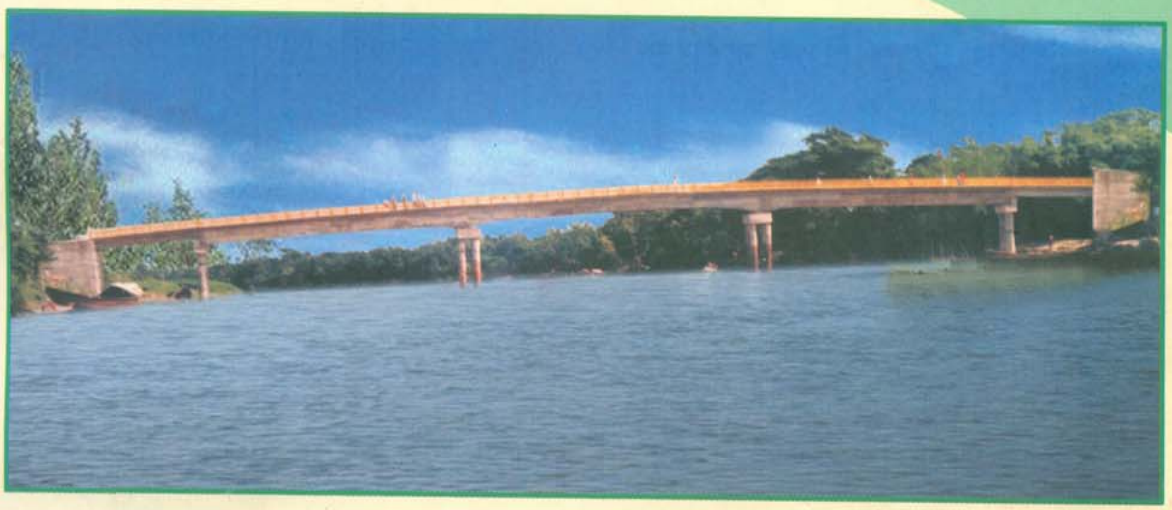
GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
LOCAL GOVERNMENT ENGINEERING DEPARTMENT



TECHNICAL SPECIFICATIONS FOR BRIDGES ON THE UPAZILA AND UNION ROADS

March, 2004

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March, 2004

THE REVIEW COMMITTEE

1.	Md. Wahidur Rahman Superintending Engineer, LGED	Convener
2.	Rubaiyat Nurul Hasan Consultant, LGED	Member
3.	Abdus Sobhan Managing Director, DPMC Ltd.	Member
4.	Md. Haider Ali Project Director, LBC, LGED	Member
5.	Md. Abdus Shahid Project Director, RDP-25, LGED	Member
6.	Md. Torab Ali Khan Deputy Project Director, RDP-26, LGED	Member
7.	Md. Amir Azam Executive Engineer, HQ, LGED	Member
8.	Mollah Azizul Haque Executive Engineer, HQ, LGED	Member
9.	Md. Mizanur Rahman Deputy Consultant, CHTRDP, LGED	Member
10.	Noriyasu Nishino, Design Expert, JICA, LGED	Co-opted Member
11	Mofizul Islam Khan Design Engineer, RDP-21, LGED	Co-opted Member
12.	Syed Abdur Rahim Assistant Engineer, GJDIDP, LGED	Co-opted Member

The Chief Engineer
Local Government Engineering Department

FOREWARD

Technical Specifications constitute an important part of any Tender Documents. The Government of the People's Republic of Bangladesh has circulated recently "The Public Procurement Regulations, 2003". This Regulation, while coming into force, has further emphasized the need for Technical Specifications for the purpose of any procurement.

LGED, like previously, strongly acknowledges the need for structural safety and serviceability of the bridges to be built in the coming days also and the demand for Technical Specifications for such structures has obviously become immense. It is not a lopsided way of emphasizing the place of a document, but a ground reality.

This document is a compilation of the specifications comprising different aspects of bridge construction works. It has been prepared in the light of internationally recognized standards within the socio-economic scenario of Bangladesh. This document can either be followed in the LGED by the different projects exclusively or an individual project may prepare its own document considering it as a launching pad to proceed. They can tailor this document in a manner to suit their needs by making some addition, alteration and modification to it, if necessary.

Although the compiler has made every effort and has made extensive references to various international Standard Specifications to make this document comprehensive to its optima and to make it conducive for local conditions, it is by no means conclusive or the last word on the subject.

I am happy that publication of the Technical Specifications on Bridges has ultimately become possible for us. It will act as a powerful catalyst on the part of the LGED Engineers to uphold quality and standard of bridge construction works. This is an adroit stride from our end to push the level of our excellence and competence up by adopting many documents like one of this kind. I do hope that the various projects, as relevant, will make best use of this document. Let us expect a candid adoption of this document by the LGED Engineers.

Md. Shahidul Hassan

The Superintending Engineer
Local Government Engineering Department

Acknowledgement

Technical Specification for Bridge and Culverts on the Upazila and Union Roads is an integral part for implementation of Schemes under the Local Government Engineering Department. The need for continuous updating of the Technical Specifications for Road Structural works in consideration to better safety and economically viable is felt both by the designer as well as the executing agency.

The Document is a compilation of specifications comprising all aspects of bridge construction. It is prepared on the basis of internationally practiced standards that suit the socio-economic aspects of Bangladesh.

