominal diameter of single wire or strand tendons, or in the case of multiple wire or strand tendons, the inside cross-sectional area of the sheathing shall be at least two times the net area of the pre-stressing steel. When tendons are to be placed by the pull through method, the duct area shall be at least 2½ times the net area of the pre-stressing steel.

Sheathing

All sheathing shall be of ferrous metal, corrugated type, galvanized and fully mortar tight. The sheathings shall be strong enough to maintain their shape under such forces as may be expected to act on them.

Corrosion inhibitor

This is a vapor phase inhibitor powder, which shall correspond to the provisions of Federal Specifications MIL P 3420. If approved by the Engineer, it may comprise any water-soluble oil or as otherwise required by the Engineer.

25.4 Pre-stressing Equipment

Hydraulic jacks be used to stress tendons. It shall be of the type capable of producing and sustaining necessary forces shown on the Drawings and applicable to the system adopted. They shall be equipped with arrangement to record jacking stress either by a pressure gauge or a load cell. The jacking system shall provide an independent means for measuring tendon elongation. The pressure gauge shall have an accurately reading dial or digital display and each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force. The load cell shall be calibrated and shall be provided with an indicator to determine the pre-stressing force in the tendon.

All pre-stressing equipment shall be accepted by the Engineer prior to use. It is required that the strands in each multi-strand tendon be stressed simultaneously. Certified calibration by an approved laboratory shall be provided for all dynamometers or pressure gauges.

The calibration certificate shall not be more than 4 weeks old at the time the equipment is brought on at Site.

For the whole duration of the stressing operations, intermediate tests on equipment will be required every 2 weeks or when the Engineer has cause to believe that the gauge is giving incorrect readings

at stressing, whichever is earlier. This may be done on Site by means of calibrated master pressure gauge.

For cutting strands after installation in the member or after stressing, oxygen flame or mechanical cutting devices shall be used. Use of electric arc welders are totally prohibited.

25.5 Construction Methods

General

The Contractor shall provide a technician skilled in the use of the actual system of pre-stressing to supervise the work and to give the Engineer any necessary assistance.

The Contractor shall provide all equipment necessary for the construction and the pre-stressing. Pre-stressing shall be done with approved jacking equipment. If hydraulic jacks are used, the combination of jack and gauge shall be calibrated and a graph or table showing the calibration shall be furnished to the Engineer. Should other types of jacks be used, calibrated proving rings or other devices shall be furnished to establish jacking forces accurately.

If alternative systems are adopted, the Contractor shall submit for the approval of the Engineer drawings and calculations, which show the arrangements of tendons, anchorage assemblies, etc. and verify that the pre-stress occurring at every section is equal to that produced by the system originally used in the design.

Pre-tensioning systems

Pre-stressing strand and wire to pre-cast piles shall be seven-wire strand and wire in accordance with ASTM A 416.

Pre-stressing tendons can be directly substituted by other types of equivalent strength tendons conforming to BS 3617, BS 2691 or any other appropriate Standard.

Certificates

Manufacturer's test certificate for breaking strength shall be obtained for each delivered coil or bundle and a stress/strain diagram shall be obtained for every fifty coil or bundle.

Each coil or bundle of pre-stressing steel shall be delivered with charge number and markings to allow identification of the corresponding tests carried out.

Copies of the manufacturer's test certificate with dates of routine testing shall be submitted to the Engineer for his approval.

Tests

Tests in addition to those to be carried out by the manufacturer as specified herein will be required.

Supervised by the Engineer, the Contractor shall cut out samples (approximately 1m) for each 25 tons of steel or as directed by the Engineer.

Tests for breaking load, 0.2% proof load and elongation shall be carried out by an approved testing laboratory in accordance with ASTM A 370 or as will be decided by the Engineer.

Expenses incurred in connection with cutting out, transporting and testing of the samples shall be borne by the Contractor.

No tendon shall be used in the construction before the testing has been carried out and approved by the Engineer.

Handling and storage of materials

All pre-stressing steel shall be protected against physical damage at all times from manufacture to grouting or encasing in concrete. Pre-stressing steel that has sustained physical damage at any time

shall be rejected. Bars shall be handled so that those are kept straight and shall be stored straight. Those shall be suitably supported to prevent excessive bending stresses and any threaded portions shall be adequately protected.

Pre-stressing steel shall be packaged in containers or shipping forms for the protection against physical damage and corrosion during shipping and storage. A corrosion inhibitor, which prevents rust or other results of corrosion shall be placed in the package or form, or shall be incorporated in a corrosion, inhibitor carrier type packaging material, or when permitted by the Engineer may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete.

Packaging or forms damaged from any cause shall immediately be replaced or restored to original condition. The name and any other information of the corrosion inhibitor shall be supplied to the Engineer on request.

The shipping package or form shall be clearly marked with a statement that the package contains high strength pre-stressing steel; care to be used in handling' the type, type and amount of corrosion inhibitor used (including the date when placed); safety orders and instructions for use.

The Engineer may deem steel suitable for use in the works that exhibits a light brown surface coating of rust without flaking or pitting.

Steel shall be rejected by the Engineer as unsuitable for use in the works, if either of the two following conditions occur:

- The steel exhibits sufficient evidence of corrosion such as may reduce its strength or ductility.
- There is evidence to show that the steel, prior to placing of concrete, has been in contact with deleterious substances, or subject to the splashes from the cutting operation of an oxy-acetylene torch or arc-welding processes in the vicinity, such as may reduce its strength or ductility or bond characteristics in the permanent works.

Pre-stressing steel for post-tensioning which is installed in members, prior to placing and curing of the concrete, shall be continuously protected against rust or other corrosion until grouted by means of a corrosion inhibitor placed in the ducts or applied to the steel in the duct.

When acceptable pre-stressing steel for post-tensioning is installed in the ducts on completion of concrete curing and if stressing and grouting are completed within 10 calendar days after the installation of the pre-stressing steel, rust which may form during the said 10 days will not be the cause for rejection of the steel.

Pre-stressing steel, installed as above but not grouted within 10 calendar days, shall be subjected to all the requirements in this section pertaining to corrosion protection and rejection because of rust.

Coils and bundles of pre-stressing steel shall be stored flat on a floor raised off the ground and under full cover from the weather. They shall be protected from damage, oil, grease, wax or paint corrosion or any deleterious matter and shall not be opened until required. Before being fabricated in to pre-stressing tendons, the strands or bars shall be cleaned of loose rust and any deleterious matter and inspected by the Engineer for approval.

Pre-stressing steel reinforcement, which shows signs of pitting or has any surface defects such as splits, roughness or necking shall not to be used and be rejected.

Corrugated sheathing is to be delivered to the Site, coiled on to large diameter wooden drums, securely fastened and protected from damage. They shall be stored at Site under cover from the weather and shall be protected from rusting, damage, oil or any other deleterious matter and shall be clean and free from all such matter before using in the works.

Manufacture of tendons

Pre-stressing cables shall be prepared on Site from coils of wires or strands. Tendons which consist of a number of high tensile steel strands shall be formed in a manner approved by the Engineer. In

estimating the length of all cables extra allowance must be made for applying either one or two tensioning jacks.

Sheathing shall be carefully examined prior to use and any damaged lengths shall be cut away and rejected.

Suitable spacers shall be provided, if required, to hold the strands or bars in correct position, in the sheathing to ensure that there is sufficient space around each wire or cable to allow proper grouting.

Joints in corrugated sheathing shall be formed by the use of couplers and/or by wrapping the joints with tape. They shall be so designed as to prevent the ingress of concrete or other material during casting. All joints in sheathing shall be approved by the Engineer.

Placing pre-stressing steel

Tendons shall be carefully handled so as to avoid sharp bends or kinks. The sheathing and/or the tendon shall be rigidly supported in the exact positions as shown on the Drawings so that no movement can take place during casting of elements to be pre-stressed.

The tendons shall be placed with the following tolerance:

Vertical	+10mm
Horizontal	-20mm

The tendons shall be supported by special supporting arrangements as proposed by the Contractor and approved by the Engineer.

Post-tensioning

All pre-stressing steel, pre-assembled in ducts and installed prior to the placement of concrete, shall be accurately placed and held in position during concrete placement.

When the pre-stressing steel is installed after the concrete has been placed, the Contractor shall demonstrate to the satisfaction of the Engineer that the ducts are free from water and debris immediate before the installation of the steel. The total number of strands in an individual tendon may be pulled in to the duct as a unit, or the individual strand may be pulled or pushed through the duct.

Anchorage devices or block-out templates for anchorages shall be set and held so that their axis coincides with the axis of the tendon and anchor plates are normal in all directions to the tendon.

The pre-stressing steel shall be distributed so that the force in each girder stem is equal or as required by the Drawings, except as provided herein. For box girders with more than two girder stems, at the Contractor's option, the pre-stressing force may vary up to 5% from the oretical required force per girder stem provided the required total force in the superstructure is obtained and the force is distributed symmetrically around the center line of the typical section.

Pre-tensioning

Pre-stressing steel shall be accurately installed in the forms and held in place by the stressing jack or temporary anchors and, when tendons are to be draped by hold-down devices. The hold-down devices used at all points of change in slope of tendon trajectory shall be of an approved low-friction type.

Pre-stressing steel shall not be removed from its protective package until immediately prior to installation in the forms and placement of concrete. Openings in the package shall be resealed as necessary to protect the un-used steel. While exposed, the steel shall be protected as needed to prevent corrosion.

Sheathing/placing ducts

Ducts shall be strongly fixed at the required locations by ties to the pre-stressing steel so that displacement during pouring of concrete is prevented. In order to maintain right alignment of the duct supplementary support bars shall be used, if needed. In addition, ties shall be used to the forms when

the buoyancy of the duct in the fluid concrete tends to lift reinforce steel. In order to prohibit flow of water or debris in to the ducts, their ends shall be kept covered.

The sheathing shall be rigidly supported in the exact positions as shown on the Drawings to prevent displacement during placing and compaction of concrete.

Joints in the sheathing for the tendons shall be minimized and in any event not closer than 5 m. No joint shall be permitted in the sheathing for temporary tendons. The joints between sections of sheathing and between sheathing and anchorage shall be properly sealed.

In order that friction losses are kept to a minimum, the Contractor shall take every care to prevent deformation of the sheathing cross-section during handling and concrete casting and to ensure that the sheathing is placed accurately to the required lines and levels. Based on the tendon profile information given on the Drawings, the Contractor shall prepare Shop Drawings of the tendon profiles for construction purposes. These Drawings shall show locating dimensions for each of the tendons at 600mm centres or less, and shall be submitted to the Engineer for checking and acceptance. The sheaths shall be firmly fixed to or supported from the steel reinforcement within the forms at 600mm centres or less. The tolerance in the location of the sheathing shall be 3mm from the true position.

Unless otherwise specified on the Drawings, the minimum cover of concrete to the outside surface of any sheathing shall be 50mm for beam soffits and 40mm elsewhere. This minimum cover shall be increased by 12mm for members in contact with earth or water or over salt water and by 25mm for members in contact with salt water.

Placing anchorage

The Contractor shall take all cares for the proper placement of anchorage hardware according to the Design Documents of the Engineer and the Specifications of the anchorage device supplier.

No damaged anchorage devices shall be used and all parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes by suitable plugs until used.

All bearing surfaces of the anchorage shall be clean prior to pouring concrete and stressing. The anchorage itself shall be adequately protected against corrosion following the completion of the final stressing operation.

Anchorage shall be positioned and maintained during placing concrete so that the centre line of the duct shall pass through the anchorage assembly and shall be normal to the bearing surface.

The systems used for coupling or providing dead end anchorage for the strands shall be accepted by the Engineer. The use of blind end anchorage or anchorage using bonded bulbs is not permitted. Should swaged anchorage be used, special cares shall be taken during the swaging operation to ensure that the ends of the strands are not contaminated with oil or any substance likely to affect the integrity of the connection. If the swages incorporate teeth to assist in gripping the strand, it is essential that they are installed in the correct direction, as a reversal of the swage will impair the efficiency of the grip and may result in slippage of the strand under load.

The swaging pressure shall be carefully monitored during each swaging operation and shall not vary by more than +5%. Should a fall-off in swaging pressure be observed, tests shall be immediately carried out to check the gripping efficiency of the swage by means of a mono-jack. The procedures to be adopted for testing the gripping efficiency shall be subject to the Engineer's prior acceptance. In addition, the diameter of each swage, after installation on the strand shall be checked.

Protection of steel after installation

Prior to placing and curing of the concrete pre-stressing steel installed in members or installed in the duct but not grouted within the time limit specified below, shall be continuously protected against rust or other corrosion by means of a corrosion inhibitor placed in the ducts or directly applied to the steel. The pre-stressing steel shall be so protected until grouted or encased in concrete. Pre-stressing steel installed and tensioned in members after placing and curing of the concrete and grouted within the time limit specified below will not require the use of a corrosion inhibitor described herein. Rust, which

may form during the interval between tendon installation and grouting will not be the cause for rejection of the steel.

The permissible interval between tendon installation and grouting without use of a corrosion inhibitor for various exposure conditions shall be as follows:

Very damp atmosphere or over saltwater (Humidity > 70%)	7 days
Moderate atmosphere (Humidity from 40% to 70%)	15 days
Very damp atmosphere or over saltwater (Humidity > 40%)	20 days

After tendons are placed in ducts, the openings at the ends of the ducts shall be sealed to prevent any entry of moisture.

When steam curing is used, steel for post tensioning shall not be installed until the steam curing is completed.

25.6 Post-tensioning Procedure

Prior to construction work the Contractor shall submit a table, which shows the tensioning order of all tendons to be tensioned at each construction stage, pressure of hydraulic jack or pumps, anchor pull in and elongation of each tendon subject to approval by the Engineer

The Contractor shall carry out tensioning test as to a few tendons designated by the Engineer and the result shall be taken in to consideration for the table preparation. The result of the tensioning work for each tendon shall be submitted in a form designated by the Engineer and subject to approval by him.

Tensioning shall be carried out only in the presence of the Engineer and by trained crews experienced in this type of work and in the use of the particular equipment involved. Unless otherwise described in the Contract, concrete shall not be stressed until it has reached at least the age at which two test cylinders taken from it attain the specified transfer strength. The test cylinders shall be made and tested in accordance with the standard procedure. The Contractor shall cast sufficient additional cylinders to demonstrate that the required strength of the concrete at transfer has been reached.

Immediately before tensioning, the Contractor shall prove that all tendons are free to move between jacking joints and that members are free to accommodate the horizontal and vertical movements due to the application of pre-stress.

Where members consist of jointed elements, the strength at transfer of the jointing material shall be at least equivalent to the specified transfer strength of the member.

Tendons shall be tensioned to the loads and in the sequences given on the Drawings.

The tendon force shall be raised to specified maximum value uniformly in such a way that the force is gradually transferred to the concrete. Elongation readings shall be commenced after 10% of the load has been applied in order to ensure that the datum is set after slack cable has been taken up. For each tendon, the strands at the non-stressing end shall be marked with chalk or by other means so that any movement of strands relative to each other during tensioning may be observed. The draw-in at the non-stressing end shall be measured so that the appropriate allowance can be made in the measured elongation.

Every endeavour shall be made to obtain the force required by the Drawings or requested by the Engineer. A tolerance of the +5% of the required force will then be permitted for individual tendons, provided that the total force in the member is within 2% of the required value. Members, which do not comply with these requirements may be rejected.

The values for the expected tendon elongation shall be determined by the Contractor. The actual elongation measured on Site shall be compared with the calculated elongation on a check on the loss of force due to friction in the ducts. If the elongation measurements indicate that friction is higher than computed, using the design friction and wobble factors given on the Drawings, the Engineer may direct the Contractor to the tendons with water soluble oil to reduce friction to the level given by the design factors.

When stressing the tendons with a stressing anchorage at both ends, the pull in at the end remote from the jack shall be accurately measured and the appropriate allowance made in the measured extension at the jack end.

When the pre-stressing has been applied to the satisfaction of the Engineer, the tendons shall be anchored. After a tendon has been anchored, the jack pressure shall be released gradually and evenly so as to cause no shock to the anchorage or tendon.

If the pull-in of the tendons at completion of anchoring is greater than that agreed by the Engineer, the load shall be released at a gradual and steady rate and tensioning carried out afresh.

In the event of a tendon breaking or slipping after tensioning so that allowable tolerances as specified are exceeded, the tendon shall be released and replaced, if necessary, and re-stressed.

Full records shall be kept of all tensioning operations including the measured elongation, pressure gauge or load-cell readings and the amount of draw-in at each anchorage. Copies of these records shall be supplied to the Engineer within 24 hours of each tensioning operation.

Following approval of the tensioning operation by the Engineer, the ends of the tendons shall be cut off with a disc cutter within 6mm of the anchorage.

Grouting

In following the post-tensioning methods while pre-stressing steel, the same shall be bonded to the concrete by completely filling the void space between the duct and the tendon with grout. Grouting shall be carried out in accordance with the procedures as illustrated under the relevant Sub-section on 'Concrete Work' of this document.

Finishing of tendons

After grouting, the ends of the anchorage and any projecting ends of cut-off tendons shall be covered by concrete or special mortar mix.

25.7 Pre-tensioning Procedure

Stressing shall be applied by either single strand stressing or multiple strand stressing. Amount of stress to be accomplished in each strand shall be as shown on the approved Working Drawings.

All strand to be stressed in a group shall be brought to a uniform initial tension before being given full pre-tensioning. The initial tension shall be minimum required to eliminate all slacks and to equalize the stresses in the tendons as determined by the Engineer.

Draped pre-tensioned tendons shall either be partially tensioned by jacking at the end of the bed and partially by uplifting or depressing tendons or they shall be tensioned entirely by jacking. The tendons shall be held in that draped positions by means of rollers, pins or other approved methods during jacking operations.

If the load for a draped strand is more than 5% less than that indicated by the jack gauges, the strand shall be tensioned from both ends of the bed and the load as computed from the sum of elongation at both ends shall agree within 5% of that indicated by the jack gauges.

Transfer of stress shall take place slowly to minimize shock. Test specimens, manufactured and cured, may be requested for verification of concrete strength before releasing the stress of the steel.

The specified force shall be maintained by the use of fixing devices at the end of the tensioning steel during pouring of concrete and curing until the concrete has attained the specified strength or other strength approved by the Engineer. The tensioning steel shall then be released gradually and uniformly.

All details and function of the "pre-stressing bed" shall be approved by the Engineer. The amount of tensioning shall be as shown on the Drawings or approved by the Engineer.

Straight tendons

In the long line method of pre-tensioning, sufficient locator plates shall be distributed throughout the length of the bed to ensure that the wires or strands are maintained in their proper position during pouring of concrete. Where a number of units are made in the line, they shall be free to slide in the direction of their length and thus permit transfer of the pre-stressing force to the concrete along the entire line.

In the individual mould system, the mould shall be sufficiently rigid to provide the reaction to the pre-stressing force without distortion.

Deflected tendons

Where possible, the mechanisms for holding down or holding up tendons shall ensure that the part in contact with the tendon is free to move in the line of the tendon so that frictional losses are nullified. However, if a system is used that develops a frictional force, this force shall be determined by test and due allowance made.

For single tendons, the deflector in contact with the tendon shall have a radius of not less than 5 times the tendon diameter for wire or 10 times the tendon diameter for a strand, and the total angle of deflection shall not exceed 15°.

The transfer of the pre-stressing force to the concrete shall be affected in conjunction with the release of hold-down and hold-up forces as accepted by the Engineer.

Positioning

Unless shown otherwise on the Drawings, tendons when stressed shall not, be further from their required positions than 5mm at any point.

De-bonding sleeves shall be chemically neutral to the steel, the grease and the concrete. The material should be either High Density Polyethylene or Polypropylene. Paper and Polyvinyl chloride are not permitted. The thickness shall be 0.75mm minimum.

