SESSION-1

Topic: Overview of LGED

Contents

1.0 Administrative norms and practices

2.0 Evolution, Organogram, Sectors, Units of LGED.

3.0 Major Functions of LGED

4.0 Terms of Reference (TOR) of SAE

Session Objective:

At the end of the session the participants will be able to know about overall LGED activities throughout Bangladesh and also able to know about history of LGED. Participants will be aware about their duties and responsibilities.

Time: 1hr 30 min.

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD and Hand out

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will discuss Administrative norms and practices in LGED	15min.
03.	Through a participatory approach, the facilitator will present the history of LGED and will show LGED Organogram, Sectors, and Units of LGED.	30 min
04.	Through a participatory approach, the facilitator will brief major functions of LGED as well as duties and responsibilities of SAE.	30 min
05	The facilitator will conclude the session by getting feedback from the participants.	10 min

Overview of LGED

1.0 Administrative norms and practices

The norms of conduct of public officials and employees that you must observe in the performance of your official duties are as follows:

1.1 Commitment to Public Interest. Always uphold the public interest over and above your personal interest. All government resources and powers of your office must be used efficiently, effectively, honestly and economically, to avoid waste of public funds and revenues.

1.2 Professionalism. Perform your duties with the highest degree of excellence, intelligence and skill. You must serve with utmost devotion and dedication to duty.

1.3 You must also endeavor to discourage wrong perceptions of your role as dispenser or peddler of undue patronage.

1.4 Justness and Sincerity. Remain true to the people at all times. Be honest, just and sincere. Do not discriminate against anyone, especially the poor and the underprivileged.

1.5 You are expected to respect at all times the rights of others and to be honest in all your transactions. Refrain from doing acts contrary to law, good morals, good customs, public policy, public order, public safety and public interest.

1.6 Political Neutrality. Provide service to everyone, without unfair discrimination and regardless of party affiliation or preference.

1.7 Responsiveness to the public. Extend prompt, courteous, and adequate service to the public. Unless otherwise provided by law or when required by the public interest, provide information on policies and procedures in clear and understandable language.

1.8 Ensure openness of information by public interest; provide information on policies and procedures in clear and understandable language. Ensure openness of information by public consultations and hearings whenever appropriate.

1.9 Encourage suggestions, simplify and systematize policies, rules and procedures, and avoid red tape. Lastly, develop an understanding and appreciation of the socio-economic conditions prevailing in the country, especially in depressed rural and urban areas.

1.10 Nationalism and Patriotism. Be loyal at all times to the Republic and to the Bangladeshi people, promote the use of locally-produced goods, resources and technology and encourage appreciation and pride of country and people.

1.11 Commitment to Democracy. Commit yourself to the democratic way of life and values, maintain and/or observe the principle of public accountability, and manifest by deeds the supremacy of civilian authority over the military. You must all times uphold the Constitution and put loyalty to country above loyalty to persons or party.

1.12 Simple Living. You and your family are expected to lead modest lives appropriate to your position and income. Do not indulge in extravagant or ostentatious display of wealth in any form.

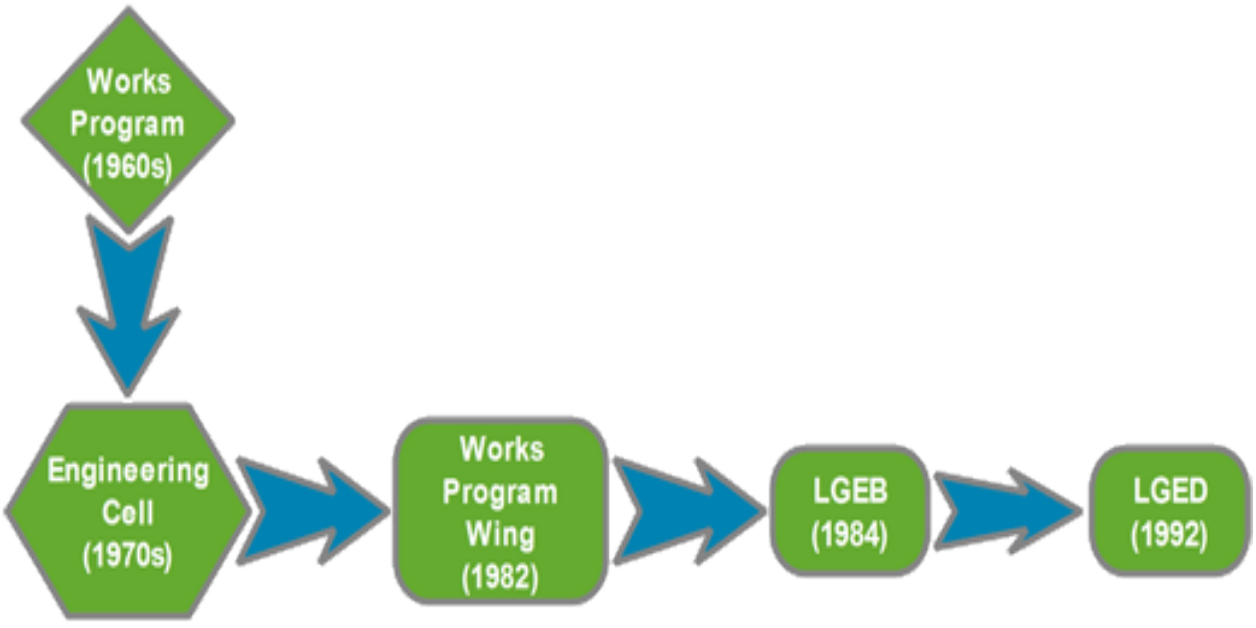
2.0 Evolution, Organogram, Sectors, and Units of LGED).

History of LGED

The rural development paradigm was first conceptualized at Bangladesh Academy of Rural Development (BARD), Comilla in early sixties which is popularly known as 'Comilla Model'. The components of Comilla Model are as follows:

- Two tier Cooperatives - KrishakSamabayaSamity (KSS, i.e. farmers cooperative association) and Thana (Upazila) Central Cooperatives Association (TCCA)
- Rural Works Programme (RWP)
- Thana (Upazila) Irrigation Programme (TIP)
- Thana (Upazila) Training and Development Centre (TTDC)

Three components out of four (except no. 1) are now being implemented by LGED. An Engineering Cell was established in the Local Government Division (LGD) under the Ministry of Local Government, Rural Development and Cooperative (MLGRD&C) in 1970s to oversee the rural works program. To administer rural works program nationwide in an organized approach, the Works Program Wing (WPW) was created in 1982 under the Development Budget. It was transformed into the Local Government Engineering Bureau (LGEB) under Revenue Budget of the Government in October, 1984. LGEB was upgraded as the Local Government Engineering Department (LGED) in August, 1992. The organizational evolution of LGED can be illustrated as follows:



LGED Organogram

LGED HQ Level Manpower: (HQ: 219, Deputation Reserve: 204)

*

Chief Engineer

Additional Chief Engineer (Maintenance, Asset Mgt& Road Safety)	**Additional Chief Engineer (Urban Management)**	**Additional Chief Engineer (Implementation & Building Maintenance)**	**Additional Chief Engineer (Planning, Design & Procurement)**	**Additional Chief Engineer (IWRM)**

LGED Divisions: (Manpower: 60)

Additional Chief Engineer (Dhaka Division)	**Additional Chief Engineer (Rajshahi Division)**	**Additional Chief Engineer (Chittagong Division)**	**Additional Chief Engineer (Khulna Division)**	**Additional Chief Engineer (Rangpur Division)**	**Additional Chief Engineer (Sylhet Division)**	**Additional Chief Engineer (Barisal Division)**

LGED Regions: (Manpower: 140)

Superintending Engineer (Rangpur Circle)	**Superintending Engineer (Rajshahi Circle)**	**Superintending Engineer (Khulna Circle)**	**Superintending Engineer (Faridpur Circle)**	**Superintending Engineer (Barisal Circle)**
Superintending Engineer (Dhaka Circle)	**Superintending Engineer (Mymensingh Circle)**	**Superintending Engineer (Sylhet Circle)**	**Superintending Engineer (Comilla Circle)**	**Superintending Engineer (Chittagong Circle)**
Superintending Engineer (Patuakhali Circle)	**Superintending Engineer (Jessore Circle)**	**Superintending Engineer (Dinajpur Circle)**		**Superintending Engineer (Bogra Circle)**

LGED District Level: (Manpower: 1282)

64 Executive Engineer
(64 District)

LGED Upazilla Level: (Manpower: 9279)

489 Upazila Engineer
(489 Upazila)

Staff in the Office of XEN	Staff in the office of UE
1 Senior Assistant Engineer	1 Assistant Upazila Engineer
1 Assistant Engineer	1 SAE (Construction)
1 Assistant Engineer (Mechanical) (in 22 Gr. District)	1 SAE (Maintenance)
1 District Sociologist	1 Draftsman (SAE)
1 Sub-Assistant Engineer	1 Community Organizer
1 Laboratory Technician	1 Accountant
1 Upper Division Assistant	1 Surveyor
1 Accountant	4 Work Assistant
1 Steno Typist	1 Electrician
1 Jeep Driver	1 Accounts Assistant
1 Truck Driver	1 Office Assistant
1 Road Roller Driver	1 Office Assistant-cum Typist
1 MLSS	2 * Chowkidars
Total =12/13 Nos.	2 MLSS
	Total =19 Nos.