It is hoped that this Technical Specifications for Bridges for Upazila and Union Roads will contribute in improving the quality of works by maintaining uniform design and specifications throughout the LGED as well as the other Local Government Institutions (LGI).

I express my deep appreciation to all members of the Committee for preparation of the standard specification of bridge & culverts. Any suggestions related to its improvement will be greatly appreciated and will be taken into consideration in future updating.

Md. Wahidur Rahman
Superintending Engineer (PM&E)
&
Convener, Standard Specification Committee

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GENERAL AND SITE FACILITIES

1.1 General Specification

1.1.1 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.

1.1.2 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.

1.1.3 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.

1.1.4 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.

1.1.5 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.

1.1.6 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.

1.1.7 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/she/they 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.

1.1.8 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.

1.1.9 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.

1.1.10 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.

1.1.11 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.

1.1.12 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.

1.1.13 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.

1.1.14 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
Concrete Structures	Tolerances from specified position (Structure) Maximum departure of plan position structure or element	25mm

Type of Structure	Item	Tolerance
	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

Type of Structure	Item	Tolerance
Formwork	Maximum deviation in direction of flow or normal to flow – abrupt	0 (Grind to 1 in 50 level)
	Sectional dimension	±5mm
	Plumb	±1 in 1000 of height
	Levels (before any deflections has been taken place)	±3mm
Reinforcement	Length of splice	-25mm
	Variation of protective cover	±5mm
	Variation in indicated position or reinforcement:	
	▪ Starter bars	One bar diameter
	▪ Slabs and Walls	0.25 times the indicated spacing
	▪ Beams and columns	±5mm
	Dimension of bent bars:	
	▪ Stirrups and ties	±5mm
	▪ Other bars	±10mm
Slope protection	<u>Stone Work</u>	
	Pitching and Masonry	±50mm over 3m
	Thickness of tipped rock or filter	+50mm -000
	<u>Block Work/Brick Work</u>	
	Verticality	±3mm in 1m
	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

Type of Structure	Item	Tolerance
	c) Deviation from position shown on the Plan for vertical and raker piles after driving	¼th 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.

1.1.15 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.

1.1.16 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.

1.2 Construction Materials

1.2.1 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
Efflorecence	Nil
Dimensions ($\pm$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/cm^2, but not less than 170 kg/cm^2 in any individual bricks

All other requirements for First class bricks shall also apply to Picked Jhama Bricks.

1.2.2 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/she/ they 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 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 Angles 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 morters 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

1.2.3 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 160m^2/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/m^3.

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 manufactures 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 lessor period as directed by the Engineer. After this period is over, any unused cement shall be removed from the site.

1.2.4 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.

1.2.5 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/mm^2) 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/mm^2). 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.

1.2.6 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.

1.2.7 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.

1.2.8 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.

1.2.9 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.

1.2.10 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.

1.2.11 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.

1.2.12 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 under2 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/m^2, and with O_{90} 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.

1.2.13 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 Dorometer)	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 100º 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± 2ºC	Hardness (Shore "A")	50	60	70
	Shear Modulus (G) at 23± 2ºC (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.

1.3 Material Testing

1.3.1 General

Not withstanding 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.

1.3.2 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.

Water Test

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 dditional 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 m^2 of geo-textile fabric supplied. The k and O_{90} values shall be tested on samples taken from every 50,000 m^2 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 of 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%

1.3.3 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.

SECTION-2

STRUCTURES

STRUCTURES

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SECTION-2
STRUCTURES

2.1 Traffic Maintenance and Site Facilities

2.1.1 Traffic Maintenance

2.1.1.1 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.

2.1.1.2 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.

2.1.1.3 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.

2.1.1.4 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.

2.1.1.5 Removal of temporary works

Immediately upon completion of the Contract all temporary roads, temporary bridges, barricades, signs and other equipment shall be completely removed.

2.1.1.6 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

2.1.2 Office Space and Facilities for the Engineer

2.1.2.1 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 where necessary. 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/she 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.

2.1.2.2 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 filing 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.

2.1.2.3 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.

2.1.2.4 Responsibility for 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.

2.1.2.5 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.

2.1.2.6 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 Work 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.

2.1.2.7 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 accordance 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 consumable	Lump sum
Providing photographs, video clips, etc.	Lump sum

2.2 Demolition and Removal of Existing Structure

2.2.1 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.

2.2.2 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.

2.2.3 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.

2.2.4 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.

2.2.5 Measurement

The Work shall be measured according to the types of structures and shall be measured in cubic meter/ metric ton.

2.2.6 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)	Cubic meter
Removal of existing steel structure	Metric ton

2.3 Excavation and Backfill for Structures

2.3.1 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.

2.3.2 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.

2.3.3 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 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/her 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 softened, 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 material, 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 $\pm$ 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.

2.3.4 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.

2.3.5 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

2.4 De-watering System

2.4.1 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

2.4.2 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.

2.4.3 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.

2.4.4 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

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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.

2.4.5 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.

2.4.6 Measurement

The work shall be measured for payment as an item on a lump sum basis as specified in the Schedule of Items.

2.4.7 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

2.5 Earthen Ring/Cross Bundh

2.5.1 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.

2.5.2 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.

2.5.3 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.

2.5.4 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

2.6 Water Proofing Polythene Sheet

2.6.1 Description

The work covered under this item shall consist of supplying and laying in place one layer of 0.076mm thick polythene sheets in accordance with the applicable plans, schedules and these specifications.