25.8 Workmanship

Cleaning

All pre-stressing steel shall be free from loose mill scale, rust, oil, grease or any other harmful matter at the time of its placing in the member. A slight film of rust is not necessarily harmful and may improve bond.

Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing, or passing through a pressure box containing carbondum powder.

Straightening

As far as possible pre-stressing wire shall be obtained from the manufacturers in coils having diameter of not less than 350 times the diameter of the wire itself so that the wire springs back straight on being uncoiled. If due to smaller diameter of the coil or any other reason it does not happen, the wire shall be straightened before.

Pre-stressing steel bars may be obtained from the manufactures in straight condition. Any small adjustments necessary because of Site conditions shall be made by bending in a normal type bar bender.

Bars shall not be bent when their temperature is less than 10°C.

Positioning

Pre-stressing steel be accurately located and maintained in position, both vertically and horizontally as per Drawings.

The method of supporting and fixing shall be such that profile of cables is not at all disturbed by heavy and prolonged vibrations, by pressure of wet concrete or by construction traffic.

The steel sheath or duct forms shall be suitably tied to secondary reinforcement or to properly located withdrawal through shutter bolts, pre-cast concrete blocks or other effective means in such a way that they do not give rise to excessive friction when the steel is being tensioned.

Sequence of stressing

When the sequence of stressing individual tendons is not otherwise specified, the stressing of post-tensioning tendons and the release of pretensioned tendons shall be done in a sequence that produces a minimum of eccentric force in the member.

Cutting

All cutting to length and trimming of end shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel.

In post-tensioning ends or pre-stressing steel projecting beyond the anchorage shall be cut after the grout has set.

Welding

Welding of pre-stressing steel shall not be permitted.

Sheaths

Sheaths shall be sufficiently watertight to prevent concrete laitance penetrating them in quantities likely to increase friction. Special cares shall be taken to ensure water tightness at joints.

The alignment of all sheaths and extractable cores shall strictly conform to the requirements of Drawings and maintained securely to prevent displacement during placing and compaction of concrete.

Anchorage

Anchor cones, blocks and plates shall be positioned and maintained during pouring of concrete so that the centre line of the duct passes axially through the anchorage assembly.

All bearing surfaces of the anchorage shall be clean prior to pouring of concrete and tensioning.

Adequate provision shall be made for protection of the anchorage against corrosion.

25.9 Measurement

The quantity to be measured shall be the theoretical weight in metric tons of the pre-stressing steel as shown on the Drawings without sheathing, anchorage etc. and measured between the outer face of the anchorage blocks.

25.10 Payment

The work measured as provided above shall be paid for at the Contract unit price per metric ton of steel for the particular bill of item. The payment shall be the full compensation of all works including provision of anchorage, couplers, spirals, supports for the tendons, tensioning, grouting and finishing works (but excluding sheath material), all labours, equipment, tools and incidentals necessary to complete the works prescribed in this Sub-section.

Item of payment

	Unit
Pre-stressing Wire or Strand as detailed on the Drawings and as specified in the Bill of Quantities.	M. Tons

26. WELDING**26.1 General**

All welding shall be performed by certified welders and in accordance with American Welding Society (AWS) D1.1 'Structural Welding Code' or similar approved standard.

The principal forms of welding metals are as follows:

- Electric arc welding
- Gas welding

The electric arc welding process is the most important and is most extensively used for mild steels ranging from light articles with a wall or thickness of 16 gauge to heavy fabrications. This is a process whereby the metal of the two members to be welded is fused together through heat generated by an electric arc. Fusion should be complete over the whole area of the joint surface.

Gas welding is done using oxy-acetylene flame and is not adapted to structural steel work but is generally used for small jobs. The flame produced by burning oxy-acetylene is fed through a blow pipe, which is ignited at its tip. The flame is played on the two pieces to be welded until the metal becomes hot enough to fuse together adding additional metal to the joint as necessary by melting in to it a suitable electrode.

Unless otherwise specified, all welding shall be performed by the shielded metal arc process with low hydrogen electrodes for manual welding.

The Contractor shall be responsible for the quality of the welding performed by his welding organization. All welding by the Contractor shall be carried out by the electric arc method using coated electrodes or other means whereby the air is excluded from the molten metal and where applicable, automatic machines with correct procedure control shall be used.

26.2 Workmanship and Visual Quality Requirements

In addition to conforming with the procedural and quality requirements set forth in the Structural Welding Code and/or these Specifications, all manual welding shall meet the following requirements for workmanship and visual quality.

- (a) Each weld shall be uniform in width and size throughout its full length and each layer of welding shall be smooth, free of slag, cracks, pinholes and undercut and shall be completely fused to the adjacent weld beads and base metal. In addition, the cover pass shall be free of coarse ripples, irregular surface, non-uniform bead pattern, high crown, deep ridges or valleys between beads and shall blend smoothly and gradually in to the surface of the base metal.

- (b) Butt Welds shall be slightly convex, of uniform height and shall have full penetration.
- (c) Fillet Welds shall be of specified size with full throat and with each leg of uniform length.
- (d) Repair, Chipping or Grinding of welds shall be done in such a manner as not to gouge, groove, or reduce the base metal thickness.

26.3 Welding Repairs

All weld defects which are determined unacceptable, shall be removed by chipping, grinding, arc or flame gouging, following which the area shall be properly prepared for welding, repaired by an approved qualified welding procedure and re-tested as necessary. The Contractor shall establish the cause of all defects and show that such defects have been corrected before welding will be permitted. All repairing shall be done by and at the expenses of the Contractor.

26.4 Peening

The Contractor shall not be allowed to peen welds without prior approval of the Engineer.

26.5 Electrodes

All electrodes shall be purchased in sealed containers and shall be thoroughly dry when used. Electrodes, taken from sealed containers, shall be used within four hours. Electrodes not used within four hours shall be stored in electrode storage ovens. The electrode storage oven temperature shall be in accordance with the electrode manufacturer's recommendations. Electrodes with wet or damaged coatings shall not be used.

A simple test indicate the quality of an electrode or welding or welding wire can be made by laying the wire flat on a clean surface and applying the welding flame to it for a distance of about 8 - 10cm by moving the flame backward and forward until the wire becomes red and then slowly melting the wire, moving the flame in such a manner so that the wire melts only half-way thorough its diameter. If the flame is withdrawn as soon as the rod metal begins to melt, the impurities can readily be seen being thrown off in the form of sparks, or a boiling action in the case of inferior metal. When cold, an inferior metal will contain numerous spongy, volcano-like irregularities. A good metal welding rod will melt and flow evenly without any disturbing actions.

Cracks may occur in welding alloy steels owing to the rapidity with which these harden. This may largely be avoided by preheating the parent metal at 300°C or above in advance of welding to lower the normal cooling rate.

The maximum diameter of electrodes for welding have been shown in the following table:

Average thickness of plate or section	Maximum gauge or diameter of electrode to be used
Less than 5mm	3.2mm – 10 SWG
5mm to less than 8mm	4mm – 8 SWG
8mm to less than 10mm	5mm – 6 SWG
10mm to less than 16mm	6mm – 4 SWG
16mm to less than 25mm	9mm
25mm and over	9mm

The maximum width of any bead of welding, other than a cover pass, shall not exceed 3 times the diameter of the electrode being used.

Subject to the approval of the Engineer, electrodes shall be carefully selected in order to provide metal welds with mechanical properties similar to those of the metal being welded, except that for welding higher strength steel to lower strength steel, the electrodes shall be chosen to provide metal welds with mechanical properties comparable to those of the lower strength material.

26.6 Cutting and Edge Preparation

Members of structural steel and miscellaneous metal works, which are to be joined by welding shall be cut accurately to size and where required, shall be rolled or pressed to the proper curvature in accordance with dimensions shown. The edges of these members shall be sheared, flame-cut or machined to suit the required type of welding and to allow thorough penetration. The cut surfaces shall expose sound metal, free from laminations, surface defects caused by shearing or flame-cutting operations, or other injurious defects. The surface to be welded shall be free from rust, grease, paint and other foreign matter for a distance of at least 150mm back from the edge of the weld.

26.7 Grinding Wheels

Grinding wheels, which leave a deposit detrimental to subsequent welding will not be permitted. Grinding wheels, which are determined by the Engineer to be detrimental to welding shall not be used.

26.8 Qualification of Welders and Welding Operators

All welders and welding operators assigned to the work shall have passed the qualification test for welding operators as specified in the AWS Structural Welding Code. If, as determined by the Engineer, the work of any welder appears questionable, such welder will be required to pass additional qualification tests to determine his ability to perform the type of work on which he/ she is engaged. Such additional qualification tests for welders and the physical tests of the welded specimens shall be made in the presence of the Engineer. If required, the Contractor shall furnish to the Engineer a certified copy of reports of the results of physical tests of specimens welded in the qualification tests. Fulfillment of such qualification shall be at the expenses of the Contractor.

26.9 Welding Methods

Methods which are essentially required to be followed while welding are as follows:

- Welds should be made in the flat position as far as practicable.
- Freedom of movement of one member should be allowed as far as possible.
- The work should be securely held in position by means of spot welds, service bolts, clamps or jigs before commencing welding so as to prevent any relative movement due to distortion, wind or other causes.
- The parts to be welded must be thoroughly cleaned and proper flux used. Any paint or rust and loose mill scales, etc. should be removed from the surfaces to be welded and surrounding materials for a distance of at least 12mm from the weld. A coating of boiled linseed oil may be permitted. Steel to be welded should not be painted or oiled until after erection, unless all ends to be welded are left bare.
- The sequence of welding should be such that when possible the members, offering the highest resistance to compression, are welded first.

Extreme care shall be taken to ensure that correct welding sequences and procedures are observed to avoid any strains and internal stresses arising in welding.

Welding of stainless steel

Unless otherwise specified, all welding shall conform with AWD D1.1. Electrodes used for welding of stainless steel shall be Series E308 and electrodes used for welding of stainless steel to carbon steel shall be Series E309.

Welders and welding operators assigned to the work shall have passed the qualification test for welding operators as specified above under 'Qualification of Welders and Welding Operators' of this Sub-section.

Welding of reinforcement

Electric Arc Butt-welding is most suitable for bars of diameter greater than 20mm and lap welding for smaller diameters and lap welding with longitudinal beads for 6mm to 40mm diameters. However, reinforcement, specified to be welded, shall be welded by any process the Contractor can demonstrate by bend and tensile tests, which will ensure that the strength of the parent metal is not reduced and that the weld possesses a strength no less than that of the parent metal. The welding procedure established by the successful weld tests shall be maintained and no departure from this procedure shall be permitted. Following the establishment of a satisfactory welding procedures, each welder to be employed on the work shall carry out welder performance qualification tests on reinforcing bars of the same metal and size as those on the works.

Welds in positions other than those shown on the Drawings shall not be permitted.

26.10 Defects in Welded Joints

The usual defects in welded joints are :

- Lack of penetration or fusion of the metal to the bottom of the joint or welded members.
- Laps in the metal of the weld not properly fused together.

Defects are most likely to occur at the root of the weld and in this position they are liable to have the maximum effects in reducing the strength of the weld.

26.11 Inspection and Testing of Welds

The metal in a good weld when cold should show its original colour. If the metal has a rusty or dull red colour or appears crystallized, it is an indication that the heat has become too high and the metal has been burnt. A good weld will show an evenness of ripples or waves and well formed beads with good fusion along the edges of the welds. There should be no unfilled cavities, small pockets of slags or burnt metal and small air or gas pockets.

The strength of a welded joint may be taken only about 75 per cent of the stress usually allowed for common works, although tests have shown that if the welding is properly done it is possible to develop the full strength of the members jointed.

The following tests shall be carried out on the procedure, qualification, test plates and production test plates:

- Tensile and bend tests: all welds shall be subject to visual inspection.
- The procedures of visual examination shall conform to the requirements of the ASME Boiler and Pressure Vessels Code.

The following defects are unacceptable unless otherwise noted:

- Dimensional defects such as insufficient throat or leg length, excess convexity, excess or insufficient reinforcement.
- Undercuts, overlap, blowholes, slag inclusion, seams and excess weave.
- Any crack or liner indication.

Plates with laminations discovered during gas cutting, welding or any other time shall be rejected, unless approval to repair the plate is obtained from the Engineer.

Welds may also be subject to anyone or a combination of the examinations as may be required to establish the soundness of welds.

The inspection procedure for testing of all welds shall be prepared on the above basis by the Contractor and submitted to the Engineer for approval before any fabrication work is started.

26.12 Measurement and Payment

Welding shall not be measured and no direct payment shall be made. All costs of welding shall be deemed included in the related items of the Bill of Quantities unless otherwise it has been specifically mentioned in the BOQ.

27. PORTABLE STEEL BRIDGE

27.1 Portable Steel Bridge

27.1.1 Description

This work shall consist of erecting pre-fabricated steel structures as super structure of a bridge. It is presumed that structural components of the super structure of the bridge have been properly designed, manufactured, assembled, painted and furnished by the supplier/manufacturer. It is further presumed that the steel structures in the super structure have been designed sound conforming the AASHTO Specifications or any other equivalent standard.

Falsework used in the erection of the structural steel members shall conform to the Specifications and procedures illustrated under 'Scaffolding' of the Sub-section 'Concrete for Structures' of these specifications.

27.1.2 Elements of the Superstructure

Superstructure of the Portable Steel Bridge generally comprises with the following elements:

- Readymade steel Truss fabricated with H-shape and L-shape steel members
- Steel panel type deck slab comprising steel check plate, Flat Bar, High Tension Bolt
- Steel Pipe for railing
- High Tension Bolts for connection of truss and deck plate
- Steel plates for shoe and gussets
- Anchor Bolts and Round Bars for shoe anchor
- U-bolt, Bolt, Nut, Washer

27.1.3 Erection Method

There are several erection methods followed for hoisting the superstructure with steel fabricated members which are as follows:

- Assembly on staging
- Assembly by truck crane and bent
- Assembly by cable suspension
- Erection girder method

On a comparative study and analyses of all the erection schemes, launching on staging method has been found to be more convenient friendly for LGED on the following features:

- The bridge can be assembled on the approach road and as such assembly will be efficient and accurate.
- No special machine or skilled technique on required and there by the erection cost is low.
- For erection of portable steel bridges, assembly on staging is the common method in Bangladesh. This method was introduced to improve the speed and accuracy of the assembly.

Tools and equipment

Items of assembly and launching tools necessary for erection with the Launching on Staging Method are the following:

Survey tools

- Level Gauge

- Steel Measuring Tape

Erection tools

- Torque Wrench
- Socket Wrench
- Single Offset Wrench
- Sledge Hammer, Double Face
- Hand Hammer, Double Face
- Lever Block
- Bolt Clipper
- Wire Rope Clip
- Crow Bars of different designations
- Erection Bolt
- Drift Pin

Lifting equipment

- Three Pronged Lift
- Pully Block
- Shackle
- Pipe
- Nylon Sling
- Portable Winch
- Steel Wire Rope
- Stay Wire Rope
- Base Beam

Scaffolding

- Scaffolding Frame
- Stage Plank
- Jack Base
- Ladder
- Bracing

Erection truss

- Tie Beam

Launching rail

- Launching Rail
- Base Plate

Launching equipment

- Roller
- Screw Clamp
- Portable Winch
- Pully Blocks of different designations
- Stay Wire Rope
- Steel Wire Rope of different designations
- Roller Staging Beam
- Filler Plates of different designations
- Winch Staging Beam

Jack up/down equipment

- Mechanical Jacks of different designations
- Saddle

Launching on staging method

The following steps are necessary, but not limited, to be followed while adopting launching on staging method for erection of members.

One span type

- Step-1 : Installation of wooden stage and launching rail.
In the case of having the slope of the bank, the saddle is inserted under the rail and is kept in a level.
- Step-2 : Assembly of composed member.
Installation of deck plate.
Bolting.
- Step-3 : Setting of counter weight and wiring.
Launching.
- Step-4 : Moving the front roller.
Launching (rolling out).
- Step-5 : Completion of launching.
Removal of counter weight and roller.
- Step-6 : Disassembly of launching equipment.
Jack down.
Completion.

Two span type

- Step-1 : Installation of two wooden stages and launching rail.
In the case of having the slope of the bank, the saddle is inserted under the rail and is kept in a level.
First span assembly of composed member.
- Step-2 : Setting counter weight.
First launching.
Moving the front roller.
- Step-3 : Second launching arrive on next pier.
Removal of counter weight.
- Step-4 : Second span assembling of composed member.
Assembling of tie beam.
- Step-5 : Third launching.
Moving the roller.
- Step-6 : Forth launching
Moving the roller.
- Step-7 : Fifth launching.
Disassembling of launching equipment.
- Step-8 : Jack down.
Disassembling of tie beam.
Completion.

27.1.4 Erection Procedure

The Contractor shall submit to the Engineer his proposed construction method detailing the erection procedures on the Drawings which should show the staging, assembling of composed members and setting of the different components of the Portable Steel Bridge prior to starting with the erection work. His proposals shall be reviewed and approved by the Engineer. The erection procedure shall fully conform to the erection Drawings approved by the Engineer. Any modification to or deviation from this erection procedure will require revised drawings and verification of stresses and geometry.

27.1.5 Erection Stresses

Any erection stresses, induced in the structure as a result of using a method of erection, which differs from the plans, shall be accounted for by the Contractor. The Contractor, at his own expenses, shall prepare erection design calculations for such changed methods and submit them to the Engineer. The calculations shall indicate any change in stresses or change in behavior for the temporary and final structures. Additional material required to keep both the temporary and final stresses within the allowable limits used in design shall be provided at the Contractor's expenses.

The Contractor shall be responsible for providing temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure during erection.

27.1.6 Maintaining Alignment and Camber

During erection, the Contractor shall be responsible for supporting segments of the structure in a manner that will produce the proper alignment and camber in the completed structure. Cross frames and diagonal bracings shall be installed as necessary during the erection process to provide stability and assure correct geometry. Temporary bracings, if necessary at any stage of erection, shall be provided by the Contractor.

27.1.7 Field Assembly

The parts shall be accurately assembled as shown on the plans or erection Drawings, and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before installing and tightening the balance of high-strength bolts.

Pin connections

Pilot and driving nuts shall be used in driving pins. They shall be furnished by the Contractor without charge. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

Misfits

The correction of minor misfits involving minor amounts of reaming, cutting, grinding and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transporting will be the cause for rejection.

The Contractor shall be responsible for all misfits, errors and damage and shall make the necessary corrections and replacements.

27.1.8 Measurement and Payment

The work shall be measured in linear meter of the steel truss hoisted and decking installed, as shown on the Bill of Quantities. The payment shall be the full compensation for assembling, erecting, fitting, fixing in proper position, providing necessary staging and decking by arrangement of all necessary

tools and equipment, local handling of bridge parts and all incidentals required for full completion of the work.

Item of payment

	Unit
Launching of Portable Steel Bridge	Per meter
De-launching of Portable Steel Bridge	Per meter

28. BANK PROTECTIVE WORKS

28.1 Slope Protection

General

This work shall consist of protection of bank and slope of embankment following the various types. Specifications of the different types have been illustrated here under. All works shall be carried out in close conformity with the lines, grades and thickness shown on the Drawings and or as directed by the Engineer.

28.2 Grass Turf

28.2.1 Description

This work shall consist of furnishing turf and sods as required and planting them to give a healthy stable covering of grass which will maintain its growth in any weather and prevent erosion of the material in which it is planted.

28.2.2 Materials

Grass shall be of the species native to Bangladesh, harmless and inoffensive to persons and animals and not of a kind recognized as a nuisance to agriculture. It shall be free from disease and noxious weeds, deep rooted and sufficiently rapid growing and spreading to give complete cover over the planted area within the Maintenance Period.