Units of LGED

Administrative Unit	Maintenance Unit
Planning Unit	Procurement Unit
Monitoring & Evaluation Unit	Urban Management Unit
Training Unit	IWRM (O & M) Unit
Design Unit	IWRM (P & D) Unit
ICT Unit	Quality Control Unit

3.0The major functions of LGED can be broadly categorized as follows:

- Rural infrastructure development
- Urban infrastructure development
- Small scale water resources development

Other than those above, LGED is extensively involved with rural infrastructure maintenance program throughout the country.

Rural infrastructure development program:

The main intervention of LGED for rural infrastructure development programs is to develop rural road transport network to improve accessibility to Growth Centers (GC), important social & administrative points and also development of GCs to expand marketing facilities of farm and non-farm products of the rural areas. GCs are economically important markets which play role as economic nucleus of a particular rural area. There are 2100 GCs and 18000 small markets across the country.

The rural infrastructure development activities that LGED implement are listed below.

- Construction of Upazila and Union roads and bridge/culverts on those roads.
- Development of Growth Centers (GC)
- Construction of Union Parishad (Council) Complexes and Primary Schools.
- Construction of Jetty and boat landing.
- Constructions of cyclone shelters and Killas (Elevated earthen place for the shelter of livestock during flood)
- Development of technical specifications and manuals for construction of rural infrastructures.
- Development and updating of rural road master plan, infrastructure database and digital maps.
- Development of Upazila and Union plan book to facilitate local level planning and participation
- Provide technical support to Zila and UpazilaParishads
- Tree plantation on the slope of roads and embankments.

Urban infrastructure development program:

LGED provides technical and management support to Urban Local Government Institutions (City Corporations, City Councils) to implement urban infrastructure development programs. The overall activities are as follows:

- Planning and implementation of integrated town centre (bus terminals, markets etc.)
- Planning and implementation of municipal roads, bridge/culverts, drainage, water supply and sanitation projects.
- Planning and implementation of solid waste management projects

- Planning and implementation of slum upgrading projects
- Development of Land use plan, survey & digital mapping.
- Development of database and software for the use of municipalities to improve planning & management capacity and resources mobilization & management.
- Institutional development of municipalities through training and computerizations.
- Preparation of district and upazilla town master plan.
- Development of technical specifications and manuals for construction of urban infrastructures.

Small scale water resources development program :

The intervention of LGED for small scale water resources development program is limited up to the command area 1000 hectors. LGED implements the program involving the stakeholders during preparation and implementation stages and the operation & maintenance (O&M) of the project is taken-up by stakeholders through WMCA (Water Management Cooperative Association- which is an elected committee by the stakeholders). The overall activities are as follows:

- Construction of flood protection embankment
- Conservation of water for irrigation and improvement irrigation systems
- Construction of water control structures and Rubber Dams.
- Excavation and re-excavation of Canals
- Training to stakeholders and WMCA members

Rural infrastructure maintenance program:

There are total 0.265 million kilometers of roads and 1.2 million meters length of bridge/ culverts under jurisdiction of LGED and LGIs. For detail statistics and conditions of roads and bridge/culverts, see section “RIMMU – Rural Infrastructure Maintenance Management Unit”.

Once a road is developed or a bridge/culverts are constructed, it becomes a public asset. So maintenance of these assets is very vital without which transport systems turn less effective that implicates road safety, vehicle operating cost and many other things.

There are two types of maintenance:

- Routine maintenance
- Periodic maintenance

Other than above, there is Emergency Maintenance for special circumstances like disaster or other natural calamities

The maintenance functions of LGED that RIMMU performs are as follows:

- Update and maintain roads and structure database.

- Prepare annual maintenance plan and budget.
- Develop maintenance guidelines and manuals.
- Conduct traffic and road condition survey

স্থানীয় সরকার প্রকৌশল অধিদপ্তরের উপ-সহকারী প্রকৌশলীদের চার্টার-অব-ডিউটিস (দায়-দায়িত্ব) (Terms of Reference of SAE)

উপ-সহকারী প্রকৌশলী (মাঠ পর্যায়) ঃ

১) তিনি উপজেলা প্রকৌশলীর তত্বাবধানে ও নির্দেশনায় কাজ করিবেন।

২) উপজেলা ও ইউনিয়ন পরিকল্পনা প্রনয়ণে সহযোগীতা করিবেন।

৩) উপজেলা পর্যায়ে উপজেলা প্রকৌশলীর নির্দেশ মোতাবেক পূর্ত কাজের প্রকল্প প্রণয়ন, তদারকি, বাস্তবায়ন ও মনিটরিং করিবেন।

৪) ইউনিয়ন পরিষদের বার্ষিক উন্নয়ন কর্মসূচীর প্রকল্প প্রণয়নে কারিগরী সহায়তা প্রদান করিবেন।

৫) সকল পূর্ত কাজের বিষয় ভৌতও আর্থিক রিপোর্ট প্রণয়ন করে তাহা উপজেলা প্রকৌশলীর কাছে পেশ করিবেন।

৬) উপজেলা প্রকৌশলী কর্তৃক তাহার উপর দায়িত্ব অর্পিত হলে তিনি খাদ্যের বিনিময়ে কাজের স্কীম তত্ত্বাবধান করিবেন।

৭) উপজেলা প্রকৌশলীর নির্দেশে খাল, গভীর ও অগভীর নলকুপের পানি সরবরাহ পদ্ধতি, বাঁধ, স্লুইস গেইট, নিয়ন্ত্রক ক্রসড্যাম, নিষ্কাশন, সড়ক ও কালভাট, পতিত পুকুর সংস্কার ইত্যাদি কাজসহ তিনি ক্ষুদ্র সেচ, বন্যা নিয়ন্ত্রণ ও নিষ্কাশন কাজের পরিকল্পনা গ্রহণ ও বাস্তবায়ন করিবেন।

৮) উপজেলা প্রকৌশলীর নির্দেশক্রমে যন্ত্রপাতির সার্বিক পর্যালোচনা পূর্বক ইনভেন্টরী যাচাই করিয়া তার উপর মতামত উপজেলা প্রকৌশলীর নিকট প্রতিবেদন পেশ করিবেন।

৯) উর্দ্ধতন কর্মকর্তা কর্তৃক সময়ে সময়ে অর্পিত অন্য যে কোন কার্য সম্পাদন করিবেন।

উপ-সহাকারী প্রকৌশলী (বিদ্যুৎ) ঃ

১) অতিরিক্ত নির্বাহী প্রকৌশলী (বিদ্যুৎ) এর সার্বিক তত্ত্বাবধানে ও নিয়ন্ত্রণে সকল কার্যাদি সম্পাদন করা।

২) সদর দপ্তরের যে কোন ধরনের রক্ষণাবেক্ষণ কাজের যেমন, বৈদ্যুতিক সাব ষ্টেশন, ইমার্জেন্সি পাওয়ার জেনারেটিং সিষ্টেম, লিফট, ফায়ার ফাইটিং সিষ্টেম, সেন্ট্রাল এয়ার কন্ডিশনিং সিষ্টেম, পাম্পের বৈদ্যুতিক কার্যাদি ইত্যাদির ক্ষেত্রে সরেজমিনে উপস্থিত থেকে প্রতিবেদন তৈরী করে অতিরিক্ত নির্বাহী প্রকৌশলী (বিদ্যুৎ) এর নিকট দাখিল করা।