2.6.2 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.

2.6.3 Measurement

Measurement for payment shall be made in square meter of area covered by the sheets. No allowance shall be made for overlaps.

2.6.4 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 specificaitons contained in this Sub-section and acceptance of the Engineer.

Item of payment	Unit
Supplying and laying polythene sheet	Square meter

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. 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.

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 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 on observing.

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

Undisturbed samples from cohesive soil layers shall be taken from the bore holes at an intervals 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.

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 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 stout 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, $N \geq 100$ 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 as soon as directed by the Engineer.

2.7.8 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 care 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/cm^2, 1.0 kg/cm^2 and 1.5 kg/cm^2). 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 these 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/cm^2, 0.25 kg/cm^2, 0.5 kg/cm^2, 1.0 kg/cm^2, 2.0 kg/cm^2, 4.0 kg/cm^2 and 8.0 kg/cm^2.

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 as specified in the Schedule of Items and BOQ.

2.7.10 Payment

Payment shall only be admissible on completion of the item of the BOQ 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. 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

2.8 Bored Cast in Situ Piles

2.8.1 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 and 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 according to the Drawings and these Specifications.

2.8.2 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. 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 Tremies 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.

2.8.3 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/mm^2 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/m^3.

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

  Where required Bentonite, supplied to the site and prior to the mixing, shall be in accordance with the specifications conforming DFCP 4 of the Oil Companies Materials Associations.

  A certificate shall be obtained by the Contractor 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 material for the drilling fluid shall be approved by the Engineer.

- Mixing

  Bentonite and any other material shall be mixed thoroughly with clean water to make a suspension which shall maintain the stability of the pile excavation for the 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/m² or 4.0 - 40.0 N/ m²	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 to carry 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.

2.8.4 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 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.

- Drilling

  The Engineer shall approve the drilling method and the equipment to be used for the 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 an additional hole(s) 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. Final construction procedures or any subsequent modification shall be approved by the Engineer prior to commencing piling operations.

- Placing the permanent steel casing, if required, 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 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 in accordance with 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, if any. The Contractor shall submit references from similar jobs carried out by him or by the Sub-contractor.

The Contractor shall submit all requested supplementary information in writing.

After the Contract has been awarded to the Contractor, he shall carry out 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 responsibilities for the pile construction.

No boring equipment or material shall be imported before the Contractor has received the above approval.

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 (BM) 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 such as pump, welding set, etc. 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 Marks. 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 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 required to suit 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 Methods. 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 casings

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 material 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 soil or property.

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.

Unexpected ground conditions

The Contractor shall report immediately to the Engineer any circumstance, 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 sedimentation 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 matter 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 material at the base of the boring and the Contractor shall ensure that heavily contaminated Bentonite suspension, which 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 water-tight 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 48 hours after concrete has been placed, no construction operations shall be conducted that would cause soil movement adjacent to the shaft, other than mild vibration.

Portions of the pile exposed to a body of water shall be protected from the action of water by leaving the forms in place for a minimum of seven days after concrete placement.

2.8.5 Extraction of Temporary Casing

Workability of concrete

Temporary casings 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 heads 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 methods, 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.

2.8.6 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.

2.8.7 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
- River bed level at commencement of installation of pile
- Working level
- Pile toe level
- River water 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.

2.8.8 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.

2.8.9 Other requirements

Reinforcement cages of piles selected by the Engineer shall be fitted at the Contractors expenses with water-tight 50mm diameter G.I pipe from datum level down to pile toe level. Bottom of the pipes shall be closed water-proof. 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.

Piles as instructed by the Engineer shall be tested with an electronic ultrasonic device by the Contractor. 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 and 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.

2.8.10 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 by linear meter.

Permanent casing shall be measured by linear meter for each size.

2.8.11 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

2.9 Pre-cast Reinforced Concrete Piles

2.9.1 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 Drawing.

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.

2.9.2 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/mm^2 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.

2.9.3 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 as 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 the 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 these Specifications.

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 respects 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 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 procedure shall be accepted by the Engineer.

2.9.4 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 intervals along its length showing the distance from pile shoe. The top 3m of the pile shall be marked at 250mm intervals.

2.9.5 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 quoted in (a)

(c) Painting with an approved two parts coal tar epoxy paint product suitable for mixing on site immediately before application.

2.9.6 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.

2.9.7 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 the 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.

2.9.8 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, 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 Marks.

The pre-cast 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 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 are reached or the number specified on the Drawings 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 works.

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 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 those will be furnished by the Contractor and methods proposed to be followed. The Contractors 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 hammers, shall be equipped with a suitable thickness of hammer cushion material to prevent any damage 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 hammers, 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 torsional 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 concrete piles is such as to unduly injure them, 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 unnecessary 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 in the special provisions. 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 expected. The pile shoes shall be of the types and quality as shown on the Drawings and as specified in this Specification. They shall be used at the locations specified or ordered by the Engineer.

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 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/cm^2 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.

2.9.9 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.

2.9.10 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.

2.9.11 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) 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 cause, shall be driven down again.

2.9.12 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 $\pm$ 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 N/mm^2)	37D	32D
Mild Steel (f_y = 250 N/mm^2)	30D	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.

2.9.13 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.

2.9.14 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	**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

2.10 Well Foundation for Structures

2.10.1 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.