The term "grass" embraces turf and sods and if the Engineer permits, may include plants of other types capable of giving effective protection.

Fertilizer shall be approved lime or mixtures of plant nutrients or both.

28.2.3 Construction Methods

The work shall be carried out by planting sods or turfs to give continuous cover over the whole area. They shall be planted with their root system substantially undamaged, well buried in firm material and packed around with moist earth in which they have grown.

Grass shall be planted at such a time and in such a way that at the time of the final inspection, all areas are substantially covered with healthy, well-established, firmly rooted grass and the planted area becomes free from channel erosion.

Surfaces to be planted shall be trimmed in such a way that the ground surface after planting shall be as shown on the Drawings.

Fertilizer shall be added at the time of planting if necessary to ensure good ground cover within the required time.

The Contractor shall maintain the grass at his expense until the end of the Maintenance Period. Maintenance shall consist of preserving, protecting and replacing grass and such other works as may be necessary to keep it in a satisfactory condition to prevent erosion and to present a dense and uniform appearance. The Contractor shall be responsible for satisfactory growth of the grass and shall

water, fertilize and mow the grass at such intervals as will ensure good ground cover of live grass all through the Maintenance Period.

28.2.4 Measurement

The quantity measured for payment shall be the area in square meters of turfed or sodded surface whether horizontal or on slope of required and accepted grassing well established in place. Fertilizer will not be measured.

28.2.5 Payment

This work measured as provided above shall be paid for at the Contract unit price in square meter. Payment for grassing shall be made only when grass is fully-grown and at the termination of the Maintenance Period and prior to the issue of the Contract Completion Certificate. The payment will be the full compensation for furnishing all materials including grass and fertilizer, labour, equipment, tools and incidentals necessary to complete the work to the satisfaction of the Engineer.

Item of payment

	Unit
Grass Turfing	Square Meter

28.3 Hand Placed Rip-Rap

28.3.1 Description

This work shall consist of placing in position of stone boulders on earth or gravel bedding on the embankment slope or bank.

28.3.2 Materials

Boulders shall conform to the sizes/weights and grading shown on the Drawings. The material shall not be polluted and shall be free from objectionable quantities of dirt, sand, dust and elongated or flaky stones.

The boulders shall be free from cracks and veins which could lead to breakage during loading, unloading and dumping. The specific gravity of the boulders shall be between 2.4 and 2.6.

The weighted average loss of materials in the sodium sulphate soundness test shall not be more than 10% by weight in accordance with ASTM C88. Water absorption of stone material shall be 2% maximum. The percentage of wear as determined by the Los Angeles Test shall not be more than 40 as per ASTM C535. The aggregate impact value shall not exceed 30% limit included in BS 812, Part 3, Chapter 6.

28.3.3 Construction Method

Slopes shall be shaped to allow the full thickness of the specified slope protection and any bedding or filter gravel, where required. Slopes shall not be steeper than the natural angle of repose of the slope specified on the Drawings. Where the slopes cannot be excavated to undisturbed material, the underlying material shall be compacted to 95% Standard Density as per AASHTO T 99.

When called for on the plans, a layer of filter gravel or filter fabric shall be placed on the slope immediately prior to placement of the rip-rap. The layer of filter gravel shall be shaped to provide the minimum thickness specified.

When specified in the contract, filter fabric shall be spread uniformly over the prepared slope or surface. The fabric shall be unrolled directly on the surface to the lines and dimension shown. The filter fabric shall be lapped a minimum of 1300mm in each direction and shall be anchored in position with approved anchoring devices. The Contractor shall place the rip-rap in a manner that will not tear, puncture, or shift the fabric. Tracked or wheeled equipment will not be permitted on the fabric covered slopes.

The larger stones shall be placed first with close joints. The larger stones shall be placed in the footing trench. Stones shall be placed with their longitudinal axis normal to the embankment face and arranged so that each stone above the foundation course has a three-point bearing on the underlying stones. The foundation course is the course placed on the slope in contact with the ground surface. Bearing on smaller stones that may be used for chinking voids will not be acceptable. Interstices shall be filled with smaller stones and spalls.

28.3.4 Measurement

Hand placed Rip-rap shall be measured by cubic meter or as shown on the Bill of Quantities. The area will be that actually placed to the limiting dimensions shown on the Drawings or dimensions as may have been revised by the Engineer, measured along the upper surface. The volume will be computed on the basis of thickness specified on the Drawings.

28.3.5 Payment

The work measured as provided above, shall be paid for at the Contract unit prices for such work and shall be the full compensation for furnishing and placing all materials and for all labour, equipment, tools and incidentals necessary to complete the work prescribed in this Sub-section and including all excavation and slope trimming.

Item of payment

	Unit
Hand placed Rip-rap	Cubic Meter

28.4 Brick Mattressing

28.4.1 Description

This work shall consist of providing brick mattressing with single or double layer brick soling encased in wire net over a filter bed of 25mm thick on the embankment slope, bridge approaches, side and water front slopes at the required locations. All works shall be done in accordance with these Specifications and in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or as directed by the Engineer.

28.4.2 Materials

Bricks

Bricks to be used shall conform all Specifications as described under the relevant Sub-section of the Section on "Building Materials" of this Specifications.

Sand

Sand for filter bed shall have a minimum F.M. 2.50. The joints of the soling or the cushion in between the soling shall have a minimum F.M. 0.50.

Coarse aggregate

Except otherwise stated, coarse aggregate shall consist of 20mm down graded, hard, durable angular fragments to be obtained from picked jhama bricks. Picked jhama bricks shall meet all requirements as stated under the relevant Sub-section of the Section on "Building Materials" of this Specifications.

Wire mesh

The wire mesh to be used for anchoring and encasing the brick mattress shall be made of 12 BWG Galvanized Iron wire twisted to form hexagonal openings of uniform size. The mesh opening shall not have more than 112mm in linear dimension with maximum opening area of 51centimeter square. The wire netting roll shall be as larger as possible.

Bamboo pegs

Bamboo pegs, each of length 750mm, to be obtained from matured Borak Bamboo of diameter 75mm to 100mm.

28.4.3 Construction Method

Side slope surface on which the brick mattress will be placed shall be properly trimmed and compacted. A filter bed prepared from one part of sand mixed with one part coarse aggregate shall be laid on the slope. Other finishing stakes are to be set according to the Drawings and shall be inspected and approved by the Engineer.

After placing the filter bed, the wire mesh will be laid and staked with 750mm long bamboo pegs of diameter 75mm to 100mm at an interval shown on the Drawings or approved by the Engineer. The first layer of the double flat brick mattressing will be laid closely packed. Sides, interstices and the underneath of the bricks shall be tightly packed with sand. The brick mattress shall then be covered and encased by another layer of wire mesh anchored and staked securely with the bamboo pegs.

28.4.4 Measurement

The quantity of brick mattressing regardless of number of layers to be measured shall be the number of square meters along the slope completed and accepted as shown on the Drawings. No separate measurement will be made for excavation and slope trimming.

28.4.5 Payment

The work measured as provided above, shall be paid for at the Contract unit prices for such work and shall be the full compensation for furnishing and placing all materials and for all labour, materials, equipment, tools and incidentals necessary to complete the work prescribed in this Sub-section and including all excavation, slope trimming and laying filter bed.

Item of payment

	Unit
Brick Mattressing (single/double layer)	Square meter

28.5 Boulder Mattressing

28.5.1 Description

This work shall consist of providing boulder mattressing encased in wire-net over a filter bed of 25mm thick on the embankment slope, bridge approaches, side and water front slopes at the required locations. All works shall be done in accordance with these Specifications and in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or as directed by the Engineer.

28.5.2 Materials

Boulders

Boulders shall conform to the sizes and weights shown on the Drawings. The materials shall not be polluted and shall be free from objectionable quantities of dirt, sand, dust and elongated or flaky stones. It should also conform the specific gravity, if specified any (Normally 2.4 to 2.7).

The boulder shall be free from cracks and veins, which could lead to breakage during loading, unloading and dumping.

The weighted average loss of materials in the sodium sulphate soundness test shall not be more than 10% by weight in accordance with ASTM C88. Water absorption of stone material shall be 2% maximum. The percentage of wear as determined by the Los Angeles Test shall not be more than 40 as per ASTM C535. The aggregate impact value shall not exceed 30% limit included in BS 812, Part 3, Chapter 6.

Wire mesh

The wire mesh to be used for anchoring and encasing the boulder mattress shall be made of 2 ply 12 BWG Galvanized Iron wire twisted to form hexagonal openings of uniform size. The mesh opening shall not have more than 100mm square.

Wooden pegs

Wooden pegs, each of length 750mm, to be obtained from well seasoned timber sawn with cross section 75mm x 75mm.

28.5.3 Construction Method

Side slope surface on which the boulder mattress will be placed shall be properly trimmed and compacted. Finishing stakes are to be set in accordance with the Drawings and shall be inspected and approved by the Engineer.

After compaction, the wire mesh will be laid and staked with 75mm x 75mm x 750mm wooden pegs at an interval shown on the Drawings or approved by the Engineer. Boulders will be laid closely placed so as to have a minimum percentage of voids.

28.5.4 Measurement

The quantity of boulder mattressing shall be measured to the surface area in square meters computed from the dimensions along the slope completed and accepted as shown on the Drawings. No separate measurement will be made for excavation, slope trimming and filter bed.

28.5.5 Payment

The work measured as provided above, shall be paid for at the Contract unit prices for such work and the rate shall include the full compensation for clearing, trimming the formation, consolidating the ground, placing the filter bed, supplying, transporting and placing the boulders on the slope, all labour, materials, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Item of payent

	Unit
Boulder Mattressing	Square meter

28.6 Sacked RIP-RAP

28.6.1 Description

This work shall consist of supplying and placing of Sacks filled with mixture of sand and cement on the embankment slopes necessary to protect the embankment from erosion. All works shall be done in accordance with these Specifications and in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or as directed by the Engineer.

.28.6.2 Materials

Cement

Cement shall be Portland Cement Type-1 conforming the requirement of ASTM C-150. All other properties of cement shall be the same as have been described under the Section on 'Concrete Work' of these Specifications.

Sand

Sand for the Rip-rap shall have a minimum F.M. 1.0 while for the filter bed it shall have a minimum F.M. 2.50.

Sacks

Sacks shall be made of jute fabric or any other type of burlap having requisite strength. The sizes shall be approximately 500mm by 900mm measured inside the seams when the sack is laid flat. The approximate capacity shall be 0.035 cubic meter. Sound reclaimed sacks may be used.

28.6.3 Construction Method

Side slope surface on which the sacked rip-rap will be placed shall be properly trimmed and compacted. Slopes shall not be stiffer than the natural angle of repose of the soil. The underlying material shall be compacted to 95 percent standard density as per AASHTO T 99. Finishing stakes are to be set according to the Drawings and have been inspected and approved by the Engineer.

The mixture for the sacks shall consist by volume of one part of Ordinary Portland Cement and eight parts screened sand. The cement and sand shall be mixed dry thoroughly mixed on a clean watertight platform until a uniform colour is obtained.

The well mixed sand and cement mixture shall then be filled with approximately 0.0283 cubic meter leaving room at the top to fold the sacks and retained the mixture during placement. Immediately on being filled, the sacks shall be placed and lightly trampled to conform with the earth face and with the adjacent sacks.

The first layer consist of stretchers which shall be laid with long dimension of sack parallel to contour of slope and each layer shall be adjacent to each other. The second layer then be placed with long dimension at right angles to the stretchers.

Dirt and debris shall be removed from the top of the sacks of the first layer before the next layer is placed in a manner that the folded ends are not adjacent. The second layer shall be placed with the folds towards the earth face.

Sacked Rip-rap such placed shall be cured by sprinkling with a fine spray of water every two hours during day time for at least 7 (seven) days.

When required or directed by the Engineer or as shown on the Drawings, weep holes be provided through the Rip-rap.

28.6.4 Measurement

The quantity of Sacked Rip-rap shall be measured by the cubic meter of concrete placed. Measurement will be based on mixture volumes and accepted as shown on the Drawings. No separate measurement will be made for excavation and slope trimming.

28.6.5 Payment

The work measured as provided above, shall be paid for at the Contract unit prices for such work and the rate shall include the full compensation for clearing, trimming the formation, consolidating the ground, furnishing and placing the sacks filled with sand and cement mix on the slope, curing, all materials including sacks, all labour, equipment, tools and incidentals necessary to complete the works prescribed in this Section.

➤ Item of payment

	Unit
Sacked Rip-rap	Cubic meter

28.7 Brick Masonry Blocks**28.7.1 Description**

This work shall consist of furnishing and placing of brick masonry blocks on the embankment slopes necessary to protect the embankment from erosion. All works shall be done in accordance with these Specifications and in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or as directed by the Engineer.

28.7.2 Materials**Bricks**

Bricks to be used shall conform all Specifications as described under the Section on the 'Brick Masonry and Brick Work'.

Cement

Cement shall be Portland Cement Type-1 conforming the requirement of ASTM C-150. All other properties of cement shall be the same as have been described under the section on Concrete for Structures of these Specifications.

Sand

Sand shall be non-saline, hard, dense and free from deleterious materials and shall have a minimum FM.1.5. It should conform to the requirements of AASHTO Standard Specifications M-6.

28.7.3 Construction Method

Masonry blocks shall be cast in a casting yard using cement mortar prepared with one part Ordinary Portland Cement and four parts of sand by volume unless otherwise specified. The size of each block should conform to the Specifications shown on the Drawings or as directed by the Engineer.

Cement Mortar shall be prepared following the Construction Method as laid down in these Specifications under the Section. All blocks shall be cured for not less than 14 (fourteen) days by an appropriate method approved by the Engineer.

The properly cured blocks shall than be delivered to the site and be placed on the slopes in a staggered manner to proper line and grade as shown on the Drawings.

Before placing the blocks, the side slope surface shall be properly trimmed and compacted. Slopes shall not be steeper than the natural angle of repose of the soil. The underlying material shall be compacted to 95 percent standard density as per AASHTO T99. Finishing stakes are to be set according to the drawings and have been inspected and approved by the Engineer.

28.7.4 Measurement

Brick masonry blocks shall be measured in numbers corresponding to the sizes/ dimensions mentioned in the BOQ and shown on the Drawings and actually placed along the slope completed and accepted. No separate measurement will be made for slope trimming.

28.7.5 Payment

The work measured as provided above, shall be paid for at the Contract unit prices for such work and the rate shall include the full compensation for clearing, trimming the formation, consolidating the ground, furnishing and placing the brick blocks on the slope, curing, all labour, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Item of payment

	Unit
Supplying brick blocks	Each
Laying brick blocks	Hundred

28.8 Pre-Cast Cement Concrete Blocks**28.8.1 General**

Pre-cast concrete blocks shall be made to the dimensions shown on the Drawings and to the specified tolerances. The blocks shall comply with the percentages of the different block as shown on the Drawings. The Contractor shall prepare a size-wise schedule of all blocks required for the Engineer's approval before execution of the work.

28.8.2 Construction Method

Except otherwise shown on the Drawings, pre-cast concrete blocks (C.C. blocks) shall be made from concrete Class B-2 in accordance with the relevant Sub-section under Section on 'Concrete for Structures' of this Specification and cast in moulds formed from steel sheet. The moulds shall be sufficiently tight fitting to prevent grout losses and sufficiently rigid to withstand the effects of placing and vibration of the concrete without distorting and capable of releasing the hardened concrete blocks without causing damages to the blocks.

Each block shall be marked with a serial number and the date of casting. Marking shall either be engraved on the block whilst the concrete is still "green" or painted on the block with a water proof paint immediately after striking off the formwork. The Contractor shall maintain a register (officially issued by the Engineer) of the number, date of casting, date and location of placing of each block and shall make the register available at all times for inspection by the Engineer.

Blocks shall not be stockpiled until they have been cured in accordance with the relevant Sub-section on 'Curing of Concrete' under the Section 'Concrete for Structures' of this Specifications. They shall not be placed in the works until at least twenty-eight days after casting have elapsed or the specified strength has been attained.

Blocks which are damaged during transport, stockpiling or handling shall be rejected and removed from the site.

28.8.3 Measurement

Pre-cast concrete blocks placed as slope paving shall be measured to the surface area in square meters computed from the dimensions along the slope completed and accepted as shown on the Drawings. No separate measurement will be made for excavation and slope trimming.

28.8.4 Payment

The work measured as provided above, shall be paid for at the Contract unit prices for such work and the rate shall include the full compensation for clearing, trimming the formation, consolidating the ground, furnishing and placing the cement concrete blocks on the slope, curing, all labours, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Item of payment

	Unit
Cement Concrete Blocks	Square meter

28.9 Cast-In-Place Cement Concrete Slope Paving**28.9.1 General**

The work shall consist of constructing cast-in-place cement concrete slope paving.

28.9.2 Construction Method

Concrete shall be mixed and placed in conformance with the provisions of relevant Sub- Section under Section on "Concrete Structures" of this Specification and shall be spread and tamped until it is thoroughly compacted and mortar flushes to the surface. If the slope is too steep to permit the use of concrete sufficiently wet to flush with tamping, the concrete shall be tamped until consolidated and a mortar surface 6mm thick, troweled on immediately. The mortar shall consist of one part of Portland cement and three parts of fine aggregate.

After striking off to grade, the concrete shall be hand floated with wooden floats. The entire surface shall be broomed with a fine texture hair push broom to produce a uniform surface with the broom marks parallel to the edges of the panel. Edges and joints shall be edged with a 6mm radius edger prior to the brooming.

Expansion joints shall be installed transversely at intervals of 6 meter. Longitudinal expansion joints shall be installed at the locations shown on the plans. Expansion joints shall be filled with expansion joint filler 12mm thick.

Cast-in-place concrete shall be cured as provided in the aforementioned Section.

Weep holes shall be provided through the slope paving as shown on the Drawings or as directed by the Engineer.

Pervious backfill material, if required by the plans, shall be placed as shown. 0.057 cubic meter of pervious backfill material wrapped in filter fabric shall be placed at each weep hole and drain hole.

On completion of the work, footing trenches shall be filled with excavated material and compaction will not be required.

28.9.3 Measurement

Cast-in-place concrete placed as slope paving shall be measured by volume of concrete in cubic meters. The volume will be computed on the basis of the measured area and the thickness shown on the Drawing. The mortar surface shall be considered as a part of the concrete and no separate measurement will be taken therefore.

28.9.4 Payment

The work measured as provided above, shall be paid for at the Contract unit prices for such work and the rate shall include the full compensation for clearing, trimming the formation, consolidating the ground, constructing and placing the cement concrete in place on the slope, curing, all labours, equipment, tools and incidentals necessary to complete the work prescribed in this Section. As the mortar surface shall be considered as a part of the concrete, no separate payment will be made therefore.

Item of payment

	Unit
Cement Concrete	Cubic meter

28.10 Filter Materials

28.10.1 General

Filter materials shall be as specified on the Drawings and either be:

- A brick aggregate filter, crushed stone or gravel (shingle) filter;
- An inverted filter comprising of a fine filter and coarse filter;
- A geo-textile filter.

28.10.2 Brick Aggregate Filter

Brick aggregate filter material shall be made from first class bricks or picked jhama bricks as specified under the relevant Sub-section of Section 'Building Materials' of this Specifications.

The brick aggregate filter shall comply with the grading shown on the Drawings.

28.10.3 Inverted Filter Materials**General**

Filter materials shall be as described below unless otherwise specified on the Drawings.

Fine filter material

The fine filter shall comprise of sand and comply with the grading shown on the Drawings.

Coarse filter material**Coarse filter material shall be made from either:**

- Breaking first class or picked jhama bricks as specified under the relevant Sub-section of Section 'Building Materials' of this Specifications.
- Gravel (shingle) or broken stone of hard durable rock. The stone delivered to the works shall be rejected if not perfectly clean and if it contains soft, clayey, shaley or decomposed stone. The stone may be broken in a stone crusher of approved type or manually. Any dust or fine material below 5mm in size made in the stone crusher is to be removed by screening and the stone shall be thoroughly washed by an approved method.