৩) সাব-ষ্টেশনের বিভিন্ন কম্পোনেন্ট সম্পর্কে যথেষ্ট জ্ঞান আহরণ করা এবং মাঝে মাঝে প্রয়োজন অনুসারে সাব-ষ্টেশনের যে কোন ত্রুটি দেখা দিলে তাহা উর্দ্ধতন কর্তৃপক্ষকে অবহিত করা ও ত্রুটি মুক্ত করার ব্যবস্থা করা।

৪) এলজিইডির সদর দপ্তরে বিভিন্ন সেকশন-এ বৈদ্যুতিক ব্যবস্থার যেন কোন বিঘ্ন না ঘটে সেদিক নজর রাখা ও উর্দ্ধতন কর্তৃপক্ষকে অবহিত করা।

৫) সাব-ষ্টেশন থেকে শুরু করে প্রত্যেক সেকশন এর বৈদ্যুতিক ওয়ারিং পর্যন্ত কার্যাদি নিজ হস্তে সম্পাদন করা এবং প্রয়োজনীয় সমস্যাবলীর প্রতিবেদন অতিরিক্ত নির্বাহী প্রকৌশলী (বিদ্যুৎ) এর নিকট পেশ করা ।

৬) প্রতিমাসে অন্তত ৭ (সাত) দিন জেলা পর্যায়ে বৈদ্যুতিক অবস্থা সম্পর্কে সরাসরি তদারকি করা এবং প্রতিবেদন সংশ্লিষ্ট নির্বাহী প্রকৌশলী ও অতিরিক্ত নির্বাহী প্রকৌশলী (বিদ্যুৎ) এর নিকট পেশ করা।

৭) এলজিইডির সদর দপ্তর/জেলা পর্যায়ের মাধ্যমে নির্মাণাধীন বিদ্যুৎ লাইন সংযোজনের সময় উপস্থিত থাকা ও কাজ তদারকি করে প্রতিবেদন পেশ করা।

৮) এলজিইডির সদর দপ্তর/জেলা পর্যায়ের অফিস ও আবাসিক ভবন সমূহের বৈদ্যুতিক অবস্থা পরিদর্শন করা ও প্রতিবেদন পেশ করা।

৯) উর্দ্ধতন কর্তৃপক্ষ কর্তৃক সময়ে সময়ে অর্পিত যে কোন দায়িত্ব সম্পাদন করা।

এ্যাষ্টিমেটর(SAE) ঃ

১) নির্বাহী প্রকৌশলী এর তত্ত্বাবধানে ও নিয়ন্ত্রণাধীন থাকিয়া দায়িত্ব পালনকরা ।

২) সকলউন্নয়নমূলককাজেরঅগ্রগতিপ্রতিবেদনউপজেলাহতেগ্রহণকরাএবংযাচাই/বাছাইপূর্বকসংকলিতআকাওেনির্বাহীপ্রকৌশলীরমাধ্যমে সদর দপ্তওে নির্ধারিত সময়ে প্রেরণ নিশ্চিত করা।

৩) নির্বাহী প্রকৌশলী কর্তৃক আহ্বানকৃত সকল দরপত্রের ওপেনিং মেমো প্রস্তুত, তুলনামূল কবিবরণী তৈরী করিয়া উর্দ্ধতন কর্মকর্তার নিকট পেশকরা ।

৪) নির্বাহী প্রকৌশলীর দপ্তরের সকলভবন সমূহের (অফিস/আবাসিক) প্রাক্কলন প্রস্তুত সহ নিয়মিত রক্ষণাবেক্ষণএর কাজ নিশ্চিত করা।

৫) নির্বাহী প্রকৌশলীর দপ্তরের আ্ওতাধীন সকলপূর্ত ও সরবরাহ কাজের প্রাক্কলন প্রস্তুত এবং উপজেলা হতে প্রাপ্ত প্রাক্কলন সমূহের প্রয়োজনীয় পরীক্ষা/নিরীক্ষা করে উর্দ্ধতন কর্মকর্তার নিকট পেশ করা।

৬) নির্বাহী প্রকৌশলীর দপ্তরের প্রাঙ্গন ও নার্সারীর নিয়মিত রক্ষণাবেক্ষণ ও পরিষ্কার/পরিচ্ছন্নতা নিশ্চিত করা।

৭) উর্দ্ধতন কর্তৃপক্ষ কর্তৃক সময়ে সময়ে অর্পিত যে কোন দায়িত্ব সম্পাদনকরা।

নক্সাকার(SAE) ঃ

১) নির্বাহী প্রকৌশলী এর তত্ত্বাবধানে ও নিয়ন্ত্রণাধীন থাকিয়া দায়িত্ব পালনকরা।

২) জেলার সকল প্রকার ম্যাপ তৈরী ও হালনাগাদ করা।

৩) উপজেলা হতে প্রেরিত সড়ক ম্যাপ ও অন্যান্য ম্যাপ সমূহের প্রয়োজনীয় পরীক্ষা/নিরীক্ষা কওে নির্বাহী প্রকৌশলীর মাধ্যমে সদর দপ্তরে প্রেরণকরা।

৪) সকল উন্নয়ন মূলক কাজের তালিকা প্রস্তুত করা এবং তা ডিসপ্লে বোর্ডে প্রদর্শনের ব্যবস্থা করা।

৫) জেলার সকল উন্নয়ন মূলক কাজ জেলা ম্যাপে প্রদর্শনকওে ডিসপ্লে করার ব্যবস্থা করা।

৬) নির্বাহী প্রকৌশলীর দপ্তরের সকল আবাসিক ও অফিস ভবনের নিয়মিত রক্ষণাবেক্ষণ এর দায়িত্ব পালন করা।

৭) নির্বাহী প্রকৌশলীর অফিস প্রাঙ্গনে ও নার্সারীর নিয়মিত রক্ষণাবেক্ষণ ও পরিষ্কার/পরিচ্ছন্নতা নিশ্চিত করা।

৮) উর্দ্ধতন কর্তৃপক্ষ কর্তৃক সময়ে সময়ে অর্পিত যে কোন দায়িত্ব সম্পাদন করা।

SESSION-2

Topic: Quality of Construction Materials

Contents

1.0 Types of Construction Materials

2.0 Common Properties and Field Test of Construction Materials

2.1 Soil

2.2 Bricks

2.3 Sand

2.4 Cement

2.5 M.S Bar

2.6 Water

2.7 Aggregates

2.8 Bitumen

Session Objective:

At the end of the session the participants will be able to understand and also will be able to explain to others about types of Construction Materials, Common Properties and Field Test of Construction Materials.

Time: 1 hour

Methodology

- Lecture Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD and Hand out

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02.	The facilitator will ask the participants about their concept regarding Types of Construction Materials and their physical properties and write their opinion in the white board/poster paper. Later the facilitator will discuss and give clear idea about the types of Construction Materials and their physical properties &Field Test of Construction Materials.	35 min
03.	The facilitator will verify on the participant's learning on the session by asking them about properties of good quality construction materials and way of ensure good quality materials in the field.	10 min
04.	At this stage, the facilitator will complement &repeat the week areas of the participant's learning.	5 min
05.	The facilitator will conclude the session by getting final feedback from the participants.	5 min

Overview

Quality of Construction Materials

1.0 Types of Construction Materials

Construction/Engineering materials commonly used in Bangladesh for construction of infrastructures are usually:

- Soil
- Bricks
- Sand
- Cement
- MS Bar
- Water
- Aggregates
- Bitumen

2.0 Common Properties and Field Test of Construction Materials

2.1 Soil

To the civil engineer, soil is any un-cemented or weakly cemented accumulation of mineral particles formed by weathering of rocks, the void space between the particles containing water and or air.

Broadly soils are divided in two groups:

1) **Non-Cohesive Soil:**
   Some of the individual grains will be visible to naked eye, rough granular appearance, in dry condition when squeezed in hand and when released it will not form into ball. In wet condition may form a ball but will crumble when lightly touched. Cannot be form into ribbon without crack.

2) **Cohesive Soil:**
   Particles too much to be seen. Lumps difficult to break between fingers, sticks to hand when wet. In dry condition forms a stiff lump which can be freely handled without breaking. In wet condition forms a soft ball which can be freely handled without breaking. Can be formed into long thin ribbons and also worked into a compact ball.