2.10.2 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.

2.10.3 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.

2.10.4 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.

2.10.5 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.

2.10.6 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.

2.10.7 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 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 stenining 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 securedly 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 continuos 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.

2.10.8 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.

2.10.9 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 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 chocked 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.

2.10.10 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.

2.10.11 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 shits 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.

2.10.12 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. Incase 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.

2.10.13 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 concreteing, 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.

2.10.14 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 then 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.

2.10.15 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 upto the height shown on the Drawings or as directed by the Engineer.

2.10.16 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.

2.10.17 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.

2.10.18 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

2.10.19 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:

$$\text{Test Load} = \frac{\text{Steining Area}}{\text{Total Area of Well}} \text{ is it a multiplication (Dead Load + 2 x Live Load)}$$

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.

2.10.20 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.

2.10.21 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

2.11 Timber Piles

2.11.1 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.

2.11.2 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.

2.11.3 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.

2.11.4 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.

2.11.5 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.

2.11.6 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.

2.11.7 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.

2.11.8 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.

2.11.9 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

2.12 Pile Load Testing

2.12.1 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.

2.12.2 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.

2.12.3 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.

2.12.4 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.

2.12.5 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 kentlege 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.

2.12.6 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.

2.12.7 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.

2.12.8 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.

2.12.9 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.

2.12.10 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.

2.12.11 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.

2.12.12 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.

2.12.13 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.

2.12.14 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.

2.12.15 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
200	300	24 hours - Proof Load

Load as Percentage of Working Load		Minimum Time of Holding Load
Bored Piles	Driven Piles	
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 date 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(s) 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.

2.12.16 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.

2.12.17 Measurement

This work shall be measured as the number of pile compression load tests satisfactorily conducted and completed.

2.12.18 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

2.13 Concrete for Structures

2.13.1 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 the current British Standard 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.

2.13.2 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 material. 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 course 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-fourths 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 under 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 26.

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 ingredient in the admixture.

- Whether or not the admixture contains chlorides 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 entertainment 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. 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 Titerature 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.

2.13.3 Testing of Materials

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. Gradings 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 26.

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.

2.13.4 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/m^3	Maximum water/cement Ratio Percent	28 day Cylinder Strength in kg/ cm^2
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 40	0.78 0.78	0 – 10 0 – 25
Low	Simple reinforced sections with vibration and large sections without vibration	20 40	0.85 0.85	10 – 25 25 – 50
Medium	Simple reinforced sections without vibration and heavily reinforced sections with vibration	20 40	0.92 0.92	25 – 50 50 – 100
High	Heavily reinforced sections without vibration	20 40	0.95 0.95	50 – 125 100-175

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 :
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 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/mm^2.

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 Minimum Content	:	Type-I Cement shall be used for all classes for "Concrete" and the minimum cement content shall be as indicated above in the 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 under section on 'Coarse Aggregate' of this Sub-section.
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, 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 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, who 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 need not be required 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 aggregate 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.

2.13.5 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.

2.13.6 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.

2.13.7 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.

2.13.8 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 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 the 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^{o}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 Latinate and other objectionable material 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 smoothen 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 harden 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 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 is 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 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 compactions.

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.

2.13.9 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 method 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 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.

2.13.10 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 method.

Protection from cold weather

Under a cold weather condition the 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 pozzolon 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.

2.13.11 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 expense.

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.

2.13.12 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 without loosening 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 by 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.

2.13.13 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 then 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.

2.13.14 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.

2.13.15 Factory Made Pre-cast Concrete Elements

Any supplier of pre-cast concrete elements shall be approved in writing by the Engineer. The approval can later be withdrawn, if so desired by the Engineer.

All concrete works of such elements shall fully conform to 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 applied while concrete is placed.

Generally members those are structurally dependent on a rigid fixing with the adjoining structures will not be permitted to be constructed by pre-casting.

Unless otherwise approved by the Engineer, pre-cast concrete members shall not 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 developed a strength of 90% of the specified 28-days strength.

Extreme care shall be exercised in handling and moving pre-cast concrete member. 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 is 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 risk 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 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 no excessive stresses are set up in the units. 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 and stack the units safely and without undue stressing.

2.13.16 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.

2.13.17 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.

2.13.18 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 be 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/cm^2. 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/cm^2 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 or 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 sued 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.

2.13.19 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.

2.13.20 Control of Heat in Structures

In structures of major dimensions i.e. pile caps. etc. the heat deriving from the hydration of the concrete shall be controlled by the Contractor. Temperature gradients introducing risks of cracking shall not occur and the temperature shall not exceed 70°C.

The Contractor shall 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 such measures to the Engineer for his approval. The measures shall instantly be changed, if requested by the Engineer even later.

2.13.21 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.

2.13.22 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.

2.13.23 Measurement

The concrete shall be measured by number or/and by the number of cubic meters of the several different grades and types completed in place and accepted. 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, pipes less than 300mm in diameter, conduits, chamfers, reinforcement bars, pre-stressing tendons, expansion joints except in pre-cast work, water stops or pile heads embedded in concrete.

The quantities of reinforcing and pre-stressing steel and other items as shown in the Contract Documents which are included in the completed and accepted structure shall be measured for payment as described in 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.

The number of pre-cast concrete members of each type listed in the Bill of Quantities will be the number of acceptable members of each type furnished and installed in the work.