Filter materials be laid in two layers of equal thickness. The filter material in the bottom layer shall be well graded between 5mm to 20mm and the filter material of the top layer shall be well graded between 20mm to 40mm or in accordance with the gradings shown on the Drawings.

Foundation preparation

The foundation for the filter materials shall be thoroughly compacted and graded to the elevations shown on the Drawings prior to the placement. The filter material shall be placed in a uniform layer of the thickness shown on the Drawings or as directed by the Engineer.

28.10.4 Measurement

Filter materials shall be measured by the volume computed from the dimensions shown on the Drawings or such other dimensions as directed by the Engineer and paid for at the quoted unit rate. The unit rate shall include all labour, materials, tools and equipment for producing materials, trimming foundation surfaces placing materials and all incidentals to complete the work. No payment shall be made for any excess material produced or placed outside the specified limits.

28.10.5 Geo-textile filter

Geo-textile fabric used for the filter layer below the slope protection shall be a non-woven geo-textile of the staple or continuous fibre type or similar material approved by the Engineer. The fabric shall not be less than 6mm thick with a tensile strength not less than 12 kN/m² and weigh not less than 0.8 kg/m². O₉₀ shall not be greater than 0.07mm and the permeability shall not be less than 3.0 x 10³m/s

The Contractor shall undertake the necessary grading and permeability tests of the embankment soils to determine the required filter fabric characteristics.

A geo-textile filter shall comply with other specifications as described under the relevant Sub-sections of the Section on 'Building Materials' of this Specification.

28.10.6 Payment

Geo-textile filter shall be measured in square meter over a covered surface area computed from the dimensions on the Drawings or from such other dimensions as directed by the Engineer. The payment will be made at the quoted unit rate per square meter. Costs of all the associated items including supply, transporting, preservation, laying etc. shall be included in this rate.

28.10.7 Geo-jute on Embankment Slopes

Where specified on the Drawings, Geo-jute shall be laid on the finished soil profile/slopes. The detailed application methods may differ from site to site but generally the steps are as follows:

- Geo-jute is rolled along or down slopes and secured with wire staples.
- Geo-jute must be laid loosely and evenly without tension or stretch on either directions.
- Up-channel ends/embankment crest ends or shoulders are buried and stapled in a 150mm deep slit trench, and then fastened with a further five staples.
- Down-channel ends/embankment toes are under folded by 150mm and secured with five staples.
- All terminations are buried in a 150mm deep slit trench.
- Longitudinal edges are overlapped by 100mm and stapled at 100cm centres.
- Roll junctions are overlapped by 100mm and stapled.
- An additional row of staples is fixed at 100cm centres down each strip.
- Erosion stops of folded Geo-jute may be buried at critical points to control subsoil slippage as and when directed by the Engineer.

28.10.8 Measurement and Payment

Geo-jute shall be measured in square meter over a covered surface area computed from the dimensions on the Drawings or from such other dimensions as directed by the Engineer. The payment will be made at the quoted unit rate per square meter. Costs of all the associated items including supply, transporting, preservation, laying etc. shall be included in this rate.

28.10.9 Toe Walls

Where shown on the Drawings, toe walls shall be made of brick masonry to support the different slope protection measures. The work shall conform in all respect with the specifications including the measurement and payment procedures stated under the Sub-sections on 'Brick Masonry Works' of the Section 'Incidentals' and the Sub-section on 'Concrete for Structures' of the Section 'Structures' of this Specification.

28.11 RCC Palisading

This work shall consist of elements as shown in the drawing and shall be constructed in accordance with the specifications for the materials and elements mentioned in these specifications in relevant sections.

Measurements

Measurement will be in lin. meters of palisading provided.

Item of payment

	Unit
RCC palisading	Lin. m

29. REINFORCED CONCRETE PIPE CULVERTS**29.2.1 Description**

This work shall consist of supply and installation of reinforced concrete pipe culverts in accordance with these Specifications and to the locations, lines, levels, grades and design shown on the Drawings and or as directed by the Engineer. This shall also include colors of appropriate diameter for joining the pipes, if required.

The work shall further include connection of existing drains, which have been interrupted by the road construction to the new drainage system, as directed by the Engineer.

29.2.2 Materials**29.2.3 Reinforced Cement Concrete Pipes**

The reinforced cement concrete culvert pipes shall meet the requirements of AASHTO M 170 or AASHTO M 242 (ASTM C 76 or C 655). The pipes shall be of the tongue and group type or circular pipes joined with colors of appropriate diameter. Specifications of the concrete to be used for manufacturing the pipes shall conform to the provisions stated under the relevant Section of these Specifications. The concrete should have a mix for the strength to be achievable with a proportion 1:1.5:3. The minimum thickness of the pipe wall shall be as shown on the Drawings.

Bricks

First class bricks shall be used for the masonry work in headwall while Picked Jhama bricks, broken into appropriate gradation, shall be used for concrete work or khoa packing.

First class bricks shall comply with the following requirements:

Shape etc. : Sound, hard and well-burnt, uniform in size, shape and colour, homogeneous in texture and free from flaws and cracks. A fractured surface shall show a uniform compact structure free from holes, lumps or grits.

Minimum crushing strength: 14 N/mm².

Maximum water absorption : Increase in weight after one hours absorption in water shall not be more than 16 percent.

Dimensions : 240mm x 120mm x 70mm (all dimensions + 5mm).

Picked Jhama bricks shall comply with all the above requirements other than they shall be so over-burnt as to become vitrified or distorted but not become porous or spongy.

Cement

Cement shall be Portland cement type-1 conforming the requirement of ASTM C-150. All other properties of cement shall be the same as have been described under the section on Concrete for Structures of these Specifications.

Fine aggregate

Fine aggregate shall consist of natural sand conforming to the requirements of AASHTO Standard Specifications M-6.

Sand shall be completely non-plastic and free from all clay, roots and other organic materials.

When sand is subject is to five alternations of sodium sulfate soundness test, the weight loss shall not be less than 10 mass percent.

Minimum F.M. of sand for any type of brickwork shall be 1.5.

Water

Quality of water to be used in masonry work shall be similar to the requirements as have been described under the section on Concrete for Structures of these Specifications.

Reinforcement

Reinforcement in pipes shall consist of hoops and longitudinal bars. Longitudinal reinforcement is about $1/4^{\text{th}}$ to $1/5^{\text{th}}$ of the helical reinforcement. 6mm dia bars at 23 cm centre to centre is usually adequate. Hoops are provided concentric in 1 layer in the centre for pipes upto 60 cm dia or in two concentric layers for large diameter pipes under heavy external loads or internal pressure.

Cement mortar

Unless otherwise specified in the Drawings, cement mortar shall consist by volume of one part Ordinary Portland cement and two parts screened sand. In each mortar just enough water shall be added and the components mixed and thoroughly incorporated together to give a workability appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed with the evidence that the mixture has taken an uniform colour. Approved quality of water shall then be added sparingly, only the minimum necessary, being used to produce a workable mixture of normal consistency. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform and cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour and then the mortar shall be mixed for at least two minutes after addition of water.

Only a sufficient quantity of sand and cement shall be mixed with water as can be used within 30 minutes after the addition of water. The adding of additional water to and re-tempering cement mortar that stiffened because of evaporation of water, shall be permitted only within thirty minutes from the time of addition of water at the time of initial mixing. Mortar, which has taken the initial set shall neither be used nor be re-mixed with fresh mortar and such mortar shall be discarded and removed from the work site.

At the close of each day's work, the mixing trough and pans shall be thoroughly cleaned.

29.2.4 Construction Methods**Excavation**

Procedures for earth excavation as laid down under the Section on "Excavation and Back fill for Structures" of these Specifications shall be followed.

The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe. Before laying, the ground shall be trimmed true to line and grade, as directed by the Engineer, over sufficient width to permit satisfactory construction of the bedding. Special care shall be taken to remove any hard or deleterious material from the foundation area. When soft, spongy or unstable soil is encountered, such soil shall be removed from under the pipe for a width and to a depth as directed by the Engineer and replaced with sand or other suitable selected material properly compacted to provide adequate support to the pipe.

The prepared surface shall provide a firm foundation of uniform density throughout the length of the culvert. Excavated materials shall not be deposited in the drainage channel and shall be utilized according to suitability as a common fill to the landscape area.

The Contractor and the Engineer shall agree on the location, line and level of each pipe culvert before excavation commences. The excavation of the foundation will include provision of suitable outlet.

Concrete cradle bedding

In order to provide a strong foundation, the bottom must be shaped to fit the pipe and hollowed out to receive the socket and make joints so that the pipes rest throughout their entire length on the solid foundation and the bearing of a pipe is eventually taken by the body of the pipes and not by the sockets. This methods can be adopted in firm ground but in a soft soil the trench bottom must necessarily be flat and a cradle of lean concrete is necessary. The bedding should extend at least 150mm beyond and both sides of the projections of the pipe. The thickness of the concrete below the pipe shall not be less than 150mm and over in diameter. It may be placed over a layer of brick flat soling with Specifications and in a manner stated under the Sub-section on 'Brick Flat Soling'.

Lean concrete used for cradle shall have 28 days compressive strength (cylinder test) of 10 N/mm².

The pipes shall be laid on the concrete bedding before the concrete has set. The shape and dimension of the Cradle shall be as indicated on the Drawings.

Installation of pipe

Each pipe should be carefully examined for soundness before laying. It should be rung with a light hammer and those that do not ring true and clear be rejected.

The outlet shall be excavated before the pipe is laid. Pipe laying shall commence at the downstream end of the pipe line with pipe collars upstream. The pipe shall be laid in a straight line with the pipe joints made as follows:

Jute fiber packing shall be placed around the full circumference of the groove of the pipe already laid.

The lower half of the groove shall then be filled with sufficient mortar to bring the inner surfaces of the abutting pipes flush.

The upper half of the tongue of the pipe to be laid shall be similarly filled with mortar.

After laying, the inside and outside of the joint shall be grouted with mortar to a smooth finish.

The joint shall be kept moist and protected for at least two days before back filling commences.

Before succeeding sections of pipe are laid, the lower half of the groove of the preceding section shall be plastered on the inside with cement mortar of sufficient thickness to bring the inner surface of the abutting pipes flush and even. At the same time the upper half of the succeeding pipes shall be similarly plastered with mortar.

Head wall

On laying of pipe culvert, head walls on both ends shall be constructed with brick work in cement mortar of proportion stated above under the section "Cement Mortar".

Back filling

The complete pipe run shall be inspected and accepted by the Engineer, including the level and grade before back filling commences.

The trench shall be back filled with sand or granular material, placed, watered and compacted in layers, to give a minimum cover of 300mm above the top of the pipe. The back fill shall be brought up evenly on either side of the pipe.

The sand back fill shall be inspected and accepted by the Engineer before the trench is back filled to ground level with ordinary fill. This ordinary fill shall not contain stones and other objectionable material and shall be compacted in layers with approved equipment and procedures to the same density as the adjacent sub-grade.

29.2.5 Measurement

The concrete cradle, brickwork and back filling shall be measured as the volume in cubic meters. Back filling shall be measured as the accepted compacted volume in cubic meters. Brick flat soling in foundation shall be measured in square meter as per drawing. Pointing shall be measured in exposed surfaces of the brickwork in square meter. The volume shall be computed as the volume bounded by the measured length of pipe run, the trench width shown on the Drawings or ordered by the Engineer. The installation of the pipe shall be measured as the length in linear meters of pipe installed complete and accepted.

29.2.6 Payment

The work measured shall be paid at the Contract unit prices as shown in the Bill of Quantities. The payment shall be full compensation for the supply of materials and execution of the work including all necessary labour, equipment, tools and incidentals.

Item of payment

	Unit
Supplying pre-cast RCC Pipes	Linear meter
Brick flat soling (Single layer)	Square meter
Concrete cradle Bedding, Brickwork and Sand Back filling	Cubic meter
Pointing to exposed surface in brick work	Square meter

30. INCIDENTALS**30.1 Brick Masonry Works****General**

This Section shall apply to all brick masonry works in constructing at the different places of a bridge.

30.1.1 Description

This item of work shall consist of construction of brick masonry work in cement mortar with specified proportion in required thickness and heights. The work shall include supply of all labour, materials, tools and equipment, carriage and the performance of all works necessary for the construction of the brick masonry. All works shall be carried out in accordance with these Specifications conforming to the levels, dimensions and designs as shown on the Drawings or as directed by the Engineer.

30.1.2 Materials**Bricks**

Bricks shall be of First Class in quality unless otherwise required and shall comply with the requirements as stated under the relevant Sub-section on 'Construction Materials' of this Specification.

Cement

Cement shall be Portland cement Type-1 conforming to the requirements of ASTM C-150 or BDS 232. All other properties of cement shall be the same as have been described under the relevant Sub-section on 'Construction Materials' of this Specification.

Fine aggregate

Fine aggregate shall consist of natural sand conforming to the requirements of ASTM C 144.

Sand shall be completely non-plastic and free from all clay, roots and other organic materials.

Minimum F.M. of sand for any type of brickwork shall be 1.5.

All other properties of Fine Aggregate shall be the same as have been described under the relevant Sub-section on 'Construction Materials' of this Specification.

Water

Quality of water to be used in masonry works shall be similar to the requirements as have been described under the relevant Sub-section on 'Construction Materials' of this Specification.

30.1.3 Soaking of Bricks

Before use in works, all bricks shall be soaked in clear water for a minimum period of 6 hours. Soaking shall be discontinued two hours before use so that at the time of laying they are skin dry. Such soaked bricks shall be stacked on a clean place where they shall not be spoiled by dirt or any other objectionable materials.

30.1.4 Mortars

Unless otherwise specified on the Drawings, cement mortar for brick masonry works shall generally consists by volume of one part Ordinary Portland cement and four parts screened sand or one part Ordinary Portland cement and six parts screened sand unless otherwise required by the Drawings or instructed by the Engineer. In each mortar, just enough water shall be added and the components mixed and thoroughly incorporated together to give a workability appropriate to its use. Mortar shall be used whilst freshly mixed and no softening or retampering will be allowed.

Mortar shall be mixed in an approved mechanical mixer unless hand-mixing is specifically permitted by the Engineer and in a manner as to accurately determine and control the quantity of each ingredient in the mortar. The cement and sand shall be first mixed dry until thoroughly mixed before adding mixing water. If hand mixing is permitted, the operation shall be carried out on a clean watertight platform and cement and sand shall be first mixed dry in the required proportion to obtain a uniform colour of the mixture and then the mortar shall be mixed for at least two minutes after addition of water.

Only a sufficient quantity of sand and cement shall be mixed with water that can be used within 30 minutes after the addition of water. The adding of additional water to and re-tempering (cement mortar that stiffened because of evaporation of water) shall be permitted only within 30 minutes from the time of addition of water at the time of initial mixing.

30.1.5 Construction Methods

The method and equipment used for transporting and placing the bricks and mortar shall be such as will not damage the brick or delay the use of mixed mortar. All equipment and tools used for mixing or transporting mortar and bricks shall be clean and free from set mortar or other deleterious foreign substances.

All brick works shall be placed only after the foundation surfaces have been prepared satisfactorily in accordance with the Specifications and the Engineer's instructions.

The bricks shall not be placed during rain sufficiently heavy or prolonged, which will wash the mortar from the bricks. Mortar already spread, which becomes diluted by rain, shall be removed and replaced before continuing the work at the expenses of the Contractor.

All bricks to be used in brickwork with mortar joints shall be completely soaked in water for a minimum period of 24 hours before they are used. The bricks shall be used within two hours of taking out of water.

All bricks shall be free from water adhering to their surface when they are placed in the brickwork.

Before laying bricks in foundation, a layer of not less than 12mm of mortar shall be spread to make the surface on which the brick work will be laid even. Immediately thereafter, the first course of bricks shall be laid.

Bricks shall be laid in English bond unless otherwise directed by the Engineer and shall be set with both bed and vertical joints filled with mortar and shall be bedded in by firmly tapping with the handle

of the trowel. The face with the frog mark shall be placed upward to ensure that the frog mark is filled with mortar. Bricks shall be skillfully laid with the level courses, uniform joints, square corners, plumb verticals and true surfaces except when otherwise shown on the Drawings or directed by the Engineer.

Bricks, used on face, shall be selected whole or uniform size and with true rectangular face. Only full bricks shall be used in the brick work unless absolutely necessary for breaking points or maintaining bond.

Bricks shall be laid on full bed of mortar and shall be slightly pressed so that mortar gets into all the surface pores of bricks to ensure proper adhesion. Bricks shall be laid, where possible, from one face only and each brick shall be set with both horizontal and vertical joints filled with mortar and the bricks shall be bedded in by firmly tapping with the handle of the trowel. Mortar joints shall be checked and any hollow or defective joints shall be racked and filled with mortar immediately.

Each course shall break the joints with the course below. All horizontal joints shall be parallel and all vertical joints in alternate courses shall be directly over one another. In thick walls or foundations, not only the face joints but the joints inside also shall break course.

The thickness of mortar in any joints shall not be less than 6mm and not more than 10mm and the height of four courses as laid shall not exceed more than 25mm the height of four dry bricks stacked one upon the other.

All brick works shall be truly plumbed and shall always be carried out regularly along their entire length throughout the structure. When the entire works cannot be carried out in even courses, the break shall be made at regular steps each of a length of at least 1-1/2 times its height. Unless otherwise directed, no overhead work shall be allowed. Toothering may be done where future extension is contemplated but shall be used as an alternative to racking back.

Where specified, fabric reinforcement shall be embedded completely in mortar. During construction of steining members, bars shall be placed accurately in accordance with the Drawings.

The surface of each course shall be thoroughly cleaned from all dirt before another course is laid on top of it. If the mortar in any course has begun to set, the joints shall be racked out to a depth of 25mm before any subsequent course is laid. When the top course has been exposed for more than two weeks, it shall be removed and the surface below shall be thoroughly cleaned before any more courses are added.

When fresh masonry is to be placed against the existing surface of structures, these surfaces shall be cleaned of all loose materials, roughened and wetted as directed by the Engineer so as to effect a good bond with the new work.

30.1.6 Scaffolding

The scaffolding shall be sound and strong to withstand all loads likely to be imposed upon it and subject to the Engineer's approval. Pole going into the masonry should be at a place, which can be filled with a header brick. The holes, which provide resting space for horizontal members shall not be left in masonry under 1m in width or immediately near the skewbacks of arches. The holes left in the masonry work for supporting the scaffolding shall be filled and made good.

30.1.7 Protection and Curing

Brickwork shall be protected during construction and for 3 days after laying against harmful effects of weather by suitable covering. During hot weather, all finished or partly completed works shall be covered or wetted in such manner as will prevent rapid drying of the brickwork.

All brickwork requiring mortar, shall be cured as it is constructed for not less than 7 days on completion of the last course by keeping continuously wet with water or by covering with water saturated material or other curing methods approved by the Engineer.

At the completion of the work, all visible surfaces shall be free from damage or debris and shall look clean. Cares shall be taken that bricks are not stained or coated as the work proceeds. No rubbing of the faces to remove coating shall be allowed.

30.1.8 Finishing of Surfaces**General**

The surfaces shall be finished by "Jointing" or "Pointing". The surfaces which shall remain exposed shall be pointed and those which shall be buried underground shall be jointed. The mortar for finishing shall be prepared as stated under the Sub-section on 'Mortars' of this Section.

Jointing

In jointing, the face joints of the mortar shall be worked out while still green to give a finished surface flushed with the face of the brickwork. The faces of brickwork shall be cleaned to remove any splash of mortar during the course of raising the brickwork.