The liquid limit and plastic limits are used internationally for soil classification of cohesive soil and for strength correlations**.**

Plastic Limit (P_L**):**The plastic limit of a soil is the moisture content below which the soil behaves as a non-plastic material. The plastic limit (P_L) is an indication of percentage of moisture content at which the soil changes from a semi-solid to plastic state.

Liquid Limit (L_L**):** The liquid limit of a soil is the moisture content below which the soil is plastic. The liquid limit (L_L) is an indication of the percentage of moisture content at which the soil changes from a plastic state to a viscous liquid state.

Plasticity index (PI): The difference between the liquid limit (L_L) and plastic limit (P_L) is the plasticity index (PI) and this gives a good identification of the amount of clay present in the soil. Higher the PI, the greater amount of clay present.

2.2 Bricks

First Class Bricks shall comply with the following requirements:

Appearance: Sound, hard and well burnt, uniform in size, shape and color, homogeneous in texture and shall have plane rectangular faces with parallel sides and sharp straight right- angled edges. They shall be of uniform colour (generally deep red or copper), homogeneous in texture and free form cracks, flaws and nodules of free lime. Shall emit clear metallic sound when struck. When scratched by steel or nails there should be no permanent mark on the surface.

Compressive strength	: 170 kg/cm^2(average of 12 bricks) but
Minimum for individual	:140 kg/cm^2
Maximum water absorption capacity	: 15% of dry weight
Efflorescence	: Nil
Dimensions (+/- 3mm)	: 240mm x 115mmx70mm

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 dimensions slightly below those for first class bricks but not less than 235mm x110mm x70mm.Water absorption, as a percentage of the dry weight, shall not exceed 15%.Crushing strength should be on average 210 kg/ cm^{2}in any individual bricks

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

Field Test of Brick

The following tests may be performed for quick determination of the quality of brick.

Marking Test

Try to make a mark on the surface of the brick by nail. If it is possible to mark, it is not a good brick; if not it is very hard and compact.

Sound Test

Strike a brick with another brick, If the brick gives clear metallic Sound , the brick is good one, if not a bad one.

T-Test

Take two brick and form a '**T'**. The markings on the bricks should be in same side. Drop the T form a height of 4ft. on a more or less solid surface. If they unbroken, they are good bricks. However, the failure of a brick in T-test always does not mean its poor strength.

2.3 Sand

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.

Impurities of sand

Sand shall be clean and free from injurious amount of organic impurities. Deleterious substation shall not exceed the following percentage by weight.

Materials passing No. 200 sieve	: 2.0
Shale, coat, soft or flaky fragments	: 1.0
Sulphur compounds	: 0.3
Clay Lamps (Wet, on No. 4 sieve)	: 0.0

Field Test of Sand

(i) Rub a little sand between figures. Stains left on the fingers will indicate the presence of undesirable clay impurities.

(ii) Stir a sample of sand (1/3rd part of the glass) vigorously in a glass of water and allow it to rest. The amount of clay or silt present in it would settle over the sand in a distinct layer

(iii) Stir a sample of sand in a (3 percent) solution of caustic soda (NaOH) and keep the bottle corked for 24 hours. If the colour of liquid turns brown then the presence of organic matter is indicated.

F.M of Sand

The fineness modulus (F.M) of sand is defined as the sum of the cumulative percentages retained by the standard sieves (ASTM standard sieves 3/8 inch, No.4, No.8, No.16, No.30, No.50 and No.100 respectively) divided by 100. F.M of local river sand found normally 1.2 to 1.5 but desirable minimum value 1.80 for concrete. Sylhet sand on the other hand are relatively coarse grained and have 2.0 to 2.50. In that case local sand can be blended with the Syhet sand to obtain the desired F.M of 1.80.

2.4 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 requirements of ASTM C150 Type 1 or BS 12 BDS 232 or equivalent standard. Special cements shall conform to the requirements provided in writing by 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.

Six types of cement shown in the table below are available in Bangladesh

Name	Bar Code	% of clinker	Remarks
OPC	CEM I	95-100 %	USE GYPSUM UP TO 5%
	CEM II/AM	80-94 %	USE M.A.* UP TO 20%
PCC	CEM II/BM	65-79%	USE M.A.* UP TO 35%
PSC	CEM II/AS	80-94 %	ONLY SLUG USE AS M.A.*
PLC	CEM II/AL	80-94 %	ONLY LIMESTONE USE AS M.A.*
SULFATE	CEMV/A	40-65 %	BELOW 5% OF C.A CLINCKER

*M.A= Mineral Admixture

OPC CEM I & CEM II/AM are commonly used in LGED.

Field Testing of Cement:

Field Testing should be used only for preliminary investigation, and it does not replace the importance of laboratory tests. Some of the common field testing is described below for Port Land Cement:

Feel Test: In this test the hand is plunged into a bag of cement. The cement is then rubbed between the thumb and the forefinger. If it feels cool and not warm and does not have a lumpy or gritty feel, the cement is good.

Floating Test: In this test a handful of cement is thrown into water. If it does not float, but sinks, the cement is good.

Shrinkage Test: The test entails making a thick paste of cement with water on a piece of thick glass. It is then immersed under water for 24 hours.If it does not crack, the cement is good.

Flexure Test: The test requires making a 25mm x 25mm x 200mm (1"x1"x8") block of cement with water. The block is then immersed under water for three days. After removing, it is supported 150mm apart and a weight of 15kg uniformly placed over it. If it shows no sign of failure, the cement is good.

Cement shall comply with the following requirements in the laboratory tests:

Setting Time:
Initial Setting Time : Minimum 45 mins.
Final Setting Time : Maximum 8 hours

Compressive Strength
(Standard 50mm mortar cube)
3 days : 12.4 MN/m^2
7 days : 19.3 MN/m^2
28 days : 27.6 MN/m^2

2.5 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 yield strength of not less than 280MPa (N/mm2) i.e. 40 grade.

High strength deformed rod

Reinforcement steel under this type comprises Grade-60 Deformed re-bars. The steel conform to ASTM Specification A-617M or A-615M with an yield strength of not less than 420MPa (N/mm2). Percent elongation (50mm gauge) minimum 23%.

All bars, prior to its use, shall be clean 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.

ASTM A 615M-16 Weight Requirements and Nominal Area of bars:

Bar designation / Nominal Dia ., mm	**10**	**12**	**16**	**20**	**22**	**25**	**28**	**32**	**36**	**40**	**50**	**60**
Nominal Area, sq.mm	**79**	**113**	**201**	**314**	**380**	**491**	**616**	**804**	**1018**	**1257**	**1963**	**2827**
Nominal Weight, kg/m	**0.617**	**0.888**	**1.578**	**2.466**	**2.984**	**3.853**	**4.834**	**6.313**	**7.99**	**9.865**	**15.41**	**22.2**

Measured unit Weight shall not be less than 94% of the Nominal Weight.

Area and Weight of 22m dia. bar is derived based on principle followed for other sizes in Table above

Actual dia. and TS/YS ratio are provided for informative purpose only. These are not requirements of ASTM A615M-16

ASTM A615M-16 Tensile requirements for Common Steel Grades

	Grade 60 [420]	Grade 75 [520]	Grade 80 [550]
Tensile strength, min. psi [MPa]	90 000 [620]	100 000 [690]	105 000 [725]
Yield strength, min, psi [MPa]	60 000 [420]	75 000 [520]	80 000 [550]
Elongation in 8 in. [200mm], min, %			
Bar Designation No.			
10,12,16,20	9	7	7
25,22	8	7	7
28,32,36,40,50,60	7	6	6

2.6 Water

Water shall be clean, fresh and free from oil, acid, alkali, salts, organic matter in solution or suspension and shall be comparable quality with drinking water. A decrease in more than 10% mortar strength resulting from the use of water when compared with similar mortar made with distilled water, will make the water unfit for use.

2.7 Aggregates:

Construction aggregate, or simply “aggregate”, is a board category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geo-synthetic aggregates

Aggregates of different sizes are being used as natural filler in concrete and road construction.

Aggregates should be durable strong, tough, well graded and free from harmful ingredients. If aggregates are weak, then whatever the quality of cement/ mix-proportion/water-cement ratio/ compaction /curing etc. the concrete will also be weak.