Joints including fillers and expansion joints shall not be measured separately unless they are specified as separate items in the Bill of Quantities.

2.13.24 Payment

The cubic meters of concrete and the number of pre-cast concrete members, as measured above for each type or class listed in the Bill of Quantities, will be paid for at the Contract prices per cubic meter or the Contract unit prices per each member.

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 specified. Such payment also includes full compensation for furnishing and placing expansion joint fillers, sealed joints, waterstops, drains, vents, miscellaneous metal devices and the drilling of holes for dowels and the grouting of dowels in drilled holes, unless payment for such work is specified to be included in another Tender item.

Payment for all type of concrete work shall be considered to be the full compensation for the cost 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 is self-supporting and can perform its intended function.

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.

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	Numbers

2.14 False Work and Forms

2.14.1 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 shal not be less than 75mm in dia 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.

2.14.2 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 term 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^{o} 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 straightedge 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 and all changes and modification 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 from approved standard sized 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 uniform finish. The finish of the concrete, when shuttering and formwork is 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 surface.

The finished surface shall be within the tolerances specified 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 surface shall be within the tolerances specified 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/m^3.

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 $\pm$ 5mm
- Plumb $\pm$ 1 in 1000 of height
- Levels $\pm$ 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^{o} 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/mm^2 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 of the Section on 'Building 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 the structure.

2.14.3 Measurement

Formwork and false work shall not be measured separately but shall be deemed to be an integral part of the concrete items.

2.14.4 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.

2.15 Joints in Concrete

2.15.1 Construction Joints

General

Conduction 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 angles 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. To ensure an excess of mortar at the juncture of the hardened and the newly deposited 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 a round mild steel bar of the diameter and length indicated on the Drawings. The grout shall be a neat cement paste of Portland cement and water or an epoxy. Immediately prior to placing the dowels, the holes shall be cleaned off dust and other deleterious materials shall be thoroughly saturated with water, have all free water removed and the holes shall be dried to a saturated surface dry condition. Sufficient grout or an epoxy shall be placed in 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 dowels 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.

2.15.2 Expansion and Contraction Joints

2.15.2.1 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-moulded 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 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.

2.15.2.2 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.

2.15.2.3 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 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.
- 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.

2.15.2.4 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.

2.15.2.5 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:

- **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/cm^2 (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
  - Tensile strength 193 kg/cm^2 (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.

2.15.2.6 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^{o} 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.

2.15.3 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.

2.15.4 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 made 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.

Item of payment	**Unit**
Expansion joints	Linear meter
Contraction joints	Linear meter

2.16 Wearing Course

2.16.1 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.

2.16.2 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.

2.16.3 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.

2.16.4 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 than 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.

2.16.5 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.

2.16.6 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

2.17 Repair of Existing Concrete Structures

2.17.1 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 Sections titled 'Concrete Work' and 'Reinforcing Steel' of this Specification and the extension work shall be measured and paid for under those Sections.

2.17.2 Materials

Concrete shall conform to the specifications under Section on 'Concrete Work' of this Specification.

Cement mortar shall comply with Section on 'Brick Masonry and Brick Works' of this Specification except that the mix may vary as shown on the Drawings.

2.17.3 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 technical staff are permanently available on 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/she/they propose to adopt is capable of giving a face equivalent to the workmanship standards 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.

2.17.4 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.

2.17.5 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.

2.18 Bearings

2.18.1 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.

2.18.2 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.

2.18.3 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	-0, +3mm
	Design Thickness over 32mm	-0, +6mm
2.	**Overall Horizontal**	
	Dimensions 0.914m or less	-0, +6mm
	Over 0.914m	-0, +12mm
3.	**Thickness of Individual**	
	Layers of Elastomer (Laminated Bearings only)	±20% of design value but no more than ±3mm.
	At any point within the bearings	
4.	**Parallelism with Opposite Face**	0.005 radians
	Top and bottom sides	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**	-0, the smaller of 1.5mm and
	Top and bottom cover layer (if required)	+20% of the nominal cover layer thickness.
8.	**Size**	
	Holes, slots, or inserts	±3mm

2.18.4 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.

2.18.5 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 row 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.

2.18.6 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.

2.18.7 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 expirty 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.

2.18.8 Measurement

The quantity of elastomer bearings shall be measured in set of given dimension as installed and accepted.

2.18.9 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

2.19 Inserts and Fittings

2.19.1 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.

2.19.2 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.

2.19.3 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.

2.19.4 Measurement

The work shall be measured in terms of number of inserts and fittings installed complete and accepted.

2.19.5 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	Number

2.20 Drainage of Structures

2.20.1 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.

2.20.2 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.

2.20.3 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.

2.20.4 Measurement

The work of Rain Water Down Pipes shall be measured in linear meter of such pipes.

2.20.5 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

SECTION-3

REINFORCING STEEL

REINFORCING STEEL

SECTION-3

SECTION-3
REINFORCING STEEL

3.1 Reinforcement for RCC

3.1.1 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.

3.1.2 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/mm^2) 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 a yield strength of not less than 280 MPa (N/mm^2) in case of Grade 40 and with a yield strength of not less than 410 MPa (N/mm^2) 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 a specified yield strength fy exceeding 410 MPa (N/mm^2), fy 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 fy exceeding 410 MPa (N/mm^2), fy 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 (fy) exceeding 410 MPa (N/mm^2), fy 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 a specified yield strength exceeding (fy) 410 MPa (N/mm^2), fy shall be the stress corresponding to a strain of 0.35 percent.