Pointing

For pointing, the joints shall be squarely raked out to a depth of 15mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted. The mortar shall be filled and pressed in to the raked out joints before giving the required finish. The pointing shall then be finished to proper type given on the Drawings.

If type of pointing is not mentioned on the Drawings or BOQ, flush pointing shall be used. For groove pointing, after the mortar has been filled and pressed into the joints and finished of level with the edges of the bricks, it shall while still green be grooved along the centre with a half round tool of such width as may be specified by the Engineer. The excess mortar shall then be cut off from the edges of the lines and the surfaces of the masonry shall also be cleaned of all mortars.

30.1.9 Repairing of Masonry Brickwork

After the completion of any masonry brick work, if any brick is found out of alignment or level or does not conform to the lines and grades shown on the Drawings or shows a defective surface, it shall be removed and replaced by the Contractor at his expenses unless the Engineer grants written permission to patch or replace the defective area.

30.1.10 Extension to Existing Masonry Brickwork

Where existing masonry brick work is to be extended, the existing skin courses shall be carefully removed as directed by the Engineer. The old exposed brick works and joints shall be carefully prepared and cleaned and thoroughly watered immediately prior to commencing extension of the brick work.

30.1.11 Replacement of Defective Masonry Brickwork

The extent of replacement of defective masonry brick works shall be jointly surveyed by the Contractor and the Engineer at the start of the work and the location of all repairs needed shall be recorded and permanently marked in paint.

Defective brick work shall be carefully removed in a sequence as instructed by the Engineer. The existing stability and structural integrity of walls and arches shall not be impaired during this operation and the Contractor shall be responsible for ensuring that all necessary temporary supports are provided. The defective brick works shall be removed on an incremental basis, if this is deemed desirable and new brick works shall be carefully constructed so that the structural integrity is maintained.

30.1.12 Re-pointing of Existing Masonry Brickwork Joints

The extent of re-pointing of existing masonry brickwork shall be jointly surveyed by the Contractor and the Engineer at the start of the work and the location of all repairs needed shall be recorded and permanently marked in paint.

The defective mortar shall be carefully removed from the joints and the joints shall be cleaned immediately prior to re-pointing. The re-pointing shall be done with cement mortar to full depth, penetration and trimmed flush with the face of the brickwork.

Cracks in the existing brickwork shall be treated in the same way. Defective materials shall be carefully removed and the crack shall be filled with cement mortar.

30.1.13 Measurement

The quantity of masonry brickwork (both new and extension of the existing masonry brickwork) including flush pointing shall be measured in cubic meter in accordance with the dimensions shown on the Drawings or as directed by the Engineer. The quantity of the surfaces finished by jointing, pointing and re-pointing shall be computed from the surface areas in square meter.

30.1.14 Payment

The work measured shall be paid at the relevant Contract unit prices as shown in the Bill of Quantities. The payment shall constitute the full compensation for furnishing, storage, transporting, preparing, laying, racking out joints and curing of all materials and labour including scaffolding, tools and equipment and all incidentals necessary to complete the item. The payment shall also constitute full compensation for all temporary measures to retain the stability of existing structures and for breaking any defective brickwork and mortar.

Item of payment

	Unit
New and extended masonry brickwork	Cubic meter
Replacement of existing defective masonry brickwork	Cubic meter
Brick Pointing	Square meter
Re-pointing of existing masonry brickwork joints	Square meter

PART -9: ENVIRONMENTAL & HEALTH SAFETY SPECIFICATIONS

1. ENVIRONMENTAL SPECIFICATIONS

1.1 PRE-CONSTRUCTION STAGE

Land and building acquisition, training, work site survey, pegging and all approvals/permits shall be undertaken or obtained prior to the commencement of improvement works

1.1.1 Clearances, Approvals and Permits

Environmental Clearance

According to the Environmental Conservation Rules, 1997, the project falls under category Organge B and thus under the provisions of the Bangladesh Environment Conservation Act, 1995, LGED shall need to obtain Environmental Clearance from the Department of Environment, Govt. of Bangladesh before commencement of the road improvement works.

Approvals and Permissions

Approvals/permits will be required from the concerned District Collector to undertake sand mining in the rivers, if proposed by the Contractor. Permissions from private landholders will also be required to undertake activities on their land.

Responsibilities

LGED, as the Proponent of the road improvement works, shall obtain the necessary environmental clearance. Prior to the commencement of any related work the Contractor shall obtain all necessary permits, approvals and consents for the following:

Permission for Sand Mining: A letter of request shall be sent to the District Collector to undertake sand extraction from river beds. The permission shall be obtained by the Contractor. The Contractor shall provide a copy of all permits/approvals/permissions to the DSM Consultants and the LGED. The Contractor shall adhere to the terms and conditions of the permits/permission and comply with all statutes relevant to environmental management at site.

Permissions from Private Land owners: The Contractor shall obtain permissions in writing from all private landowners whose land will be temporarily utilised for borrow pits, brick fields, brick breaking yards, materials storage, workforce camps etc. Permission shall be obtained prior to the commencement of these activities and copies shall be provided to the Engineer and the DSM Consultants.

1.1.2 Land Acquisition

Private land and buildings will need to be acquired for the proposed road widening and minor realignments. Acquisition of structures, which are located within the proposed RoW, will occur in most markets and villages along the project road. Acquisition shall be undertaken in accordance with the provisions of the Land Acquisition Act, 1894.

These provisions have been supplemented with additional guidelines and resettlement Policy Framework contained in the RTIP Resettlement and Rehabilitation Action Plan (RAP). Together, the provisions and guidelines require the successful initiation of land acquisition procedures prior to the commencement of construction work.

Responsibilities

LGED, as the Project Proponent, shall ensure that the necessary land acquisition procedures are completed prior to the commencement of any improvement works at site. These required procedures are detailed in the. RAP.

LGED shall provide copies of the World Bank approved RAP for the sub-project to the DSM

Consultant and Contractor. The DSM Consultant and Contractor shall adhere to these relevant provisions contained in the RAP.

1.1.3 Training

In order to help improve the understanding and appreciation of the required standard of quality for road improvement and environmental management works, Road Construction and Environmental Management training and accreditation is required for Contractor's Field Supervisors.

LGED shall arrange a Specialist to conduct the Training Workshop on Road Construction and Environmental Management at the commencement of the implementation of works programme. The workshop shall focus on the relevant improvement works and good construction practices and techniques to be employed in the RTIP, including best operating practices on earth works, vegetation management, pavement construction, bridge construction, construction equipment and environmental management, monitoring and reporting. Periodic training to the Environmental Field Supervisors of the Contractor and DSM Consultant shall also be undertaken during construction stage to ensure effective compliance, supervision and monitoring.

Responsibilities

LGED shall organise and convene a 2-3 day "Road Construction and Environmental Management Training Workshop" at least 1 month prior to the commencement of the implementation of works programme. The DSM Consultant shall conduct the Workshop.

The Contractor shall ensure that his/her Site Manager and Field Supervisors attend the "Road Construction and Environmental Management Training, Workshop" and receive accreditation before commencing work at the site.

The DSM Consultant shall also ensure that all his/her field staff attend the Training Workshops prior to commencing site duties.

The Senior Environment Personnel of the Contractor and DSM Consultant shall organise periodic training programmes for the field supervisors at the work site.

1.1.4 Worksite Survey, Pegging and Approval

The proposed road widening and ancillary sites shall be surveyed and pegged prior to any construction or related activities to ensure the correct setting out of the lines and levels of formations, side slopes, drainage works, carriageway and shoulders in accordance with the detailed road designs and permits/approvals obtained from the Engineer.

This allows previously unnoticed design and environmental issues to be recognized prior to construction, and either avoided or mitigated. It also allows the final verification of affected persons and assets, to be undertaken prior to the commencement of the road improvement works.

The pegging of the road formation areas and ancillary sites enables works to be confined to the minimum area required, reducing the area of disturbance and loss of productive resources. Construction workers can clearly see the proposed extent of work and confine their activities to those areas and landowners/land users can recover or harvest resources prior to commencement of works at the site.

Responsibilities

The Contractor shall survey at least 1000m of the sub-project corridor and peg the road centre-line and extent of all works prior to the commencement of road improvement. The LGED authorised engineer, DSM Consultant and Contractor shall then jointly inspect the surveyed alignment and road formation width area. The Contractor shall continue to survey and peg at least 1000m of the road in front of the furthest extent of road improvement work underway. But box cutting will be extended only upto 500 m to avoid damaging existing road bed and to avoid difficulty in traffic movement.

The Contractor shall locate and peg each ancillary site prior to the commencement of any ancillary site activities (including fill disposal sites, borrow pits, brickfields / brick-breaking yards, stockpile site, workforce camps and material storage areas). Sites shall be located in accordance with the following

criteria:

- No ancillary site shall be located within 100m of an identified archaeological, religious or cultural site
- Ancillary sites shall be above flood level and at least 10m away from watercourses
- Borrowpits, workforce camps, material storage areas shall be sited as per the relevant contract specifications

Ancillary site areas shall be kept to a minimum to reduce the area of vegetation clearance and ground disturbance. The Contractor shall seek approval to commence work at each ancillary site from the Engineer / DSM Consultant prior to commencing any related activities.

Note: All requirements to survey, peg and seek approval for proposed road works relate to the initial 1000m of the road or the minimum 100m of road in front of road improvement at any one point in time, not the entire contract length of road. But box cutting will be extended only upto 500m.

1.1.5 Construction Machinery and Vehicles

All the construction machinery and vehicles to be used for road improvement and ancillary works shall be of proven efficiency and shall conform to GOB standards for emissions and noise levels. All the construction machinery and vehicles shall be operated and maintained at all times so as to conform to GOB standards for emissions and noise levels, as compiled in Appendix I for easy reference.

Responsibilities

The Contractors shall be required to give a trial run of its machinery and vehicles for ascertaining that their emissions and noise levels conform to the standards stipulated by the GoB. The Contractor shall regularly maintain the construction machinery and vehicles so that emissions, vibrations and noise levels conform to GoB's relevant standards.

The Engineer / DSM Consultant shall ensure that the Contractor adheres to these requirements throughout the construction period.

1.2 CONSTRUCTION STAGE

"Mainstreaming" of environmental concerns and mitigating actions has been an important consideration in the design and implementation of the RTIP. Accordingly, consideration of environmental issues as an integral part of the planning and design of the sub-project to avoid unnecessary problems or impacts has been the guiding principle in development of the EMP.

"Mainstreaming recognizes that the most efficient and cost effective way to ensure that improvement works are environmentally sound is to include these requirements in the construction contract provisions. The RTIP will include provisions to establish the scope and conditions under which the work is to proceed and ensure financial sanctions for non-compliance, if any. Re-vegetation survival, for example, must be checked and found adequate before Contractors are fully compensated for plantings."

The RTIP feeder road improvement sub-projects will generally be implemented as per the LGED's Standard Contract Specifications for Feeder Roads and Structures incorporating these Environmental Specifications. Provisions for the protection of the environment are included in this document that includes clauses particularly in provision of specific mitigation and enhancement works related to the RTIP feeder roads improvement works. The recommended additional environmental specifications based on the EMP recommendations are provided in this section.

Road improvement (construction) methods largely dictate the degree of direct environmental impacts that will result from the execution of the road improvement works. The key principles that have to be adhered to are: limiting the area of disturbance and land-take, sequencing construction activities to save the double handling of materials, and progressively re-vegetating the completed batters.

1.2.1 Vegetation Clearance

Vegetation clearance shall be confined to the minimum area required for improvement activities within

the proposed formation width in order to limit the loss of productive resources, limit damage to surrounding features and limit ground disturbance and the associated erosion hazard. This shall be achieved by clearly marking out the extent of the proposed clearing and ensuring that clearing is only undertaken within these areas. Trees within the boundaries of ancillary sites shall be retained wherever possible.

The pits resulting from uprooting of trees and stumps shall be backfilled and compacted to prevent soil erosion and sedimentation. Trunks, branches, stumps of trees, boulders, stone, brick bats and other materials resulting from road improvement activities shall be stocked/disposed in such a manner that these do not find its way to nearby watercourse. Stocked materials should be used where possible, (i) for filling up of existing pits along the road (ii) for roadway embankment, and (iii) for landscaping of the road side in accordance with the Specifications Clause or as directed by the Engineer.

Responsibilities

Before commencing operations, the Contractor shall submit his Work Plan to the Engineer / DSM Consultant for approval. This shall include the procedure to be followed for disposal of cleared vegetation and waste materials in accordance with the instructions of the Engineer. The Contractor shall clearly mark out the extent of clearing with pegs at 50-m intervals or less as per the Engineer's instructions. The Contractor shall stay strictly within the approved work site areas. The Contractor shall identify individual trees within the extent of clearing that shall be retained, and flag mark them. The Contractor shall seek approval for vegetation clearance from the Engineer / DSM Consultant at least 1 week prior to the intended commencement date.

The Contractor shall instruct all construction workers to restrict clearing to the marked areas and not to harvest any firewood for personal consumption or sale.

The Contractor shall ensure that all clearing is undertaken manually within the extent of approved sites only. Vegetation clearance along each section of the alignment shall only be undertaken within 1 week prior to the associated road construction activities in order to minimize the period of erosion hazard created by ground disturbance and the removal of vegetative cover.

Where possible, the Contractor shall stockpile cleared shrub foliage within the RoW for later use as a brush layer for better re-vegetation. The Contractor shall stack/dispose of the trunks, branches and stumps etc. at appropriate locations approved by the Engineer/ DSM Consultant in such a manner that these do not find its way to nearby watercourses

The Contractor shall protect all remaining vegetation within the road, extent of works and at ancillary sites by ensuring that:

- No spoil or topsoil is removed or added to the base of remaining trees;
- No harmful materials are placed adjacent to the remaining vegetation;
- No vegetation is harvested by construction workers for their personal use or sale.

1.2.2 Retaining Wall / Toe Wall Construction

Retaining walls or Toe wall as per site conditions shall be constructed or strengthened where the road formation is required to be extended towards an abutting pond / waterbody. This will prevent potential erosion of the road embankment as well as limit the potential siltation of the pond.

All preventive measures such as temporary installation of silt fencing shall be undertaken to control potential siltation of the ponds during retaining wall construction and / or embankment widening.

Responsibilities

The Contractor shall survey and peg all retaining walls / toe walls sites as per the detailed designs prior to any formation widening along a pond / waterbody ensuring that they are correctly sited horizontally to minimize the land-take, erosion and sedimentation. The Engineer, DSM Consultant and Contractor shall then jointly inspect all pegged retaining wall sites.

The Contractor shall construct retaining walls before earthwork for extension of the road formation towards an abutting pond / waterbody. The Contractor shall do all preventive measures such as temporary installation of silt fencing or similar equally effective measures to control potential siltation of the ponds during retaining wall construction and / or embankment widening. Earth filling in front of the wall shall only be commenced once the Engineer / DSM Consultant has certified the retaining wall.

1.2.3 Formation Widening

Road embankments are often not adequately compacted. This unstable feature results in slope failures, especially on high embankments near bridge approaches or running along rivers, and erosion, off-site sedimentation, road closure and high maintenance costs.

All fill works shall be strictly constructed to design specifications to ensure that correct batter slopes, road widths and soil compaction is achieved. This shall be accomplished by fully surveying and pegging roadwork prior to construction, and strictly inspecting and certifying them against the detailed designs following construction.

While planning or executing embankment widening all adequate precautions against soil erosion and water pollution shall be taken and adequate drainage measures shall be installed where required in accordance with the Engineer's instructions.

All necessary actions shall be taken to ensure embankment stabilization, including the selection of less erodable material, use of mulch (straw with cow dung), re-vegetation with grazing-resistant plant species (turfing with jute netting or coir netting), sand gunny bag riprap, brick mattressing, Cement concrete block riprap, loose stone riprap (in hilly areas), rock gabions or other appropriate technologies and employing sound construction methods, particularly around bridges and culverts and along ponds/tanks/rivers/canals.

The earthen shoulders and batter slopes of road embankments shall be seeded with a fast growing native seed-mix immediately after fill placement to prevent scour and to expedite stabilization. Where appropriate, grass sods shall be placed in the form of tiles in accordance with the Engineer's instructions. Berms and embankment slopes and road cuts shall be stabilised by mulching (straw with cow dung), re-vegetation with grazing-resistant plant species (turfing with jute netting or coir netting) sand gunny bag riprap, brick mattressing, Cement concrete block riprap, loose stone riprap (in hilly areas), rock gabions or other appropriate technologies. Installation of drainage structures and raising of the road formation level may create bare slopes that shall be stabilised before the onset of the monsoon. Discharge zones from drainage structures shall be furnished with riprap to reduce erosion. Down drains/chutes will be lined with riprap & masonry or concrete to prevent erosion. Construction in erosion and flood prone areas will be restricted to the dry season.

Batter re-vegetation shall be undertaken in two phases:

1. Cover crop establishment and hand broadcasting seed shall be undertaken immediately following certification of each batter slope and prior to the monsoon.
2. Long-term vegetation establishment shall be undertaken during the optimum plant establishment season/s by the LCS or Union Parishad under an agreement with the LGED as per the Tree Plantation Strategy of the Local Government.

The establishment of ground cover is the initial priority of re-vegetation. Ground cover reduces raindrop impact, binds the soil surface and creates a micro-climate favorable for the establishment of other vegetation.

The establishment of long-term vegetative cover requires the adequate follow-up maintenance, including replanting for at least 2 years.

Vegetation maintenance is essential to the success of batter re-vegetation and protection of the vegetation from grazing shall also be implemented.

The batter shall have a topsoil cover spread on it. If no topsoil is available from road work sites, some oil preparation is required such as fertilising or organic mulch from cow dung manure.

A mulch layer shall be placed on the batter. This would ideally be brush matting (small tree branches and foliage, shrubs), as it has sufficient weight to hold itself in place. The revegetated batter shall be fenced off to prevent disturbance to establishing plants by grazing. Brush fencing, made of thorny lushes, or a bamboo woven fence shall be used for this purpose.

1.2.4 Stabilizing Batter Slopes

In the case of stabilizing road batter slopes, there are two essential procedures, which need to be undertaken prior to re-vegetation:

1. Ensure bulk stability of the slope, if necessary, and cut the slope back to a stable grade. If the slope is currently at 1:1.5, and has been established for some time, and is not sliding or slumping, this tends to indicate that the slope will stand up at this grade, therefore it is acceptable.
2. Control run-on drainage from the slope above such as by constructing a catch drain to collect run-on above the batter and divert it to a stable location or drainage line if sufficient room exists and the above hill slope is not excessively steep. This could take the form of a vegetated catch drain such as a concave drain about 1 m wide at the crest and vegetated. Ideally this is located close to the crest of the batter, and on a grade of 1 % or so.

Construction activities shall be planned to minimize the area of vegetation cleared at any time and exposed earth shall be turfed or covered as soon as possible after disturbance. The construction area shall be pegged out to ensure that the disturbance is limited.

The Contractor shall survey and peg the crest of all cut batters and the toe of all earth embankments prior to any related excavation. The Engineer, DSM Consultant and Contractor shall then jointly inspect all pegged banks.

The Contractor shall bench the natural surface foundation of earth embankments prior to filling to enable the keying in and compaction of earth in accordance with the Engineer's Instructions. Filling shall then occur as per the technical specification, with each layer compacted with a small mechanical compactor or hand held tamper before the next layer is applied.

The Contractor shall take all adequate measures against soil erosion, sedimentation, water pollution etc. through use of berms, dikes, sediment basin, fibre mats, mulches, grasses, slope drains and other devices, as appropriate.

1.2.5 Drainage

Adequate and stable crossroad and road surface drainage is essential to ensure that storm runoff across the project roads causes minimal or no damage to the road and down slope features. Crossroad drainage shall be improved by bridges and culverts (see Table of the Sample Case Study). Road surface drainage shall be provided by cross-fall drains and lined side drains to direct runoff off the road surface, as directed by the Engineer.