For durable road surface/wearing course in addition to other factors the aggregates must have proper resistance against abrasion.

Aggregates are used in many civil engineering and construction applications including:

a) Reinforced concrete/ Plain concrete
b) Asphalt concrete
c) Base materials for roads
d) Ballast (rail road)
e) Foundation
f) Plaster, mortar, grout, filler materials, etc.

Coarse aggregate:

Coarse aggregate shall be obtained from breaking hard durable rock or gravel, 1st class bricks or Picked Bricks 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 aggregates, it shall produce a workable mixture of maximum density.

Fine aggregate:

Fine aggregate shall be angular (gritty to touch), hard and durable, free from clay mica and soft flaky pieces. Sand shall be clean and free from injurious amount of organic impurities.

Gradation of Aggregates:

Gradation refers to the grain-size composition of a material or the amount of various particle sizes. Gravels and sands are either well-graded or poorly-graded.

Well-graded materials have various amounts of larger and smaller particles such that the voids between the larger particles can be filled with smaller and smaller particles to make a tight, dense and stable mass.

Poorly-graded or uniformly graded materials may have all the particles of nearly same particle size, or same of the intermediate sizes are missing, such that it does not meet the requirements of the well-graded material.

The term **"gap-graded"** is used to indicate an aggregate in which some of the intermediate sizes are missing.

Gradation of aggregates of concrete work and Pavement work can be different according to design and Specifications based on the required design strength and the places. Where they will be used

Brick Aggregates

Brick aggregate shall consist of first class Picked Jhama Brick chips graded as to be specified. All Brick aggregate shall be screened and washed and shall consist of clean, well-shaped cubical particles, free from splintered or flaky particles, soil, organic matter or any deleterious material.

Stone Aggregates

Crushed 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
Specific gravity	:	2.4-2.7
Unit-Weight	:	2245 - 2566kg/cum
Porosity	:	2% -6%
Water absorption	:	1.5%-5% by weight

The stone aggregates shall be of uniform light colour as approved and shall be free from thin lamination, adherent coatings and deleterious substances. The wear loss of stone aggregate of all types shall not exceed 35% by weight when tested by the Los Angles Abrasion Test.

2.8 Bitumen

Bitumen is a black, oily, viscous material that is a naturally-occurring organic by product of decomposed organic materials. Also known as asphalt or tar, bitumen was mixed with other materials throughout prehistory and throughout the world for use as a sealant, adhesive, building mortar etc.

Straight run bitumen: Substance which has come straight from an atmospheric distillation unit and has not been cracked or reformed, and which is usually used as a feedstock or as a utility fuel.

Penetration grades are straight run bitumen classified according to their hardness and are designated by their penetration limits at 25°C in tenths of a mm, with the exception of grade 65/13 (designated by the mid-values of the softening point and the penetration respectively). The grades with penetrations greater than 40 are mostly used in road construction and occasionally in industrial applications. The grades with penetrations less than 40 are used exclusively in industrial applications. BP Penetration Grades 40/50, 60/70, 80/100 and 150/200 hold the South

African SABS 307 mark. They are available from BP's refinery in Durban, South Africa. AT Penetration Grade Bitumen (AT Pen 60/70 & AT Pen 80/100) is widely used in road and airport constructions and other similar applications. It is obtained from the vacuum distillation of an atmospheric residue derived from crude oil.

Bitumen Emulsion: A liquid product in which a substantial amount of bitumen is dispersed in finely divided droplets in an aqueous medium containing an emulsifier and a stabilizer. The emulsifying unit breaks up the asphalt cement and disperses it, in the form of very fine droplets, in the water carrier. When used, the emulsion sets as the water evaporates. The emulsion usually contains55-75% asphalt cement and up to 3%emulsifying agent.

Tars: Asphalt and tars are somewhat similar in appearance and general composition. But they are produced by greatly dissimilar processes and differ sharply in certain properties that are of importance in highway work. Generally speaking, tars are more susceptible to temperature change than asphalts of similar grade. They are toxic in nature, they possess more free carbon than do asphalts, and they harden more rapidly when exposed to the air after being incorporated in a wearing surface or pavement. Tar may be generally defined as a substance obtained by the condensation of distillates resulting from the destructive distillation of organic substances such as wood, coal or peat. Today, tars are not extensively used as binders for highway pavements. Therefore, the subject of tars is only treated lightly here.

Laboratory Tests of Bituminous Material

Different Laboratory Tests are performed on bituminous materials for the purpose of checking compliance with the specifications. Most commonly used tests are:

1. Specific Gravity
2. Solubility
3. Penetration
4. Flash point
5. Softening point
6. Ductility
7. Volatility

SESSION-3

Topic: Road Construction

Contents

1.0 Classification of Roads in Bangladesh

2.0 Rural Road and Road Geometry

3.0 Typical Upazila Road X-section

4.0 Technical Specifications of Layers of Flexible Pavement

5.0 Aggregate grading

Session Objective:

At the end of the session the participants will be able to name, understand and also explain to others aboutthe classes of roads in Bangladesh, Important Road Geometry, draw Upazila road X-sections and narrate technical specifications of road pavement layers as LGED rate Schedule.

Time: 1hour

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD and Hand out

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will present in details the classes of roads in Bangladesh & important geometry of the road.	15min.
03.	Through a participatory approach, the facilitator will explain in detail the Upazila Road X-section and different layers of flexible road Pavement.	20 min
04.	Latter the facilitator will give a class room exercise for drawing an Upazila Road X-section (Practice task), at this stage the facilitator will verify the misconception of participant's learning.	15 min
05	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Road Construction:

1.0 Classification of Roads in Bangladesh

A road is a route or way on land between two places, which typically has been paved or otherwise improved to allow travel by some conveyance, including a horse, cart or motor vehicle. There are lots of road in Bangladesh of various standard, some are earthen, some are paved etc. Higher road system and Rural road are two broad Classifications for which agencies responsible are RHD and LGED/LGI. National road classification is shown below in Table

Table : Description of the Types[τ] , Definitions and Agencies Responsible for Roads in Bangladesh (2003)

Sl. No.	Type	Definition	Ownership and Responsibility
01.	National Highways	Highways connecting National Capital with Divisional HQ/s or seaports or land ports or Asian Highways.	RHD*
02.	Regional Highways	Highways connecting District HQ/s or main river or land ports or with each other not connected by National Highways.	RHD
03.	Zila Road	Roads connecting District HQ/s with Upazila HQ/s or connecting one Upazila HQ to another Upazila HQ by a single main connection with National/Regional Highway, through shortest distance/route.	RHD
04.	Upazila Road	Roads connecting Upazila HQ/s with Growth Center/s with another Growth Center by a single main connection or connecting Growth Center to Higher Road System**, through shortest distance / route.	LGED*/LGI*
05.	Union Road	Roads connecting Union HQ/s with Upazila HQ/s, Growth Centers or Local Markets or with each other.	LGED*/LGI*
06.	Village Road	a) Roads connecting Villages with Union HQ/s, local markets, farms and ghats or with each other. b) Roads within a Village.	LGED*/LGI*
τ	The above road types do not include the roads belonging to the Pourashavas and the City Corporations. The responsibility for development and maintenance of such roads will lie with the respective Pourashavas and the City Corporations.		
*	RHD-Roads and Highways Department, LGED - Local Government Engineering Department, LGI - Local Government Institutions.		
**	Higher Road System - National Highway, Regional Highway and Zila Road.		

2.0 Rural Road

Rural road comprises of Upazila roads, Union roads and Village roads in the rural areas of Bangladesh.

Road Geometry

There are five basic geometric design types for Upazila, and Union Roads all based on traffic characteristics. A traffic criterion for each design type is shown in Table

Table: Geometric Design Standards of Rural Roads

Road Type	Design Type	Daily Commercial vehicles max.	Carriage Way (m)/(ft)	Hard Shoulder (m)/(ft)	Verge (m)/(ft)	Crest Width (m)/(ft)
Upazila Road	Type 4	600	5.5 / 18	0.0 / 0	2.15 / 7	9.8 /32
Upazila Road	Type 5	300	3.7 / 12	0.90 / 3	0.90 / 3	7.3 / 24
Upazila Road	Type 6	200	3.7 / 12	0.0 / 0	1.8 / 6	7.3 / 24
Union Road	Type 7	100	3.7 / 12	0.9 / 3	0.9 / 3	7.3 / 24
Union Road	Type 8	50	3.0 / 10	0.0 / 0	1.25 / 4	5.5 / 18
Village Road	Type 8	50				

Carriageway

A carriage way is that portion of a road which is constructed for vehicular traffic. A carriageway generally consists of a number of traffic lanes together with any associated shoulder, but may be a sole lane in width.