3.1.3 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.

3.1.4 Process

The steel shall have been made by one or more of the following processes:

- open-hearth
- basic oxygen
- electric furnace
- acid besmear

3.1.5 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 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.

3.1.6 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) 4, 5 [13, 16]	 11 12	 9 9

Item	Requirements	
	Grade 40 [300]*	Grade 60 [420]
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].

3.1.7 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] (90^0)	-	9d

* Test bends 180^0 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.

3.1.8 ASTM Code Requirements for Deformations

Deformations shall be spaced along the bar at substantially uniform distances. The deformations on 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^o. Where the line of deformation forms an included angle with the axis of the bar from 45^o to 70^o 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^o, 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 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.

3.1.9 Binding Wire

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.

3.1.10 Wire Mesh

Wire mesh shall conform to the requirements of AASHTO Standard Specification M 55 Welded Steel Wire Fabric for Concrete Reinforcement.

3.1.11 Ordering Material

The name of the proposed supplier (or suppliers) 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 later it enables identification of the steel corresponding to each certificate.

3.1.12 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, if the testing facilities are not available in the LGED Laboratories. Approximately three samples shall be tested from each 10 tons of reinforcement delivered to the Site. Expenses incurred in connection with cutting, carrying and testing the samples shall be borne by the Contractor at his own costs.

3.1.13 Construction Methods of Reinforcing Bar

Storage and care

All reinforcing steel when received on 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 or 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 on 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 and 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^o turn plus an extension of at least 4 bar diameters but not less than 60mm at the free end of the bar.
- 90^o 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^o 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^o 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^o 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^o 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
$10mm \leq d_b \leq 25mm$	$6d_b$
$25mm < d_b \leq 40mm$	$8d_b$
$40mm < d_b \leq 55mm$	$10d_b$

* 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 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
$d \leq 200$mm	$\pm$ 10mm	- 10mm
$d > 200$mm	$\pm$ 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 $\pm$ 50mm, except at discontinuous ends of members where tolerance shall be $\pm$ 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 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 work. 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 block 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 the 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 concreting operations, shall also be removed.

3.1.14 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 storey 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 not more than 135^{o}. 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 a 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..

3.1.15 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 nor 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.

3.1.16 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 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 approval in accordance with the guidelines provided on the Contract Drawings.

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 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/mm^2 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 yeild strength f_y of the bar.

Welded splices or mechanical connections used where area of reinforcement provided is atleast 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/mm^2 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/mm^2 or less or (0.13 f_y – 24)d_b for f_y greater than 410 N/mm^2, but not less than 300mm. For f'_c (specified compressive strength of concrete, N/mm^2) less than 20 N/mm^2, 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 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 yeild 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^o of a right angle to the axis of the bars, and shall be fitted within 3^o 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, buttwelded 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 to 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 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.

3.1.17 Substitutions

Substitutions of different size bars shall be permitted only with specific authorization by the Engineer and at no additional cost to the Department. 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/she/ they require for the execution of the work to the Engineer's satisfaction.

3.1.18 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

3.1.19 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.

3.1.20 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 stagger.

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.

3.1.21 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.

3.1.22 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 Specifications shall be used.

The computed weight shall not include the extra material incurred when bars larger than those specified are used or the extra material 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.

3.1.23 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

3.2 Pre-Stressing Reinforcement

3.2.1 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.

3.2.2 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.

3.2.3 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.

Anchorages 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 $1.25 f_c'$

At transfer Load -
$f_{cp} = 0.8\, f_c' \,(A_b'/A_b - 0.2)^{0.5}$

but not greater than $1.25 f_{ci}'$

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 are 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.

3.2.4 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.

3.2.5 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 $\pm$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.

3.2.6 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/her.

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 $\pm$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.

3.2.7 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, it 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^{o}.

The transfer of the pre-stressing force to the concrete shall be effected 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.

3.2.8 Workmanship

Cleaning

All pre-stressing steel shall be free form 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 carbordum 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 $10^{o}C$.

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.

3.2.9 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.

3.2.10 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

3.3 Welding

3.3.1 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 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 adopted 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.

3.3.2 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.

3.3.3 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.

3.3.4 Peening

The Contractor shall not be allowed to peen welds without prior approval.

3.3.5 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^{o}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.

3.3.6 Cutting and Edge Preparation

Members of structural steel and miscellaneous metalwork 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.

3.3.7 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.

3.3.8 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. Such qualification shall be by and at the expenses of the Contractor.

3.3.9 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 greatest 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 test weld 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.

3.3.10 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.

3.3.11 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.

3.3.12 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.

SECTION-4

BEARING DEVICES

BEARING DEVICES

SECTION-4

SECTION-4
BEARING DEVICES

4.1 General

This work shall consist of furnishing and installing bridge 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 unreinforced elastomer slabs.

Bearings shall be constructed in accordance with the details shown on the plans and specified. When complete details are not provided, bearings shall be furnished that conform to the limited details shown on the plans and shall provide the design capacities for loads and movements shown or specified and the performance characteristics specified.