All additional proposed drainage structures shall be installed before the road improvement works to ensure that the potential erosion problem created by embankment widening through drainage lines is minimized.

Responsibilities

The Contractor shall survey and peg all additional designed drainage structures prior to the commencement of construction. Wherever possible, drains shall outlet into stable drainage lines. Where this is not possible, the Contractor shall consult with adjoining down slope landowners on mutually acceptable locations for drain outlets.

The Engineer / DSM Consultant and Contractor shall then jointly inspect all pegged drainage structures.

The Contractor shall construct all designed drainage structures prior to, during or immediately

following road improvement works in order to minimize potential erosion problems

1.2.6 Topsoil Saving and Re-use

Topsoil is a valuable resource for the re-vegetation of cut and fill batters. Accordingly, it shall be saved from all RoW sites and ancillary sites that will be disturbed during road improvement. Topsoil shall be stripped from each site prior to any associated filling or sub-surface excavation. It shall be saved by stockpiling it at designated locations for reuse in covering embankment slopes, cut slopes, berms and other disturbed areas where the need for re-vegetation is identified.

The method for saving topsoil embankment requires stripping of the section to be excavated and re-spreading immediately onto the previously completed adjacent section of road. This has the advantages of only single handling the material and using topsoil when it is fresh, when soil fertility and seed viability have not been reduced by stockpiling.

If topsoil is to be stockpiled it shall only be done above the excavation site to avoid mixing it with excavated sub-soil.

Topsoil shall only be spread on batters with a grade of 1:1.5 or flatter. Topsoil spread on steeper batters will not stay in place.

The Contractor shall save all available topsoil from construction sites within the ROW and re-use this material on completed road formation batters approved by the Engineer / DSM Consultant. Topsoiling of a batter shall not occur until the Engineer / DSM Consultant has approved the completed batter.

The Contractor shall also strip and stockpile topsoil from all temporarily acquired ancillary site areas that are to be disturbed for subsequent re-use in rehabilitation of these sites.

Stockpiled topsoil shall be kept separate from other materials.

The Contractor shall sow a cover crop on each topsoiled batter within 2 days of Topsoiling

1.2.7 Disposal of Unsuitable Excess Materials /Spoil

Cut and fill equalization is constrained by the geometry of the existing road, as this is an improvement / upgrading project. Except in the case of soils with high organic material (peat) contents, or black cotton soil or mug sections earthworks are typically cut to fill, with the excess material cut to spoil. The excavated top layer of pavement including HBB / scarified black tops shall be utilized as fill in widening of the project road. Unsuitable materials shall be disposed of properly. This material could also be used for improvement of access roads to ancillary sites (e.g. borrow areas, brickfields, break crushing yards, workforce camps).

The disposal of spoil at low impact sites shall be undertaken to minimise damage to environmental and social features in accordance with the instructions of the Engineer. Spoil shall generally not be sidecast over the edge of the excavation or placed in small drainage lines, above houses or at other sites where it is likely to cause damage to natural features or structures.

Responsibilities

The Contractor shall identify and peg out permissible spoil disposal locations. Permissible spoil disposal locations may include:

- Roadway embankment;
- Existing pits in the ROW;
- Building sites;
- Erosion gullies to be rehabilitated.

The Contractor shall seek approval from the Engineer / DSM Consultant for the use of these sites prior to commencement of works. Where permissible sites are not available within 300 m of the excavation site, the disposal of fill will be at the discretion of the DSM Consultant, but shall not be undertaken on private land.

The DSM Consultant shall inspect and approve all correctly located disposal sites.

The Contractor shall instruct the construction workforce of the approved locations for fill disposal and shall strictly supervise the correct placement of fill at these locations.

Note: the Contractor shall construct all road works in accordance with the detailed designs. Constructed works, which do not strictly follow approved designs, shall not be certified for payment.

1.2.8 Reinstatement of Services

Local services, including tubewells, drains, cables, irrigation channels, drainage ditches and trails, are Commonly cut during road earthworks. These services are required by local people for crop production, drinking water and access and have the potential to damage road works. These services are often either inadequately reconnected or not reinstated at all.

All irrigation tubewells, channels, drainage ditches and walking trails shall be maintained during improvement works or, if necessary, temporary services shall be arranged or the owner/user's permission for temporary cessation shall be gained. Services shall be progressively reinstated as soon as road improvement works has been completed in the vicinity.

Responsibilities

The Engineer / DSM Consultant, accompanied by the Contractor, shall inventory all services to be reinstated during Pre-construction Inspection.

The Contractor shall liaise and reach agreement with affected landowners, local authorities, public undertakings and local people regarding which services must be maintained, which services can be temporarily cut, the timing of cuts and reinstatements, and the location of reinstated services. The Contractor shall obtain written permission from affected people to temporarily cease any services.

As agreed the Contractor shall maintain or provide temporary services during construction. The Contractor shall make temporary provision for water supply and irrigation and drainage channels interrupted by road widening. The Contractor shall progressively reinstate all interrupted services immediately following earthwork completion, ensuring that reinstated or repaired services operate to their previous capacity.

The Engineer / DSM Consultant shall inspect and certify the adequate reinstatement of all previously inventoried services to be reinstated.

1.2.9 Borrow Pits

The right to create borrow pits is generally negotiated between the contractor and individual landowners. Farmers often sell topsoil for fill materials on assumption that the topsoil will be replenished during the next flood. The contractor should preferably obtain earth from sites at proposed / potential fish ponds or alternatively they should minimize the loss of valuable agriculture land by removing a thin layer of soil from a wide area. If the fill materials are taken from farm topsoil or upper layer, the contractor should ascertain that the silt deposition is sufficient to rehabilitate the farmland within three years and the deposited soil is not at the expense of the fertility of adjacent properties. Farmland should be given the lowest priority in sourcing the fill materials. Farmland should be used only if there is no other alternative within 5 km of the construction site. The use of dredged materials from rivers should be given priority especially if the materials are sandy and relatively free from organic materials compared to farmland topsoil. Organic materials will decay and reduce the stability of the road. The second preferred source of fill materials is excavation from pond construction. If the borrow pit is not used for aquaculture, the side of the pit must be compacted to prevent soil erosion and native fish and other aquatic life introduced to control insects such as mosquitoes.

Responsibilities

The Contractor in consultation with the community and landowners shall identify Borrow pits outside the road reserve. A borrow area management (development and rehabilitation) plan should then be prepared. The plan shall be approved by the Engineer before commencing work. Before opening

additional borrow pits, operating pits shall be closed by the Contractor as per the agreed rehabilitation plan. The following principles for location, depth and drainage of borrow pits shall be followed:

- earth for the embankment should be obtained:
 - from barren land or land without tree cover outside the road reserve;
 - by excavating land and creating new water tanks/ponds;
 - from land acquired temporarily outside the road reserve;
 - from excavation of proposed culverts;
 - from river bed
- Borrow pits shall be rectangular in shape with one side parallel to the centre line of the road and generally maintain the form of the land;
- No borrow pits shall be dug within 5 m of the toe of the final section of the road embankment;
- Borrow pits shall be dug continuously. Ridges of not less than 8m width shall be left at intervals not exceeding 300m and small drains should be cut through the ridges to facilitate drainage;
- To ensure efficient drainage, the bed level of the borrow pits shall, as far as possible, slope down progressively towards the nearest cross drain, if any, and shall not be lower than the bed of the cross-drain;
- When it becomes necessary to borrow earth from temporarily acquired cultivable lands, the depth of borrow pits shall not exceed 45 cm. The topsoil to a depth of 15 cm shall be stripped and stockpiled for later rehabilitation of the pit. Thereafter, soil may be dug out to a further depth not exceeding 30 cm and used in forming the embankment. Once the borrow pit is no longer required, the stockpiled top soil shall then be spread back on the land;
- Borrow pits shall not be located within 500m of any identified archaeological, religious or cultural sites.
- Haulage of material to embankments, or other areas of fill, shall proceed only after sufficient spreading and compaction plant is operating at the place of deposition;
- Recommended mitigation measures for rehabilitation and restoration of borrow areas are:
 - if used for agriculture, stockpiled topsoil should be returned to the borrow pit;
 - if used as a fish pond, the banks should be stabilised by compaction and any additional excavated material disposed of in accordance with good operating practice
 - for all other uses, stockpiled topsoil should be returned to the borrow pit and all worked areas stabilized through revegetation using local plants.
- Sediment shall be controlled at each site by ensuring that the base of the borrow pit drains into a sediment trap prior to discharging from the site.

After obtaining approval from the Engineer, the Contractor shall locate and peg out the full extent of proposed extraction areas prior to the use of a borrow area. For location, depth and drainage of borrow pit, the principle criteria mentioned above shall be followed by the Contractor. Once borrow pit sites have been determined they will be inspected by the DSMC.

The borrow areas shall be rehabilitated as per the provisions of the approved rehabilitation plan.

Borrow pits may be converted to fishponds or multipurpose ponds for community use. The dimension of the pond should be 1000 m² X 2 m depth.

Bathing Ghat may be constructed for the community ponds as per design and direction of the Engineer and in consultation with the local community. In some cases road improvement may disrupt existing Bathing Ghats and new Ghats should be constructed. Construction of Bathing Ghats may be considered also to protect slope protection works; otherwise movement of people may destroy the protective works.

1.2.10 Stockpiling

The stockpiling of bricks, topsoil, sub-soil and other materials will be required during road improvement works. These materials shall be stockpiled to prevent damage to local features, which can be caused by diverting runoff and creating sedimentation.

Stockpiled materials shall be stored on non-hazardous sites, away from both habitation and drainage lines to minimize off-site sedimentation and protect off-site features.

Stockpiling of backfilling materials shall not be allowed within the right of way especially on the side slopes of the roads. There is a common tendering of contractors to stockpile backfilling materials on the batter slope and utilize these materials without compacting them in layers. This practice shall be stopped completely.

Responsibilities

The Contractor shall locate and peg stockpile sites in accordance with the following criteria:

- At least 10m away from drainage lines and out of flood level;
- On land with less than a 10° slope;
- On sites already clear of trees and shrubs;
- Not above any structure;
- Further than 2m away from vegetation to be retained.

If stockpiling is planned on private land, the Contractor shall obtain written permission from the landowner for use of the site. The Contractor shall seek approval from the Engineer / DSM Consultant for the location of stockpile sites prior to commencing the related extraction operations. The Engineer / DSM Consultant shall inspect and approve all correctly located sites.

The stockpiling of fill material shall not be permitted during the monsoon season unless it is appropriately covered. Where topsoil is to be stockpiled for longer than one month the stockpile shall be seeded with an appropriate cover crop.

1.2.11 Workforce Camps

Workforce camps are temporarily required during the period of construction. Only one camp will generally be required along each 5 - 10 km length of the project road or at a major bridge site. Camps shall be located on low impact sites where temporary damage to local resources is minimized.

Sufficient measures shall be taken to ensure provision of drinking water, garbage bins and sanitation facilities in the construction camps; All practical measures such as provision of septic tanks and soakage pits shall be made to prevent the wastewater produced in the 'construction camps from entering rivers and irrigation system. Vehicle maintenance and refueling shall be confined to areas in construction camps designed to trap discarded lubricants and fuel spills. Separate drains to carry runoff from contaminated area/servicing ramp leading to oil traps shall be provided. Regular health check-up and medical facilities shall be provided to the workforce.

Responsibilities

The Contractor shall locate and peg workforce campsites in accordance with the following criteria:

- Above flood level and at least 10m from any drainage line;
- Preferably on degraded land of low production value;
- On cleared land requiring no or minor vegetation clearance

- Not immediately upstream of local drinking water off-takes;
- Only one camp site per sub-project or every 5 - 7 km length of alignment.

The Contractor shall seek approval for the use of the campsite from the Engineer / DSM Consultant. The Engineer / DSM Consultant shall inspect and approve all correctly located campsites. The contractor shall also obtain approval of the layout of the camp from the supervision Consultant.

The Contractor shall ensure that proper drinking water as well as sewage and waste disposal facilities are provided and maintained. In water deficient areas, the Contractor shall provide drinking water from outside the area. Solid waste generated at the camp shall be recycled or disposed of as directed by the Engineer / DSM Consultant. The Contractor shall undertake all precautions for proper management of solid and liquid wastes generated in the workforce camps. Appropriate facilities shall be provided for women, where they are employed under contract.

The Contractor shall provide regular health check-ups including HIV tests and medical facilities to the workforce. The Contractor, in association with voluntary organizations shall organize AIDS awareness programmes at the workforce camps.

1.2.12 Workforce Management

Workers will generally live in temporary workforce camps in close proximity to the road works and numerous local communities.

Workers shall act in a responsible manner during and after working hours, respecting the rights, property and practices of local people.

Responsibilities

The Contractor shall liaise with affected communities regarding proposed construction activities. The Contractor shall ensure that workers act in a responsible manner towards local people and do not harvest or take personal resources.

The Contractor shall ensure that workers do not fell or cut trees or other vegetation for fuel wood or any other purpose.

The Contractor shall ensure that no wood is burnt by any workers on or off site by providing kerosene to workers for all cooking needs.

Working hours within village areas shall not extend beyond 7.00 a.m. - 9.00 p.m. to ensure that local people are not unduly disturbed.

The incidence of child labour shall be monitored in consultation with local communities and officials to prevent exploitation.

1.2.13 Dust Nuisance and Noise Pollution

In order to suppress dust generation, water shall be sprayed on road surfaces, excavation sites, sand and earth mixing sites, asphalt mixing sites, and on temporary roads. After compacting, water spraying shall be done at regular intervals to prevent dust nuisance. Brick crushing yards, bituminous hot mix plants and concrete batching plants shall be located sufficiently away from habitation (at least 1/2 km), Vehicles delivering materials shall be covered to reduce spills.

Vehicles and machinery shall be regularly maintained and fitted with pollution control devices to keep emission and noise levels at a minimum. Construction would be stopped between 9.00 p.m. and 6.00 a.m. in the residential areas and the public shall be informed about the regulations of noise pollution. Workers in the vicinity of strong noise shall wear earplugs and their working time shall be limited.

Responsibilities

The Contractor shall ensure that construction activities do not generate unacceptably high levels of dust emission and noise. The Contractor shall keep the local people fully informed of construction activities including blasting operations. The Contractor shall also control air and noise pollution by prohibiting construction activities between 9.00 p.m.- 6.00 a.m.; maintaining vehicles and construction machinery regularly; and prohibiting the use of air horns on construction vehicles in settlement areas.

The Contractor shall take every precaution to reduce the levels of noise, vibration, dust and emissions from the plant, machinery and vehicles and shall be fully responsible for meeting GOB's relevant regulations (See Appendix I of the EMP).

The contractor shall spray water at regular intervals as directed by the Engineer / DSM Consultant.

The Contractor shall seek prior approval from the Engineer / DSM Consultant for locating and operating machinery and vehicles on site.

BASIS FOR PAYMENTS

The payments for dust suppression measures shall be made on the basis of per km of the project road on completion and certification of each section of the completed road improvement works to the entire satisfaction of the Engineer and DSM Consultants.

Pay Item shall be:

Description	Unit
Taking dust control and other Pollution control measures as per environmental requirement.	Per Km

1.2.14 Soil Erosion and Sedimentation Control

Construction activities would be planned so as to minimize the area of vegetation cleared at any time and exposed earth will be turfed or covered as soon as possible after disturbance. Clearance of vegetation on steep slopes shall not be undertaken during the monsoon period.

Borrow pits have potential to be areas of high erosion unless works are controlled and appropriate measures for rehabilitation are undertaken. The locations and operations of borrow pits shall be as per the sub-clause 5.2.9. Potential borrow areas and brick crushing sites shall be identified by the DSM Consultant during Design stage. All the Borrowpit sites after use, shall be rehabilitated / re-vegetated appropriately to prevent potential land degradation.

Responsibilities

Prior to the start of construction, the Contractor shall obtain approval from the Engineer / DSM Consultant for his plan of carrying out temporary and permanent erosion / sedimentation control works applicable for the items of clearing, embankment widening, construction of bridges and other structures across watercourses, pavement courses and shoulders. He shall also submit for approval his proposed methods of erosion / sedimentation control at borrow pits and brick crushing sites and his plan for disposal of waste material. Work shall not be started until the erosion/sedimentation control schedules and methods of operations has been approved by the Engineer / DSM Consultant.

The Contractor shall be required to incorporate all temporary / permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sediment control measures. The Contractor shall rehabilitate all the brickfield / brick crushing sites and Borrowpits sites after use as per the EMP recommendations or directions of the Engineer / DSM Consultant.

1.2.15 Wetland / Ponds / Rivers / Canal

The potential adverse impacts on water resources during proposed road improvement works will predominantly be from erosion and sedimentation resulting from the exposed earth and stock piled areas near water crossings; affect on portion of water bodies (ponds and tanks) due to their partial filling and siltation as well as interrupting access to users; contamination from fuel, lubricants, tar,; and improper sanitation and waste disposal.

Adequate mitigation measures shall be undertaken to limit the impact on the water resources. Earth moving in the vicinity of watercourses will be kept to a minimum to avoid sedimentation and contamination from fuel and lubricants. Proper disposal of bricks, cement and steel reinforcement which will be removed as part of the reconstruction of bridges/culverts will be ensured so as not to block the stream flow. Temporary erosion and sedimentation control measures during rehabilitation of cross-drainage structures will be undertaken to ensure that sediment laden run off does not enter the adjoining watercourses. Prior to commencement of the construction, ditches or diversion channels will be formed, where necessary, around the disturbed areas.

The specific mitigation measures to minimize / mitigate -impacts on water bodies / ponds to be undertaken are described below:

Mitigation Measures for Environmental Impacts on Water Resources

Impacts	Mitigation
Partial filling of ponds /water bodies	Standing water bodies, which are affected by more than 25% of its capacity, will be mitigated by providing an equivalent capacity by either deepening or extending on the other side of the water body. If the surrounding land-use does not permit extension of the existing water body; compensatory water restoration areas will be identified within the vicinity of the settlement
Erosion and Siltation	Construction materials will be stacked together, fenced by brick or earth walls and kept away from water bodies and drainage lines. Construction/rehabilitation works of cross-drainage structures will be undertaken during dry seasons only. On sections with high filling or deep cutting, slopes will be covered by stone pitching and / or planted with grass etc.
Contamination from fuel and lubricants	Vehicle maintenance and refilling would be confined to areas in construction camps designed to trap discarded lubricants and fuel spills.
Contamination from wastes	Workforce camps will be located away from water resources All practical measures such as provision of septic tanks, garbage bins, and other sanitation facilities will be taken in the construction camps to prevent the wastewater and solid wastes from entering rivers/ponds/ irrigation system.
Interrupting access to water supply	All open wells / tube wells/ hand pumps affected will be replaced or relocated
Use of water for construction works	The construction contract specifications, will clearly state that water from standing water bodies used for construction activities by the contractor will be paid for by the contractor at a price agreed to by the owner of the water body or as per the Water Access ACT, 1978) to the Village Panchayat/ Urban local body.

The exact chainage, location and proposed mitigation/enhancement measures for the potentially affected water bodies (ponds/ tanks) are presented in Annexure 2.1 of the EMP document.

Responsibilities

The Contractor shall be responsible for undertaking all mitigation measures described in EMAP Table-3.1 in the EMP, under supervision of the Engineer / DSM Consultant. The rehabilitation of affected

ponds/tanks shall be carried out in accordance with the details given in Table 3.1 of the EMP. The Contractor will also submit its proposed Environmental Management Plan for the workforce camps including the provision for water supply, sanitation, health, waste disposal, fuel for cooking etc. to the Engineer / DSM Consultant for approval. The Contractor would be responsible for all the activity and operations within the workforce camps meeting the relevant provisions of the Bangladesh Environment Conservation Act, 1995 as well as local labour laws as stipulated by the Government of Bangladesh.