Extra Width of Pavement at Horizontal Curves:

On all horizontal curves some extra width of the carriageway is to be provided. The widening will start at the beginning or tangent point of the transition curve and progressively increases at the uniform rate till the maximum designed widening is reached.

Camber:

Camber or cross-fall is the convexity provided to the cross-section of the surface of carriage way and is the difference of level between the highest point known as the crown, and the edge. It's expressed in percentage. It is provided mainly to drain surface water.

Super- Elevation:

In passing from a straight to curve path, a vehicle is under the influence of two forces, namely (i) the weight of the vehicle, and (ii) the centrifugal force; both of them acting through its centre of gravity. The centrifugal force always acts in the horizontal direction and its effect is to push the

vehicle off the track. To balance this, it is customary to make the road surface perpendicular to the resultant of the above two forces i.e. the outer edge of the road is to be raised above the inner edge. This is known as Super- Elevation.

Road Drainage

One of the major causes of the failure of roads and highways is water. Stability of the road can only be possible to maintain if the surface and foundation remain in a relatively dry condition. Water brings about the destruction of high-ways by:

(i) Washing out unprotected areas of the top surface, erosion of side slopes, erosion of side drain, erosion of shoulder etc.
(ii) Softening the subgrade soil and decreasing its bearing capacity.

Drainage works designed to protect the road from these effects may be grouped under the following heads:

(i) Interception and diversion of the surface water which would otherwise flow across the road or along the road and cause erosion.
(ii) Interception and rapid removal of seepage of sub-surface water.
(iii) Interception and disposal of natural drainage water under the road surface.

Surface Drainage: The collection of water falling on the road surface is made by allowing it to flow to the sides by providing a camber to the road. The road surface is also made impervious as far as possible to prevent the water entering underlying layer. At curves, super-elevation helps to allow the water to flow laterally or obliquely.

Further disposal of this water depends upon the topography and land use and will be considered under the following conditions:

(a) Drainage on rural plain area
(b) Drainage on urban plain area
(c) Drainage in hilly terrain

Drainage on rural plain area: Common practices to allow the flow of water continue across the shoulder and down the side slopes to the natural ground. Where the side slopes, are properly protected by well compaction of shoulder and side slope filling and turf, and flow from the road surface is fairly uniform, erosion will be very little. Where the flow is obstructed collect water at the outer edge of the shoulder from which it is removed and led down the slopes to the natural ground.

Drainage on urban plain area: In urban areas, drainage problem is complicated due to the absence of natural water courses and non-availability of land for open side drain. In such areas, water from the road surface is taken to a system of underground pipes known as storm drains.

Drainage in hilly terrain: For proper maintenance of hill roads, an effective drainage system is very important. In the case of hilly roads surface water is drained by the provision of side drains and catch water drains.

Sub-Surface Drainage: Stability of the road surface depend upon the strength of the subgrade which is its foundation. The strength of the subgrade depends upon the moisture content. It is

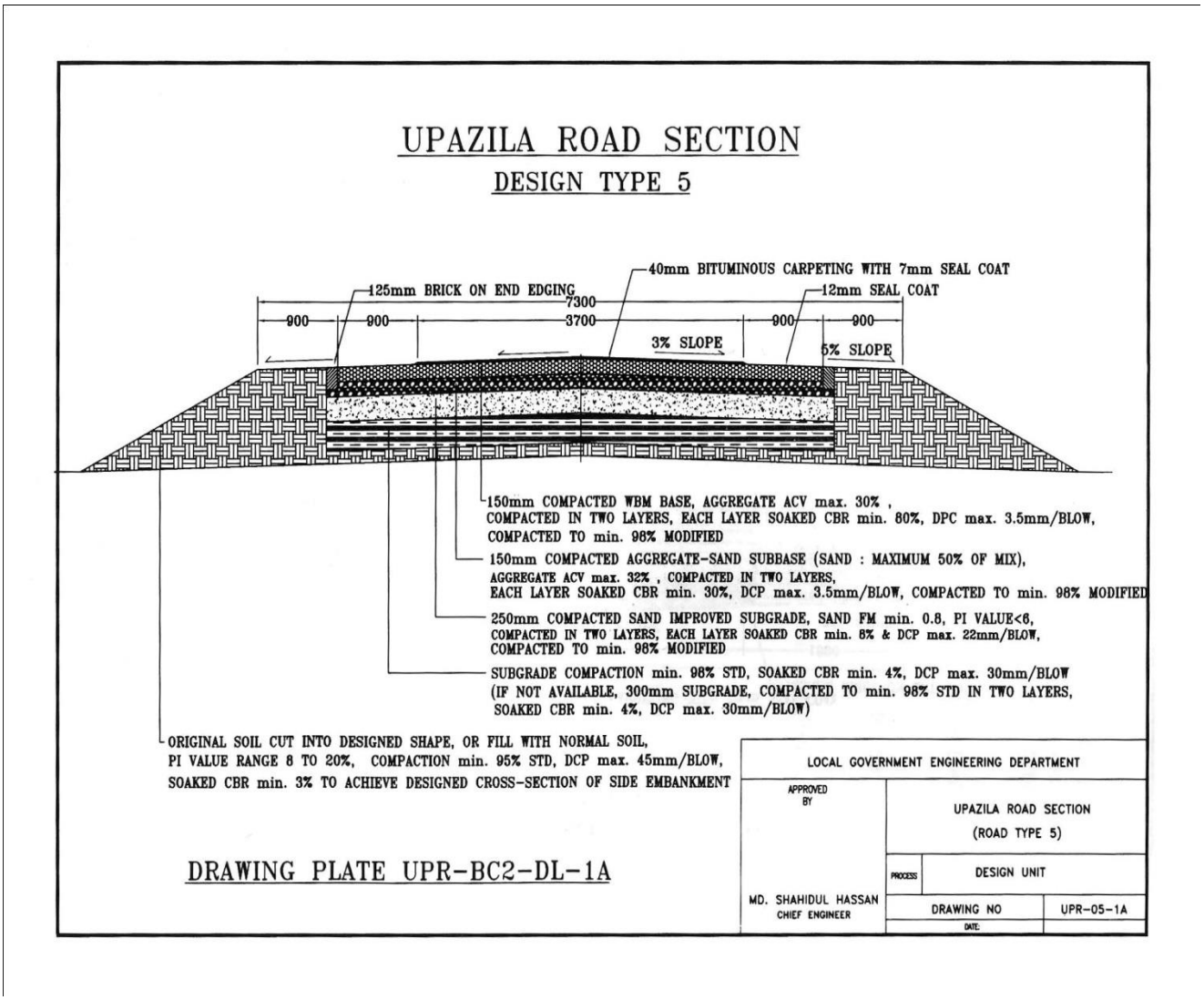
weakest when saturated or oversaturated. There are various causes of moisture variation in subgrade such as Seepage, Penetration of water, Water table rise, Capillary rise etc.

Cross-Drainage: The construction of the road interferes with the natural drainage of the area. The usual methods of taking the water across the road are:

1. X-drains
2. Culverts
3. Bridges
4. Causeways.

3.0Typical Upazila Road X-section

There are five basic design types for Upazila, and Union Roads based on traffic characteristics as shown in the table below. The typical design sections of Upazila Road Design Type 5 is shown below:



4.0 Technical Specifications of Layers of Flexible Pavement

Some important items are highlighted below:

Improved Subgrade (ISG)

a. Sand (FM 0.50) filling on the road bed in the improved subgrade with sand free from dust, earth, other vegetable growth and foreign materials including supplying all materials, spreading, watering, compacted by appropriate mechanical means to obtain a minimum soaked CBR 8% or design CBR at minimum compaction 98% of MDD (Modified) etc. all complete as per direction of the E-I-C.

b. Sand (FM 0.80) filling on the road bed in the improved subgrade with sand free from dust, earth, other vegetable growth and foreign materials including supplying all materials, spreading, watering, compacted by appropriate mechanical means to obtain a minimum soaked CBR 10% or design CBR at minimum compaction 98% of MDD (Modified) etc. all complete as per direction of the E-I-C.