4.1.1 Working Drawings

Whenever complete details for bearings and their anchorages are not shown on the plans, the Contractor shall prepare and submit working drawings for the bearings. Such drawings shall show all details of the bearings and of the materials proposed for use and must be approved by the Engineer before fabrication of the bearings is begun. Such approval shall not relieve the Contractor of any responsibility under the contract for the successful completion of the work.

4.1.2 Materials

The elastomer to be used for bearings of the bridge, shall conform all specifications as have been stated under the Sub-section 'Construction Materials' of this Specification.

4.1.3 Packaging, Handling and Storage

Prior to shipment from the point of manufacture, bearings shall be packaged in such a manner to ensure that during shipment and storage the bearings will be protected against damage from handling, weather, or any normal hazard. Each completed bearing shall have its components clearly identified, be securely bolted, strapped or otherwise fastened to prevent any relative movement and marked on its top as to location and orientation in each structure in the project in conformity with the plans. Dismantling at the site shall not be done unless absolutely necessary for inspection or installation.

All bearing devices and components shall be stored at the work site in an area that provides protection from environmental and physical damage. When installed, bearings shall be clean and free of all foreign substances.

4.1.4 Specification for Fabrication

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 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 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 in Table 2.8.2.

1.	Overall plan dimensions (1_e, b_e)	-0, +6mm
2.	Total elastomer thickness (h)	-0, 5%
3.	Parallelism	
	a) of top surface of bearing with respect to the bottom surface sadatum	1 in 200
	b) of on side surface with respect to the other as datum	1 in 100
4.	a) Thickness of individual internal layer of elastomer (h_i)	$\pm$20%
		-0, +1mm
	b) Thickness of individual outer layer (h_a)	-0, +1mm
5.	a) Plan dimensions of laminates (1, b)	-3mm, +0
	b) Thickness of laminate	$\pm$10%
	c) Parallelism of laminate with respect to bearing base as datum	1 in 100

4.1.5 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.

4.1.6 Acceptance 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, equipment 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 deemed necessary by him.

All acceptance testing shall be conducted by the inspector with aid of the personnel having adequate expertise and experience in rubber testing provided by the manufacturer, working under the supervision of inspector and to his complete satisfaction.

4.1.7 Quality Control Certificate

A lot under acceptance shall comprise all bearings, including a pair of extra test bearings of equal or near equal size produced under identical conditions of manufacture to be supplied for a particular project.

The size and composition of acceptance lot shall be got approved by the Engineer.

The manufacturer shall certify for each lot of bearing under acceptance:

- that an adequate system of continuous quality control was operated 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 row elastomer used (including name, source, age on shelf), test results of hardness, tensile strength, elongation at break, compression test, accelerated aging etc.

4.1.8 Certificate and Markings

Bearings shall be transported to bridge site after 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.

Name of manufacturer
Date of manufacturer
Elastomer grade used
Bearing dimensions
Production batch No.
Acceptance lot No.
Date of testing
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.

Each bearing shall be marked in indelible ink or flexible paint with an identification number as directed by the Engineer. This number shall be the bearing identification number for test certificates.

Any bearings, which fails the test requirements shall be indelibly marked 'FAILED' and shall not be used in the Work. No payment shall be made for any bearings, which has 'FAILED'.
Any bearings, which passes the requisite tests and satisfies completely the specifications shall be indelibly marked 'PASSED'.

The Contractor shall submit to the Engineer for his approval, a copy of the test certificate containing test results for each bearing, which has passed the tests.

Notwithstanding the above requirements and any consent to proceed with the Contractor of the bearings resulting from such acts shall not prohibit the Engineer from making further inspection, examination, or tests on the bearings afterwards and rejecting subsequently any bearings, if shown to be in non-compliance with this Specification. The Engineer shall reject any bearings with flaws or irregularities.

4.1.9 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 the bearing installed along a single line of support shall be of identical dimensions.

Bearings shall be placed between true horizontal surfaces (maximum tolerance 0.2% perpendicular to load) and at true plan position of their center lines marked on receiving surfaces (maximum tolerance $\pm$3mm). Concrete surfaces shall be free from local irregularities (maximum tolerance $\pm$1MM IN HEIGHT).

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 precast 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 purpose of design.

4.1.10 Maintenance

The bearings shall be subject to planned maintenance care.

The exposed bearing surfaces shall be maintained clean and free from contamination with grease or oil etc.

After installation routing 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 of 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.

4.1.11 Measurement

The work shall be measured in terms of set of elastomer bearings of given dimensions installed complete and accepted.

4.1.12 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

SECTION-5

PORTABLE STEEL BRIDGE

PORTABLE STEEL BRIDGE

SECTION-5

SECTION-5
PORTABLE STEEL BRIDGE

5.1 Portable Steel Bridge

5.1.1 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.

5.1.2 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

5.1.3 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.

5.1.4 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.

5.1.5 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 exenses, 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.

5.1.6 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.

5.1.7 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.

5.1.8 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

SECTION-6

BANK PROTECTIVE WORKS

BANK PROTECTIVE WORKS

SECTION-6

SECTION-6
BANK PROTECTIVE WORKS

6.0 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.

6.1 Grass Turf

6.1.1 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.

6.1.2 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.

6.1.3 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.

6.1.4 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.

6.1.5 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

6.2 Hand Placed Rip-rap

6.2.1 Description

This work shall consist of placing in position of stone boulders on earth or gravel bedding on the embankment slope or bank.

6.2.2 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.

6.2.3 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 1300mmin 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.