1.2.16 Hazards and Hazardous Materials

The mishandling and incorrect storage of combustible and toxic materials such as petrol, diesel, oil and lubricants can lead to explosions, spills and leaks which pose a safety hazard to workers and may cause soil and water contamination.

The Contractor will comply with the provisions of the Bangladesh Environment Conservation Act, 1995 as well as the Rules made there under with regard to transport, use and storage of hazardous and explosive substances.

Responsibilities

The Contractor shall safely handle and store hazardous materials in accordance with the following requirements:

Hazardous materials shall be stored above flood level and at least 20 m from any watercourse;

Hazardous liquid substances (e.g. petrol, diesel, oils) shall be stored on top of sealed plastic sheets in a secure, flat enclosed area. Bund walls shall be at least 25 cm high.

The Contractor shall have an emergency procedure and will seek directions from the DSM Consultant regarding the disposal of hazardous materials. Used lubricants and oils shall be collected and disposed of or recycled without causing pollution or a hazard to worker safety. Spills of hazardous materials within or outside enclosed storage areas shall be cleaned up immediately. Contaminated and torn or worn plastic-sheets shall be disposed of appropriately.

1.2.17 Grassing / Turfing

Grassing and turfing of all disturbed areas shall be undertaken as per Clause 2.16 under Specifications for Road Works.

1.2.18 Construction of Bathing Ghats

Bathing ghat may be constructed for the community ponds as per the design and direction of the Engineer and in consultation with the local community. As in some cases road improvement works may disrupt existing bathing ghats, new ghats should be constructed to provide the same facility. Construction of bathing ghats may be considered also to protect slope protection works; otherwise movement of people may destroy the protective works. The bathing ghat should include provision of sitting arrangement for users.

1.2.19 Maintenance and Protection of Traffic

The Contractor should bear the full technical and statutory responsibility in maintaining the public and vehicular access along the project right of way. The Contractor shall conduct his operations as to offer the least possible obstruction and inconvenience to the public.

At least 30 days before commencing work on any section of the road, ghat /market, the Contractor shall submit to the Engineer his proposals for the maintenance of traffic including working drawings of traffic arrangements, showing all detours, temporary roads, temporary market sheds, temporary bridges, necessary barricades, warning lights, road signs, etc.

The Contractor shall control the passage of traffic in one-way operation either manually by posting flagmen or using signals.

The Contractor shall be responsible for providing all the required barricades, flags, lamps, flagmen, etc. and for passage of public traffic on the road / ghat / market area under the contract without undue inconvenience.

1.2.20 Environmental Monitoring

The purpose of the environmental monitoring is to ensure that the EMF is implemented on a timely and effective manner and to ensure that envisaged purpose of the project are achieved and result in desired benefits to the targeted population without adversely affecting environmental resources. To ensure the effective implementation of the EMF, it is essential that an effective monitoring system be designed and carried out. During the construction phase it will be necessary to monitor and document different construction related activities that may adversely affect the environmental resources of the area or health and safety of the population and the wild life of the area.

Responsibilities

The Contractor shall keep updated record of “Temporary Acquisition of Land”, Borrow Areas Identification”, “Site Identification and Setting up of Workers’ Camp, Hot Mix Plant”, “Summary Mitigation and Enhancement”, “Redevelopment of Borrow Areas” and “Restoration of Construction Sites”. The Contractor will use prescribed Forms (R1 – R6) presented in the “Manual for Environmental Supervision and Monitoring” to keep information on above environmental parameters and will also keep photographs of different stages of development and implementation of mitigation measures.

1.2.21 Barrel Composting for solid waste management in Growth Center Markets

Barrel composting for solid waste management can be the best option of the solid waste management in GCMs of RTIP. Barrel composting is a composting technique involving aerobic digestion of organic wastes and therefore is almost free from bad smell. It is income generative and solves the solid waste management problem at the source level. It recognizes the potentiality of resource recovery from bulk volume of organic wastes and provides opportunities for income for the poor who are interested in such income generative activities.

Model barrel composting technique involves the following steps:

A 200 litter of barrel, which is made perforated enough to allow airflow in the barrel. The barrel with a lid is placed on a raised base with concrete ring. Wastes are separated into organic and inorganic; and organic portion of wastes is dumped into this perforated barrel and the inorganic portion of wastes is kept in a separate pot for ultimate disposal. In a barrel, under aerobic condition, which is maintained by the natural flow of air, the organic waste decomposes into compost in three months. It has been found that this compost has a good quality (nitrogen 1.3%, Phosphorous 0.62%, Potassium 0.8%, pH 7.5).

Due to bulk volume of organic wastes generated in a typical growth center several barrels may be required in a GCM. Poor people can be given charge of waste collection, sorting and compost making using this technology.

Once the compost is produced, the marketing of this compost has to be ensured. In the rural areas there is a high demand for compost for use in agricultural lands. Alternatively a strategy can be fixed to ensure the marketing of these compost involving large compost-dealers of the country.

1.3 POST-CONSTRUCTION STAGE

1.3.1 Re-vegetation

The greatest environmental impact associated with the implantation stage of the sub-project will be the clearing of avenue trees within the ROW along the project road. The extent of this impact could have been minimized, to the extent possible, by limiting the proposed widening of the project corridor along either left or right side of the existing carriageway. This would ensure the existing vegetation along one of the sides of the road remains intact. However, the general public opinions in the project area appears not to support this strategy and almost all local people consulted to discuss this issue

recommended both sides widening with re-plantation on the batter slopes. Tree clearing within ROW will be avoided beyond what is required for construction activities and/or reduce accidents.

Disturbed areas shall be re-vegetated following construction activities, with re-vegetation measures to stabilize cut and fill batters. The berms and slopes of road embankments shall be seeded with a fast growing native seed mix immediately after fill placement to prevent scour and expedite stabilization. The planting regime and native seed mix shall be got approved from the Engineer / DSM Consultants.

Vegetation stabilizes batters and other disturbed ground surfaces by providing ground cover to protect against raindrop impact and reduce overland runoff velocities, and binding soil through plant root development.

Batters and disturbed areas shall be progressively stabilized in order to rapidly reduce the erosion hazard of the site. Revegetation shall be undertaken in two stages following construction:

- Cover crop sowing by the Contractor;
- Long-term vegetation establishment by a local LCS under a plantation cum maintenance agreement with the LGED. The LCS approach will ensure that the re-vegetation is carried out during optimum plantation period with continual maintenance over required period and the rate of survival of the trees could be maximized. The option of handing over the ownership to the local community, Union Parishad or adjacent private land owner could also be considered of by the LGED. This would ensure increased local ownership and sustainability of the tree plantation program.

Re-vegetation has been split into these two stages in order to ensure that the cover crop is sown as soon as possible following construction and that the tree plantation is undertaken subsequently for the establishment and maintenance of long-term vegetation.

The establishment of initial ground cover with a cover crop is the first priority of re-vegetation. The cover crop provides some rapid erosion protection and creates a microclimate favourable for the establishment of other vegetation. The establishment of long-term vegetative cover requires adequate follow-up maintenance, including replanting. Vegetation maintenance is essential to the success of better re-vegetation, therefore re-vegetation maintenance will occur for a 3-year period.

Responsibilities

The Contractor shall progressively sow all disturbed construction and ancillary site surfaces with a cover crop mix immediately following the completion and certification of each batter or final use of each ancillary site, including all fill disposal sites.

The Contractor shall progressively implement the immediate re-vegetation works as per the approved Re-vegetation Action Plan on all cuts and fill batters.

The concerned Upazila Engineer / DSM Consultant shall regularly monitor the effectiveness of re-vegetation measures.

The long-term vegetation shall be established by LCS under a separate plantation cum maintenance agreement with the LGED.

1.3.2 Ancillary Site Rehabilitation

All ancillary sites have to be rehabilitated following their temporary use in order to stabilize the sites, ensure that they are non-degraded or non-polluting and return them to their previous condition.

Responsibilities

The Contractor shall ensure that ancillary sites (stockpile sites, brick crushing sites, borrow pits, workforce camps) are fully rehabilitated within 1 month of the final day of use. This shall involve the removal of all structures except, permanent buildings, if any that the landowner may have requested to remain and the Engineer / DSM Consultant has permitted for appropriate use. All refuse, stockpiles and other temporary features shall be removed.

The Contractor shall spread all previously stripped overburden and topsoil across the site, with all topsoil spread evenly on the surface. The Contractor shall provide temporary surface drainage on sites that are prone to erosion prior to re-vegetation. Where possible, the Contractor shall restrict access to these sites by placing fencing to prevent vehicle access. The Contractor shall then re-vegetate the site by hand broadcasting a cover crop and planting appropriate long-term vegetation.

Used borrow areas may be converted into ponds for multipurpose uses by the local villagers / landowner. This will also act as a rainwater harvesting structure to help recharge the ground water of the area (relevant to Barind high lands). However, the rehabilitation options shall be finalized in consultation with the landowner and Union Parishad and shall be approved by the Engineer / DSM Consultant.

1.4 CERTIFICATION OF COMPLETED WORKS FOR PAYMENTS

The correct implementation of environmental protection, mitigation and enhancement measures shall most effectively be achieved by basing contract payments on the actual quantity of works executed, and non-payment for sub-standard executed works. In case of

any conflict between the environmental specifications and other specifications in the contract documents, the Engineer's decision shall be final and binding on the Contractor.

No additional Payments, unless specifically specified, shall be made to the Contractor for complying with the above environmental specifications, as most of the works generally pertains to good construction practices, as part of the road improvement works. Therefore, the costs for these environmental management works shall be considered to have been included in the respective civil (roads and structures) works.

Responsibilities

The Engineer / DSM Consultant shall strictly certify constructed road works against the detailed designs and the EMP conditions/requirements.

1.5 ENVIRONMENTAL MANAGEMENT ACTION PLAN (EMAP)

An outline of EMP termed as Environmental Management Action (EMAP) including the environmental requirements / impacts along with mitigation actions / measures to be taken during the implementation of the subproject has been presented in the EMP Addendum and prepared as part of the Environmental Analyses of the subprojects. A brief description of the environmental problems / issues together with mitigation measures, implementing organizations, location of environmental problems / issues, and timing of implementation of mitigation measures, supervising responsibility etc, are indicated in the Environmental Management Action Plan. For each 'mitigation action / measure described, the implementing organization, supervising entity and the reference to contracts specifications along with an approximate unit cost, where applicable are listed. In general, LGED (with assistance from other agencies in some cases) is the overall responsible entity for ensuring that mitigation measures are carried out. In many cases the Contractor will be the implementing agency under the day to day supervision of the Executive Engineer as the Engineer's Representative, who will be assisted by the DSM Consultant working on behalf of the LGED.

1.6 ENVIRONMENTAL CODES OF PRACTICE (ECP)

The Contractor will follow the Environmental Codes of Practice (ECP), prepared by the Environmental Management Unit of LGED and approved by the World Bank in all phases of construction work. The ECP have been prepared to avoid or mitigate adverse environmental effects that may arise due to road, market and ghat improvement works. The ECP addresses the environmental as well as health and safety issues associated with the RTIP. The ECP will ensure that the World Bank environmental safeguard policy is being followed in implementing different subprojects.

Pay Items shall be:

Clause	Description	Unit of Measurement

Clause	Description	Unit of Measurement
1.2.6	Stripping topsoil from borrowed agricultural lands, stockpiling and replacing the same to rehabilitate the land to the satisfaction of the owner and the Engineer.	km
1.2.9	Developing an existing borrow pit / ditch into a fish pond of 1000 m ² X 2 m depth adjacent to the project road including tree plantation (coconut and / or betel nut at 2 m c/c as per the directions of the Engineer. (The Engineer in consultation with the local community shall finalize Location).	m ³
1.2.11	Campsite waste disposal facilities (one unit for each five kilometer of road).	no.
1.2.11	Providing and maintaining adequate potable water supply and sanitation facilities in camps to the entire satisfaction of the Engineer.	
	A. Water supply tube well (2 tube wells up to 15 km length of road; and 4 tube wells for roads greater than 15 km).	no.
	B. Sanitation facilities (2 sanitary latrines up to 15 km length of road; and 4 sanitary latrines for roads greater than 15 km).	no.
1.2.13	Dust suppression measures including water spraying to the entire satisfaction of the Engineer.	km
1.2.14	Water quality protection measures: Soil erosion and sedimentation control at the construction site to the satisfaction of the Engineer	km
1.2.16	Water quality protection measures: Prevention of spillages, leakages of polluting materials, etc. to the satisfaction of the Engineer.	L.S.
1.2.18	Construction of a bathing ghat 2 m X 7 m as per the approved drawings and directions of the Engineer.	no.
1.2.20	Environmental monitoring	km
1.3.2	Rehabilitation of ancillary sites including stockpile sites, brick crushing sites, borrow areas, work force camps site office, etc. to the entire satisfaction of the Engineer.	km
1.2.21	Supplying fitting and fixing of composting barrel in growth center markets along with required civil works all complete as per drawings and direction of the Engineer in Charge.	no.

2. Health and Safety Specifications

2.1 Construction and Decommissioning

Applicability and Approach

This section provides additional, specific guidance on prevention and control of community health and safety impacts that may occur during new project development, at the end of the project life –cycle, or due to expansion or modification of existing project facilities. Cross referencing is made to various other sections of the General EHS Guidelines.

2.1.1 Environment

2.1.1.1 Noise and Vibration

During construction and decommissioning activities, noise and vibration may be caused by the operation of pile drivers, earth moving and excavation equipment, concrete mixers, cranes and the transportation of equipment, materials and people. Some recommended noise reduction and control strategies to consider in areas close to community areas include:

- Planning activities in consultation with local communities so that activities with the greatest potential to generate noise are planned during periods of the day that will result in least disturbance.
- Using noise control devices, such as temporary noise barriers and deflectors for impact and blasting activities and exhaust muffing devices for combustion engines.
- Avoiding or minimizing project transportation through community areas.

2.1.1.2 Soil Erosion

Soil erosion may be caused by exposure of soil surfaces to rain and wind during site cleaning, earth moving and excavation activities. The mobilization and transport of soil particles may in turn result in sedimentation of surface drainage networks which may result in impacts to the quality of natural water systems and ultimately the biological systems and ultimately the biological systems that use these waters.

Recommended soil erosion and water system management approaches include:

Sediment mobilization and transport

- Reducing or preventing erosion by:
 - o Scheduling to avoid heavy rainfall periods (i.e. during the dry season) to the extent practical
 - o Contouring and minimizing length and steepness of slopes
 - o Mulching to stabilize exposed areas
 - o Re-vegetating areas promptly
 - o Designing channels and ditches for post- construction flows
 - o Lining steep channel and slopes (e.g. use jute matting).
- Reducing or preventing off-site sediment transport through use of settlements ponds, silt fences and water treatment and modifying or suspending activities during extreme rainfall and high winds to the extent practical.

Clean runoff Management

- Segregating or diverting clean water runoff to prevent it mixing with water containing a high solids content to minimize the volume of water to be treated prior to release

Road Design

- Limiting access road gradients to reduce runoff-included erosion.
- Providing adequate road drainage based on road width, surface material, compaction and maintenance.

Disturbance to water bodies

- Depending on the potential for adverse impacts, installing free-spanning structures (e.g. single span bridges) for road watercourse crossings.
- Restricting the duration and timing of in-stream activities to lower low periods and avoiding periods critical to biological cycles of valued flora and fauna (e.g. migration, spawning etc.)
- For in-stream works, using isolation techniques such as berming or diversion during construction to limit the exposure of disturbed sediments to moving water.
- Consider using trenchless technology for pipeline crossings (e.g. suspended crossings) or installation by directional drilling.

Structural (slope) stability

- Providing effective short term measures of slope stabilization, sediment control and subsidence control until long term measures for the operational phase can be implemented.
- Providing adequate drainage systems to minimize and control infiltration.

2.1.1.3 Air Quality

Construction and decommissioning activities may generate emission of fugitive dust caused by a combination of on-site excavation and movement of earth materials, contact of construction machinery with bare soil and exposure of bare soil and soil piles to wind. A secondary source of emissions may include exhaust from diesel engines of earth moving equipment, as well as from open burning of solid waste on-site. Techniques to consider for the reduction and control of air emissions from construction and decommissioning sites include:

- Minimize dust from material handling sources, such as conveyors and bins, by using covers and/ or control equipment (water suppression, bag house or cyclone)
- Minimize dust from open area sources, including storage piles by using control measures such as installing enclosures and covers and increasing the moisture content
- Dust suppression techniques should be implemented such as applying water or non-toxic chemicals to minimize dust from vehicle movements
- Selectively removing potential hazardous air pollutants, such as asbestos from existing infrastructure prior to demolition
- Managing emissions from mobile sources
- Avoiding open burning of solid.

2.1.1.4 Solid Waste

Non-hazardous solid waste generated at construction and decommissioning sites includes excess fill materials from grading and excavation activities, scrap wood and metals and small concrete spills. Other non-hazardous solid wastes include office, kitchen and dormitory wastes when these types of operations are part of construction project activities. Hazardous solid waste includes contaminated soils which could potentially be encountered on-site due to previous land use activities or small amounts of machinery maintenance materials such as oily rags used of filters and used oil as well as spill cleanup materials from oil and fuel spills.

2.1.1.5 Hazardous Materials

Construction and decommissioning activities may pose the potential for release of petroleum based products, such as lubricants, hydraulic fluids or fuels during their storage, transfer or use in equipment. These materials may also be encountered during decommissioning activities in building components or industrial process equipment. Techniques for prevention, minimization and control of these impacts include:

- Providing adequate secondary containment for fuel storage tanks and for the temporary storage of other fluids such as lubricating oils and hydraulic fluids.
- Using impervious surfaces for refueling areas and other fluid transfer areas.
- Training workers on the correct transfer and handling of fuels and chemicals and the response to spills.
- Providing portable spill containment and cleanup equipment on site and training in the equipment on site and training in the equipment deployment.

- Assessing the contents of hazardous materials and petroleum-based products in building systems (e.g. PCB containing electrical equipment, asbestos-containing building materials) and process equipment and removing them prior to initiation of decommissioning activities and managing their treatment and disposal.
- Assessing the presence of hazardous substances in or on building materials (e.g. polychlorinated biphenyls, asbestos-containing flooring or insulation) and decontaminating or properly managing contaminated building materials.

2.1.1.6 Wastewater Discharges

Construction and decommissioning activities may include the generation of sanitary wastewater discharges in varying quantities depending on the number of works involved. Adequate portable or permanent sanitation facilities serving all workers should be provided at all construction sites.

2.1.1.7 Contaminated Land

Land contamination may be encountered in sites under construction and decommissioning due to known or unknown historical releases of hazardous materials or oil, or due to the presence of abandoned infrastructure formerly used to store or handle these materials, including underground storage tanks. Actions necessary to manage the risk from contaminated land will depend on factors such as the level and location of contamination, the type and risks of the contaminated media, and the intended land use. However, a basic management strategy should include:

- Managing contaminated media with the objective of protecting the safety and health of occupants of the site, the surrounding community and the environment post construction or post decommissioning.
- Understanding the historical use of the land with regard to the potential presence of hazardous materials or oil prior to initiation of construction or decommissioning activities.
- Preparing plans and procedures to respond to the discovery of contaminated media to minimize or reduce the risk to health, safety and the environment consistent with the approach for Contaminated Land.

Successful implementation of any management strategy may require identification and cooperation with whoever is responsible and liable for the contamination.