Aggregate sand sub-base:

a. Providing compacted aggregate sand sub-base course with 38mm down brick chips made of 1st class /picked brick (LAA value not exceeding 40) mixed thoroughly with sand of requisite FM to obtain a homogeneous mix complying with the specified grading requirement of the relevant item of Road Design standards – 2005, including mixing, carrying, placing and spreading uniformly in appropriate layer to give specified compacted thickness not more than 100mm in a single layer, watering, compacting by 8~10 tonne road roller at OMC±3% to obtain a minimum soaked CBR 30% at minimum compaction 98% of MDD (Modified), including supplying of all materials, their carriage, labourers tools and equipment etc. all complete as per direction of the E-in-C.

Note: This Item cannot be used without prior permission of CE, LGED

b. Providing compacted aggregate sand sub-base course with 38mm down Crusher run 1st class bricks/picked chips of LAA value not exceeding 40 & sand of minimum FM 0.80 mixed in proportion 1:1 by volume placed in layer(s) to give a maximum compacted thickness of 100mm in a single appropriate layer, mixing properly, watering, compacting with 8~10 tonne road roller to give compaction to 98% of MDD (modified) including supplying of all materials, labourers, tools and equipment etc. all complete as per direction of the E-I-C. Minimum CBR requirement for sub-base course is 30%.

c. Providing compacted aggregate sand sub-base course with 38mm down Crusher run 1st class bricks/picked chips of LAA value not exceeding 40 & locally available sand (Passing <=15% through #200 sieve) mixed in proportion 1:1 by volume placed in layer(s) to give a maximum compacted thickness of 100mm in a single appropriate layer, mixing properly, watering, compacting with 8~10 tonne road roller to give compaction to 98% of MDD (modified) including supplying of all materials, labourers, tools and equipment etc. all complete as per direction of the E-I-C. Minimum CBR requirement for sub-base course is 30%.

Base Course:

a. Providing, laying, spreading and compacting 50mm downgraded crusher run 1st class and Picked brick chips of LAA value not exceeding 40% including supplying of required amount of 12mm downgraded chips made of same quality bricks including supplying and spreading uniformly in layers of specified loose thickness on road surface maintaining grade, camber and super elevation including local handling, hand packing, brooming, watering, dry rolling followed by wet rolling in layers with 8~10 tonne road roller to achieve soaked CBR not less than 80% at a degree of compaction to minimum 98% (Modified Proctor) blinding with local sand as filter material @0.012m3/m2 including cost of materials, labours etc all complete as per direction of the Engineering-in-charge. After adequate dry rolling sprinkling of water and rolling is to be continued until all the voids are filled, wave of grout/slurry flushes ahead of the roller. Thickness of each layer should not be more than 125mm loose and measurement for Payment will be made on compacted thickness.

b. Providing, laying, spreading and compacting 38mm downgraded aggregates as specified in the relevant item of LGED road design standard or wet mix macadam (WMM) specification (LAA value not exceeding 40%) made of 1st class and Picked bricks, combining brick chips of different sizes to provide requisite grading and premixing the material with water at OMC in mechanical mix plant at stack yard including carriage of mixed material by tipper with proper covering to site, laying in uniform layers of specified loose thickness not more than 125mm with Grader in base course on well prepared surface and compacting with 8~10 tonne road roller to achieve soaked CBR not less than 80% at a degree of compaction to minimum 98% (Modified Proctor) including supplying all materials, carriage, labors, tools & equipment etc. all complete as per direction of the E-I-C.

Bituminous Carpeting:

a. 25mm thick compacted pre-mixed bituminous carpeting to be prepared using 20mm down stone-chips (LAA value not exceeding 35%) of gradation as specified, mixed with heated bitumen of 80/100 or 60/70 penetration grade @85kg of heated bitumen per cum of stone-chips. The bitumen and stone-chips shall be separately heated to a temperature 140°C – 155°C and 150°C – 170°C respectively before mixing. The mixing shall be done at temperature between 140°C – 160°C at a separate place away from the fire. The bitumen and stone-chips mixture so prepared shall be laid uniformly in proper camber, grade and super-elevation, only on the prepared and accepted base or surface in a single appropriate layer to give the specified compacted thickness. The mixture should be rolled with appropriate by Steel Drum Roller (1-3 tons) & pneumatic multiple tire roller (8-10 tons) to full compaction. The rolling temperature shall be maintained not below 90°C including supplying of all materials, their carriage, labourers, tools and equipment etc. all complete as per direction of the E-in-C.

b. 25mm thick compacted pre-mixed bituminous dense carpeting with 16mm downgraded crushed stone chips complying with the specified grading requirement of the relevant item of Road Design standards –2005, of LAA value <=35%, water absorption not >2%,

flakiness index not >35% mixed with 60/70 or 80/100 penetration grade heated straight run bitumen satisfying the requirements of ASTM/AASHTO. The bitumen and stone-chips shall be separately heated to a temperature 140oC – 155oC and 150oC – 170oC respectively before mixing. The mixing shall be done at temperature between 140oC – 160oC at a separate place away from the fire. The bitumen and stone-chips mixture so prepared shall be laid uniformly on the road surface in single appropriate layer to give specified compacted thickness in proper camber, grade and super-elevation. The mixture should be rolled at a temperature not below 90oC with Steel Drum Roller (1-3 tons) & pneumatic multiple tire roller (8-10 tons) to full compaction, including supplying of all materials, their carriage, labourers tools and equipment etc. all complete as per the direction of the E-I-C. The bitumen in the mix shall be minimum 5.2% by weight of total mix or as determined by job mix design.

Surfacing:

a. 7mm thick compacted pre-mixed bituminous seal coat to be prepared using 6.33mm down crushed stone of gradation as specified in the relevant item of Road Design Standards – 2005, mixed with 80/100 or 60/70 penetration grade @96kg. Of bitumen per m3 aggregate. The bitumen and chips shall be separately heated to a temperature 140°C – 155°C and 150°C – 170°C respectively. The mixing shall be done at temperature between 140°C – 160°C at a separate place away from the fire. The mixture of bitumen and chips so prepared shall be laid uniformly on the road surface in appropriate layer so as to produce the specified compacted thickness, rolling at a temperature not bellow 130°C with appropriate Steel Drum Roller (1-3 tons) & pneumatic multiple tire roller (8-10 tons) to the desired compaction and blinding with dry sand (Min FM-0.80) @0.005m3 per m2 of road surface, including supplying of all materials, their carriage, labourers tools and equipment etc. all complete as per direction of the E-I-C.

b. Providing Sand Seal with 1.00kg of hot straight run bitumen (60/70 or 80/100 penetration grade conforming to the requirements of ASTM/ AASHTO) and 0.01m3 of sand (F. M. 2.50) per m2 of road surface including cost of materials, heating bitumen from 140°C to 155°C and Pneumatic Multiple Tired Roller (7 tires, 6-8 tons), etc. all complete as per direction of the E-I-C.

5.0 Aggregate grading

Gradation refers to the grain-size composition of a material or the amount of various particle sizes. Gravels and sands are either well-graded or poorly-graded.

Well-graded materials have various amounts of larger and smaller particles such that the voids betweenthe larger particles can be filled with smaller and smaller particles to make a tight, dense and stable mass.

Poorly-graded or uniformly graded materials may have all the particles of nearly same particle size, or same of the intermediate sizes are missing, such that it does not meet the requirements of the well-graded material.

The term **"gap-graded"** is used to indicate an aggregate in which some of the intermediate sizes are missing.

Combined Gradation of Aggregates: The aggregates must be well graded for having minimum voids after consolidation/ compaction, for this; different specifications are available on aggregate for Concrete and Road Construction work which describe the ranges of particles size. Alternatively sometimes Fineness Modulus (F.M.) is specified also. However a fine aggregate of F.M. 2 or 2.5 even may not be well-graded. But in Bangladesh in many construction works, the F.M. is specified and sometimes F.M. is used for combining aggregate either by calculation (through trials) or by graphical method, aggregates should be combined, so that different particle sizes remain within the specified range/gradation limit and it becomes well-graded.

For obtaining either a desired gradation or a desired F.M. economically, blending of different size aggregates is required so that the composite material conforms to the specification.