6.2.4 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.

6.2.5 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

6.3 Brick Mattressing

6.3.1 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.

6.3.2 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.

6.3.3 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 underneaths 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.

6.3.4 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.

6.3.5 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, 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

6.4 Boulder Mattressing

6.4.1 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.

6.4.2 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.

6.4.3 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.

6.4.4 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.

6.4.5 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 payment	**Unit**
Boulder Mattressing	Square meter

6.5 Sacked Rip-rap

6.5.1 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.

6.5.2 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.

6.5.3 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.

6.5.4 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.

6.5.5 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, 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

6.6 Brick Masonry Blocks

6.6.1 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.

6.6.2 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.

6.6.3 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.

6.6.4 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 triming.

6.6.5 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 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

6.7 Pre-cast Cement Concrete Blocks

6.7.1 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.

6.7.2 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.

6.7.3 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.

6.7.4 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

6.8 Cast-in-Place Cement Concrete Slope Paving

6.8.1 General

The work shall consist of constructing cast-in-place cement concrete slope paving.

6.8.2 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.

6.8.3 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.

6.8.4 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, 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

6.9 Filter Materials

6.9.1 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.

6.9.2 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.

6.9.3 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.

6.9.4 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.

6.9.5 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/m^2 and weigh not less than 0.8 kg/m^2. O_{90} shall not be greater than 0.07mm and the permeability shall not be less than $3.0 \times 10^3 m/s$

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.

6.9.6 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.

6.9.7 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.

6.9.8 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.

6.9.9 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.

SECTION-7

INCIDENTALS

INCIDENTALS

SECTION-7

SECTION-7
INCIDENTALS

7.1 Brick Masonry Works

7.1.1 General

This Section shall apply to all brick masonry works in constructing at the different places of a building.

7.1.2 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.

7.1.3 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 'Building 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 of the Section on 'Building 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.

When sand is subject to five alternations of sodium sulfate soundness test, the weight lost shall not be less than 10 mass percent.

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 of the Section on 'Building Materials' of this Specification.

Water

Quality of water to be used in masonry work shall be similar to the requirements as have been described under the relevant Sub-section of the Section on 'Building Materials' of this Specification.

7.1.4 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.

7.1.5 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 instrucyed 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 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.

7.1.6 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 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 joint 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 work 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.

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.

7.1.7 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.

7.1.8 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.

7.1.9 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 flush 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 off 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.

7.1.10 Repairing of Brickwork

After the completion of any 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.

7.1.11 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.

7.1.12 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.

7.1.13 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.

7.1.14 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.

7.1.15 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

7.2 Brick Flat Soling

7.2.1 Single layer brick flat soling

7.2.1.1 Description

This item of work shall consist of providing single layer brick flat soling as shown on the Drawings or directed by the Engineer and to the lines, grades levels, dimensions and cross sections shown in the Drawings and as required by the Engineer.

7.2.1.2 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 'Building Materials' of this Specification.

Sand

Minimum F.M. of sand for Brick Flat Soling shall be 0.8.

7.2.1.3 Construction Methods

The bricks shall be laid flat in one layer, frog 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 FM 0.8 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.

Laying of bricks and filling the interstices with sand shall be in a manner that no brick shall move under any circumstances.

7.2.1.4 Measurement

Brick flat soling shall be measured in square meter for areas covered by the same and accepted by the Engineer.

7.2.1.5 Payment

This item of work shall be measured as provided above and shall be paid at the relevant Contract unit prices 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 supply of all required materials, including cost of all labour, equipment, tools and all incidentals necessary to complete the work as specified in this Sub-section.

Item of payment	Unit
Single layer brick flat soling	Square Meter

7.2.2 Double layer brick flat soling

7.2.2.1 Description

This item of work shall consist of providing double layer brick flat soling shown on the Drawings or as directed by the Engineer and to the lines, grades levels, dimensions and cross sections shown in the Drawings and as required by the Engineer.

7.2.2.2 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 'Building Materials' of this Specification.

Sand

Minimum F.M. of sand for Brick Flat Soling shall be 0.8.

7.2.2.3 Construction Methods

The first layer of the brick soling shall be laid flat, frog downwards with the shortest side vertical on the compacted, trimmed and prepared surfaces unless otherwise shown on the Drawings or instructed by the Engineer. Interstices of bricks shall be filled with sand of FM. 0.8 and water shall be applied by sprinkling. Then a 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 as stated above. Interstices of bricks shall be filled with sand of FM 0.5 and sprinkling water as did in the case of first layer. No brick 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 on the Drawings.

7.2.2.4 Surface Tolerance

In the areas where Double Layer Brick Flat Soling is 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 of bricks.

7.2.2.5 Measurement

The item of work shall be measured in square meter for areas covered by the same and accepted by the Engineer.

7.2.2.6 Payment

This item of work shall be measured as provided above and shall be paid at the relevant Contract unit prices 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 supply of all required materials, including cost of all labour, equipment, tools and all incidentals necessary to complete the work as specified in this Sub-section.

Item of payment	Unit
Double layer brick flat soling	Square Meter

7.3 Reinforced Concrete Pipe Culverts

7.3.1 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.

7.3.2 Materials

7.3.3 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/mm^2.

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 $\pm$ 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 1/4th to 1/5th 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.

7.3.4 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/mm^2.

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.

7.3.5 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.

7.3.6 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