2.1.2 Occupational Health and Safety

Over-exertion

Over-exertion, and ergonomic injuries and illnesses, such as repetitive motion, over-exertion, and manual handling, are among the most common causes of injuries in construction and decommissioning sites. Recommendations for their prevention and control include:

- Training of workers in lifting and materials handling techniques in construction and decommissioning projects, including the placement of weight limits above which mechanical assists or two-person lifts are necessary
- Planning work site layout to minimize the need for manual transfer of heavy loads
- Selecting tools and designing work stations that reduce force requirements and holding times, and which promote improved postures, including, where applicable, user adjustable work stations
- Implementing administrative controls into work processes, such as job rotations and rest or stretch breaks

Slips and Falls

Slips and falls on the same elevation associated with poor housekeeping, such as excessive waste debris, loose construction materials, liquid spills, and uncontrolled use of electrical cords and ropes on the ground, are also among the most frequent cause of lost time accidents at construction and decommissioning sites. Recommended methods for the prevention of slips and falls from, or on, the elevation include:

- Implementing good house-keeping practices, such as the sorting and placing loose construction materials or demolition debris in established areas away from foot paths.

- Cleaning up excessive waste debris and liquid spills regularly.
- Locating electrical cords and ropes in common areas and marked corridors.
- Use of slip retardant footwear.

Work in Heights

Falls from elevation associated with working with ladders, scaffolding, and partially built or demolished structures are among the most common cause of fatal or permanent disabling injury at construction or decommissioning sites. If fall hazards exist, a fall protection plan should be in place which includes one or more of the following aspects, depending on the nature of the fall hazard.³

- Training and use of temporary fall prevention devices, such as rails or other barriers able to support a weight of 200 pounds, when working at heights equal or greater than two meters or at any height if the risk includes falling into operating machinery, into water or other liquid, into hazardous substances, or through an opening in a work surface.
- Training and use of personal fall arrest systems, such as full body harnesses and energy absorbing lanyards able to support 5000 pounds (also described in this section in Working at Heights above), as well as fall rescue procedures to deal with workers whose fall has been successfully arrested. The tie in point of the fall arresting system should also be able to support 5000 pounds
- Use of control zones and safety monitoring systems to warn workers of their proximity to fall hazard zones, as well as.

Securing, marking, and labeling covers for opening in floors, roofs, or walking surfaces

Struck By Objects

Construction and demolition activities may pose significant hazards related to the potential fall of materials or tools, as well as ejection of solid particles from abrasive or other types of power tools which can result in injury to the head, eyes, and extremities. Techniques for the prevention and control of these hazards include:

- Using a designated and restricted waste drop or discharge zones, and/or a chute for safe movement of wastes from upper to lower levels.
- Conducting sawing, cutting, grinding, sanding, chipping or chiseling with proper guards and anchoring as applicable.
- Maintaining clear traffic ways to avoid driving of heavy equipment over loose scrap
- Use of temporary fall protection measures in scaffolds and out edges of elevated work surfaces, such as hand rails and toe boards to prevent materials from being dislodged.
- Evacuating work areas during blasting operations, and using blast mats or other means of deflection to minimize fly rock or ejection of demolition debris if work is conducted in proximity to people or structures
- Wearing appropriate PPE, such as safety glasses with side shields, face shields, hard hats, and safety shoes.

Moving Machinery

Vehicle traffic and use of lifting equipment in the movement of machinery and materials on a construction site may pose temporary hazards, such as physical contact, spills, dust, emissions, and noise. Heavy equipment operators have limited fields of view close to their equipment and may not see pedestrians close to the vehicle. Center-articulated vehicles create a significant impact or crush hazard zone on the outboard side of a turn while moving. Techniques for the prevention and control of these impacts include:

- Planning and segregating the location of vehicle traffic, machine operation, and walking areas, and controlling vehicle traffic through the use of one-way traffic routes, establishment of speed limits, and on-site trained flag-people direct traffic

³ Additional information of identification of all hazards and design of protection systems can be found in the United States Occupational Health and Safety Administration's (US OSHA) web site:

<http://www.osha.gov/SLTC/fallprotection/index.html>

- Ensuring the visibility of personnel through their use of high visibility vests when working in or walking through heavy equipment operating areas, and training of workers to verify eye contact with equipment operators before approaching the operating vehicle.
- Ensuring moving equipment is outfitted with audible back-up alarms
- Using inspected and well-maintained lifting devices that are appropriate for the load, such as cranes, and securing loads when lifting them to higher job-site elevations.

Dust

- Dust suppression techniques should be implemented, such as applying water or non-toxic chemicals to minimize dust from vehicle movements
- PPE, such as dusk masks, should be used where dust levels are excessive

Confined Spaces and Excavations

Examples of confined spaces that may be present in construction or demolition sites include: silos, vats, hoppers, utility vaults, tanks, sewers, pipes, and access shafts. Ditches and trenches may also be considered a confined space when access or egress is limited. In addition the occupational hazards associated with confined spaces and excavations in construction and decommissioning sites should be prevented according to the following recommendations:

- Controlling site-specific factors which may contribute to excavation slope instability including, for example, the use of excavation dewatering, side-walls support, and slope gradient adjustments that eliminate or minimize the risk of collapse, entrapment, or drowning
- Providing safe means of access and egress from excavations, such as graded slopes, graded access route, or stairs and ladders
- Avoiding the operation of combustion equipment for prolonged periods inside excavations areas where other workers are required to enter unless the area is actively ventilated

Other Site Hazards

Construction and decommissioning sites may pose a risk of exposure to dust, chemicals, hazardous or flammable materials, and wastes in a combination of liquid, solid, or gaseous forms, which should be prevented through the implementation of project-specific plans and other applicable management practices, including:

- Use of specially trained personnel to identify and remove waste materials from tanks, vessels, processing equipment or contaminated land as a first step in decommissioning activities to allow for safe excavation, construction, dismantling or demolition.
- Use of specially trained personnel to identify and selectively remove potentially hazardous materials in building elements prior to dismantling or demolition including, for example, insulation or structural elements containing asbestos and Polychlorinated Biphenyls (PCBS), electrical components containing mercury⁴
- Use of waste-specific PPE based on the results of an occupational health and safety assessment, including.

Respirators, clothing/protective suits, gloves and eye protection

2.1.3 Community Health and Safety

2.1.3.1 General Site Hazards

Projects should implement risk management strategies to protect the community from physical, chemical, or other hazards associated with sites under construction and decommissioning. Risks may arise from inadvertent or intentional trespassing, including potential contact with hazardous materials, contaminated soils and other environmental media, buildings that are vacant or under construction, or excavations and structures which may pose falling and entrapment hazards. Risk management strategies may include:

- Restricting access to the site, through a combination of institutional and administrative controls, with a focus on high risk structures or areas depending on site-specific situations, including fencing, signage, and communication of risks to the local community

⁴ Additional information on the management and removal of asbestos containing building materials can be found in ASTM Standard E2356 and E1368

- Removing hazardous conditions on construction sites that cannot be controlled affectively with site access restrictions, such as covering openings to small confined spaces, ensuring means of escape for larger openings such as trenches or excavations, or locked storage of hazardous materials.

1.1.3.2 Disease Prevention

Increased incidence of communicable and vector-borne diseases attributable to construction activities represents a potentially serious health threat to project personnel and residents of local communities. Recommendations for the prevention and control of communicable and vector-borne diseases also applicable to construction phase activities.

1.1.3.3 Traffic Safety

Construction activities may result in a significant increase in movement of heavy vehicles for the transport of construction materials and equipment increasing the risk of traffic –related accidents and injuries to workers and local communities. The incidence of road accidents involving project vehicles during construction should be minimized through a combination of education and awareness-raising, and the adoption of procedures.

PART-10: SPECIFICATIONS FOR SOCIAL ASPECTS

1. SOCIAL ASPECTS

1.1 SPECIFICATIONS FOR SOCIAL ASPECTS

The rules and regulations of the Government of Bangladesh in relation to environment and social safeguard together with World Bank Policies (OP/BP/GP 4.01) will be binding upon the contractor.

1.2 CHILD LABOUR

In addition, the Contractor shall comply with the applicable minimum age labour laws and requirements of (including applicable treaties, which have been ratified by) the Government of Bangladesh and applicable World Bank Policies regarding hazardous forms of child labour. The World Bank will review compliance with such labour laws, requirements and World Bank policies or, as the case may be, any non-compliance together with the action being taken to ensure compliance. Child labour means the labour who is less than 14 years old.

1.3 GENDER ISSUE

The contractor should follow the equity in wage payment for both the men and women labour for equal level of works as required by the Government of Bangladesh. The contractor should engage women labours on priority basis in the works suitable for them and follow ILO conventions, relevant protocols etc. The contractor must consult the women UP member and others to know about availability of women workers including indigenous women workers in the area to engage them in the suitable work as per their skill.

1.4 EMPLOYMENT OF PAPS/LOCAL WOMEN/INDIGENOUS PEOPLE IN PROJECT WORKS.

The contractor should give priority to PAPs / Local women / indigenous people in employing them to suitable project works as appropriate to their skill. In case of any dispute in this regard, the decision of the Executive Engineer shall be conclusive and binding upon the contractor.

1.5 SAFETY AND SECURITY

The contractor must maintain safety and security of the workers in the working place. In case of injury, the contractor must arrange treatment of the injured workers and the cost of treatment of the injured workers.

1.6 CULTURAL PROPERTIES

The contractor must protect the cultural properties in the project area. The cultural properties include mosque, temple, shrines, old buildings, graveyard, historical place etc.

The contractor must also pay attention to keep its beauty and other elements intact so that it does not get affected by any means or any works.

PART-11: INCIDENTAL WORKS

1. INCIDENTAL WORKS

1.1 Excavation Of Side Drains

1.1.1 Description

The work shall consist of the excavation, removal and disposal of materials for the formation of roadside drains in accordance with these Specifications and as shown on the Drawings or as directed by the Engineer. The work will include excavation of the lead-offs to allow the water to flow freely away from the road.

1.1.2 Materials

Excavated materials declared suitable for incorporation in the works shall be stock piled while those declared unsuitable shall be disposed of, all at the direction of the Engineer.

1.1.3 Construction Method

The side drain works shall be set out and excavated to the lines, levels, grades and cross-sections, and in the locations as shown on the Drawings, or as directed by the Engineer, including the lead-offs. The drains shall be excavated to ensure that water flows freely away from the side of the road. The Contractor shall not excavate outside the slopes or below the established level, or loosen any material outside the limits of excavation. Any excess depth excavated below the established level shall be made good at the cost of the Contractor with suitable material and compacted.

The slopes and base of the drain shall be trimmed.

1.1.4 Measurement

Roadside drains shall be measured in linear meters of length excavated complete and accepted. Measurements shall be made along the centre-line of the drain.

1.1.5 Payment

The work as measured shall be paid for at the Contract unit price for each linear meter of side drain excavated. Payment shall be full compensation for carrying out the operations required including setting out, hauling of excavated material, trimming slopes and base, and all labour, tools, equipment and incidentals necessary to complete the work.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
1.1	Excavation of Side Drain	Linear meter

1.2 BRICK LINING OF SIDE DRAINS

1.2.1 Description

The work shall consist of brick lining and plastering of excavated side drains in accordance with these Specifications and as shown on the drawings.

1.2.2 Materials

Bricks shall be First Class as specified in Clause 3.12 of these Specifications. The plaster shall be as specified in Clause 3.12 of these Specifications.

1.2.3 Construction Method

The placing of the brick lining shall not commence until the excavated and prepared side drain has been accepted by the Engineer.

The brick lining shall be laid as brick flat soling with frogs downward as specified in Clause 3.12 of these Specifications or as shown on the Drawings. Plastering shall be of 12mm thickness or as shown on the Drawings, and shall be done as specified in Clause 3.12 of these Specifications.

1.2.4 Measurement

This work shall be measured in linear meters of side drain brick-lined complete and accepted. Measurements shall be made along the centre-line of the drain.

1.2.5 Payment

The work as measured shall be paid for at the Contract unit price for each linear metre of side drain brick-lined. Payment shall be full compensation for carrying out the operations required including materials, all labour, tools, equipment and incidentals necessary to complete the work.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
1.2	Brick-Lining of Side Drain	Linear meter

1.3 KILOMETRE POSTS**1.3.1 Description**

This work shall consist of supply and installation of pre-cast concrete bollards as kilometer posts, including necessary concrete foundation and all fixtures, in accordance with these Specifications and at the locations and in accordance with the sizes, dimensions and designs shown on the Drawings.

1.3.2 Materials

The concrete bollards shall be pre-cast in the shape and manner designated on the Drawings and the concrete shall conform to the requirements of Clause 3.3 of these Specifications. Reinforcement shall conform to the requirements of Clause 3.4 of these Specifications.

The bollards to be used shall be approved by the Engineer prior to installation.

1.3.3 Construction Methods

As progress of the work permits the Engineer will authorise the location of each kilometer post.

Foundation concrete shall be laid after holding the posts in position by suitable temporary supporting system. Soil around the posts shall be backfilled and properly compacted after installation of the posts. Temporary supporting system shall be removed only after foundation concrete has properly set and the backfilling has been completed. The posts shall be painted and marked as shown on the Drawings or as directed by the Engineer.

1.3.4 Measurement

This work shall be measured for payment as the number of kilometre posts supplied, installed and accepted.

1.3.5 Payment

This work measured shall be paid for at the Contract unit price for each post. The payment shall be full compensation for supply and installation, including all material, labour, equipment, tools, and incidentals necessary to complete the work.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
1.3	Supply and Installation of Kilometre Posts	Number

1.4 GUARD POSTS

1.4.1 Description

This work shall consist of supply and installation of the pre-cast concrete guard posts including necessary concrete foundation and all fixtures, at bridge approaches and on sharp curves in accordance with these Specifications and as shown in the Drawings.

1.4.2 Materials

The guard posts shall be pre-cast in the shape and manner designated in the Drawings and the concrete shall conform to the requirements of Clause 3.3 of these Specifications. Reinforcement shall conform to the requirements of Clause 3.4 of these Specifications.

The guard posts to be used shall be approved by the Engineer prior to installation.

1.4.3 Construction Method

As progress of the work permits the Engineer shall authorise the location of guard posts.

Foundation concrete shall be laid after holding the posts in position by suitable temporary supporting system. Soil around the posts shall be backfilled and properly compacted after installation of the posts. Temporary supporting system shall be removed only after the foundation concrete has properly set and the backfilling has been completed. The guard posts shall be painted with luminous paint either yellow and black or any other colour subject to the approval by the Engineer.

1.4.4 Measurement

This work shall be measured as the number of guard posts supplied, installed and accepted.

1.4.5 Payment

The work measured shall be paid for at the Contract unit price for each guard post. The payment shall be full compensation for all operations necessary to complete the work including all material, labour, equipment, tools and incidentals.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
1.4	Supply and Installation of Guard Posts	Number

1.5 BOUNDARY PILLARS

1.5.1 Description

This work shall consist of providing and fixing the Boundary Pillars in position along the Right of Way Line on both sides of the road alignment.

1.5.2 Materials

The Boundary Pillars shall be of precast reinforced concrete of 21 MPa strength. Steel reinforcement shall be of 40 grade hot rolled deformed bar as specified in clause No. 3.4.2.

1.5.3 Finishes

Proper care shall be taken in handling the precast Boundary Pillars in order to avoid any damage. Soil around the pillars shall be properly compacted after installation. The pillars shall be vertical in position after installation.

1.5.4 Measurement for Payment

The Boundary Pillars shall be true to the dimensions as shown in the drawing or as directed by the Engineer. The pillars shall be measured in number fixed in position and accepted. No other component therein, like reinforcing steel etc. shall be measured separately.

1.5.5 Payment

The rate shall be the full compensation for providing all materials, form work, reinforcing steel, accessories including all transportation, labour, excavation, backfill, fixing in position and any other incidentals complete.

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
1.5	Supply and Installation of Boundary Pillars	Number

1.6 ROAD SIGNS

1.6.1 Description

The work shall consist of the supply and installation of road signs and post assemblies including necessary concrete foundation along with all fixtures, as shown on the Drawings or as directed by the Engineer. The signs shall be erected at the locations shown on the Drawings or as directed by the Engineer.

1.6.2 Design

The signs to be installed are of two types:

- i) Warning, regulatory and information signs, each sign mounted on a single post;
- ii) Direction signs (including destination & place identification), each sign mounted on two posts.

All signs shall be erected vertically with proper orientation in respect of traffic flow. The actual place of installation of signs will be determined by the Engineer depending on site conditions.

Post lengths shown on the Drawing are for bidding purposes only. As progress of the work permits, the Engineer will authorise the location of each sign, with the station and offset distance from the edge of pavement. The Contractor shall be responsible for the determination of post lengths to provide the vertical clearance shown on the drawing.

At least 60 (sixty) days before the erection of any sign the Contractor shall supply detailed drawings, specifications and a sample sign for the Engineer's approval.

1.6.3 Materials

The post shall be of welded or seamless galvanised iron pipe of internal diameter not less than 75mm. Alternatively, at the option of the Contractor and if permitted by the Engineer, the posts may be fabricated from structural steel.

The sign boards shall be of sheet steel or aluminium, and shall be securely and permanently attached to the posts.

The sign boards shall be painted prior to installation.

1.6.4 Construction Methods

Foundation concrete shall be laid after holding the posts in position by suitable temporary supporting system. Soil around the posts shall be backfilled and properly compacted after installation of the posts. Temporary supporting system shall be removed only after the foundation concrete has properly set and the backfilling has been completed.

1.6.5 Measurement

This work shall be measured as the number of road signs erected and accepted.

1.6.6 Payment

The work measured shall be paid for at the Contract unit price for each sign. The payment shall be full compensation for supplying all materials, tools, labour, equipment and incidental necessary to complete the work.

Pay Item shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
1.6.2	Supply and Installation of Road Signs:	
	i) Warning, Regulatory and Information Signs	Number
	ii) Direction Signs	Number

1.7 PAINTING WORK**1.7.1 Description**

The work shall consist of painting different elements of the structure as directed by the Engineer.

1.7.1.1 Red Oxide Paint

Quality red oxide paint over a coat of priming shall be provided in two coats. The surface where paint is intended to be provided shall be cleaned in proper manner. This work shall include necessary scaffolding, supply of all materials as per specifications or as directed by the Engineer.

1.7.1.2 Synthetic Enamel Paint

The work shall consist in providing two coats of synthetic enamel paint of approved tint and brand including removing the old, cracked, bolstered paint by scraping, using a paint solvent or by any other approved method including supplying paint etc. complete as per specifications of or as directed by the Engineer.

1.7.2 Measurement and Payment

The work as measured shall be paid for at the contract price for each square meter of paintwork executed. Payment shall be full compensation for carrying out the operations required including materials, all labour, tools, equipment and incidentals necessary to complete the work.

Pay Items shall be:

CLAUSE	DESCRIPTION	UNIT OF MEASUREMENT
1.7.1.1	Providing red oxide paint	square meter
1.7.1.2	Providing synthetic enamel paint	square meter

Section 7. Particular Specifications

Notes on Particular Specifications

If an item of the Works is not covered in the General Specifications or if any specification clause requires that further details as to precise requirements for the particular Works are to be given or needs to be modified or clarified then these should be reflected in the Particular Specifications.

Where the Particular Specification clause replaces or clarifies an existing clause of the General Specification then the same clause numbering system need to be followed.

Particular Specifications are not required for the present procurement.

Section 8. Drawings

The Drawings are presented in **Volume II** of the Tender Documents.

Volume II includes the following drawings:

Part	Number of Sheets
Index Map	*** sheet(s)
Part-A: ***	*** sheets
Part-B: ***	*** sheets
Part-C: ***	*** sheets
Part-D: ***	*** sheets
Part-E: ***	*** sheets
Part-F: ***	*** sheets
Part-G: ***	*** sheets
TOTAL	*** sheets

Section 9. Bill of Quantities

The Bill of Quantities is presented in the following pages.

The Bill of Quantities uses a separate page numbering system, re-starting at 1.

The total number of pages of the Bill of Quantities is: *** Pages