Gradation of aggregates of Concrete work and Pavement work according to LGED Specifications are given below:

A. Concrete Works:

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
9.50	20-55
4.75	0-10
2.36	0-5

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 Size (mm/ micron)	% Passing by Weight
9.5	100
4.75	95-100
2.36	80-100
1.18	50-85
600	25-60
300	10-30
150	2-10

B. Pavement works:

i) Aggregate Grading for Sub-Base course:

Sieve Size	For graded Sub-Base Course
	% Passing by Weight
38 mm	100
20 mm	55-95
10 mm	35-75
4.75 mm	25-60
2.36 mm	15-50
600 micron	10-35
300 micron	10-25
75 micron	5-15

ii) Grading Requirements for Base Course/WMM:

Sieve Size	% Passing by Weight
38 mm	100
20 mm	60-80
10 mm	40-60
4.75 mm	25-45
2.36 mm	15-32
600 micron	10-20
75 micron	0-15

iii) Aggregate Grading for Bituminous Carpeting (BC):

Sieve Size	25 mmDense Graded BC	40 mmDense Graded BC	50/40 mm nominal BC	25 mm nominal BC
	% passing by weight	% passing by weight	% passing by weight	% passing by weight
25mm	100	100	100	-
20mm	100	75 – 100	75 – 100	100
16mm	100	-	-	-
12.5mm	75-100	60 -80	-	-
10mm	60-80	-	35 – 62	40 – 65
4.75mm	35-55	35 – 55	15 – 35	20 – 40
2.36mm	20-35	20 – 35	5 – 20	8 – 22
600 micron	10-20	6 – 18	-	-
75 micron	2-8	2 - 8	0 - 4	0 - 5

iv) Aggregate Grading for Bituminous Seal Coat (SC)

Sieve Size	For 7 mm Seal Coat	For 12 mm Seal Coat
	% Passing by weight	% Passing by weight
10 mm	-	100
6.3 mm	100	80 – 100
4.75 mm	80-100	70 – 95
2.36 mm	70-95	20 – 50
600 micron	20-50	5 - 15
75 micron	5-15	2 - 10

SESSION-4
Topic: Road Construction Technique

Contents

1.0 General

2.0 Road Embankment Construction

3.0 Road Pavement Construction

4.0 Bituminous Concrete Preparation

Session Objective:

At the end of the session the participants will be able to understand and also explain to others about the technique of good quality road embankment and road pavement construction, narrate important features of road drainage, Gradation of aggregate for flexible road pavement construction and Bituminous concrete preparation.

Time: 1hour

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD and Hand out

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will present in details the important features of Road embankment and Road pavement.	10min.
03.	Through a participatory approach, the facilitator will explain in detail the Road Embankment Construction technique	10 min
04.	Through a participatory approach, the facilitator will explain in detail the Road Pavement Construction technique	20 min
05	Through a participatory approach, the facilitator will explain in detail the Bituminous Concrete Preparation.	10min.
06	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Road Construction Technique

1.0 General

Primarily, the pavements are divided into two categories **(i) Flexible pavement (ii) Rigid pavement.**

Flexible pavement is based on the principle a load of any magnitude may be dissipated by carrying it deep into the ground through successive layers of granular materials that consists of good quality sand, aggregates (brick chips/stone chips), and bituminous materials processed and compacted as per drawing, design and specifications and placed one above other. The common example of flexible pavement is bituminous road with water bond macadam or wet mix macadam.

Rigid pavement is opposed to that of flexible pavement based on providing sufficient strength in the structural slab of cement concrete or reinforced cement concrete. A rigid pavement acts as a beam in the case of depression or settlement of subgrade. In the case of flexible pavement, the depression or settlement in any layers or subgrade is reflected in the successive pavement layers.

Components of a road

A road consists of two parts: Lower part is known as Road Embankment and upper part is known as Road Pavement.

Road embankment is made with the earth mainly. Earthwork is one of the major components of road construction. It is very important as quality of roads dependent on the quality of earthwork. In case of staged construction, earthwork is completed first followed by pavement works of any type in later period. Many of supervising officers consider earthwork as easy task of simple technology but in reality it is of great importance like other high tech works.

Road pavement may be built up in several layers, each layer having a special function. The concrete pavement may rest directly on properly prepared subgrade except on poor subgrades where improved subgrades even a sub base is required underneath. The flexible road pavement is built on number of layers of base course, sub base course etc. rest on properly prepared subgrade except on poor subgrades where improved subgrade is required.

2.0 Road Embankment Construction
Components of a road embankment

- Crest width
- Side Slope
- Berm
- Borrow Pit
- Base width
- Camber

Earthwork encompasses all construction operations required to the road land from its natural condition and configuration to the sections and grades prescribed in the drawing, design and specification. It also referred to as grading and drainage operations in a road project.

Choice of equipment and scheduling of operations are highly important to successful completion of the earthwork. The purposes of earthwork operations are:

(i) To bring the subgrade, together with shoulders, gutters and slope according to drawing and design.
(ii) To eliminate unsuitable materials from the subgrade and from other portions of embankment and their foundations.
(iii) To prevent saturation of soil in service or if the water cannot be eliminated, to stabilize by the use of appropriate materials .

Construction activities

The sequence of construction of earthwork follows a list of activities as below:

- Set the layout of the road. It consists of fixing the longitudinal profile i.e. the path of the road in the longitudinal direction; the transverse profile i.e. right and left sides toes of the mad and finally the height of the road.
- Preparation of the base of the road throughout the bottom width of the road.
- Selection /Collection of specified soilplacing and compacting the soil in layers.
- Finally leveling, dressing and shaping the surfaces to the required shape of the designed section.

Prior to the actual physical construction of earth works, there are various activities that need to be performed. Some of them should be performed by the contractor and some vested as the responsibility of supervising staff.

Layout of Road

Layout of road is the indication of center line, top width, bottom width and height of the road on the real ground. Lay out of the road should be given with the help of pegs so as to locate the alignment of the road. All the pegs in the longitudinal and transverse directions should be placed in such a way that it easily visible to the workers and Supervisors. Red marks may be put for easily visible. The height of the road should also be shown in the post with marks. Some reference points should also be set along the road. The formation level R.L. and chainage of the road should be written on a firm base.

Site Preparation

This denotes clearing and grubbing operations which include removal from the construction area of trees, underbrush, stumps, rubbish, abandoned drainage structures and sometimes other obstructions such as buildings, fences, utility lines etc. It may be desirable to preserve trees, shrubs, etc. growing within road limits.

Selection of soil

Only suitable and satisfactory materials as mentioned in the drawing, design and specifications obtained from road side or from borrow-pits should be placed in embankment. Organic soil should never be used in embankment. Soil contains different sizes of ingredients like clay, silt and sand. Soil property dominants the selection of earth for roads. For construction of road embankment sandy clay or sandy silt is suitable.

Super Elevation

Super elevation is provided on road at the curve. When a vehicle runs on a road having a curve, the outer wheel runs more than inner wheel and due to motion of inertia the vehicle create a tendency to go out off the curve and road. For resisting from the force a super elevation is provided in outer side of the curve. In such cases, the inner side of road is made lower than outer side. The rising of road is called super elevation. The height of rising of outer side depends on the angle of curve.

Grade

This is the slope of road that is provided at the bridge approaches or at the hill. This is also called the vertical slope of road. Generally a slope of maximum 15% is provided.

Benching

Benching is provided on the old road when it is required to extend or widening. It is important to make a farm bond between the old and new earthwork. Though continuous benching are more effective but in majority of cases, staggered benching is provided.

Al first, a bench at the toe of the existing embankment is constructed to form a platform suitable for the equipment to the work. After placing material and compact the layer, the second bench is made and the process is continued until the final layer is reached.

Earthwork Compaction

All earth filling should be compacted either manually or mechanically. Small hand durmus, concrete roller or road roller are used for compaction of soil. Compaction of soil is the process by which soil particles are packed together through a reduction in air voids, generally by manual/mechanical means. The main objectives of compaction are to:

- increase density of soil
- increase shear strength/ bearing capacity
- decrease settlement
- decrease permeability
- increase erosion resistances
- decrease water absorption

Terms related to Compaction

Density of soil: It is the weight of the soil per unit volume. The density may be classified as Dry density or Wet density depending on the moisture content. Wet density is sometimes called bulk density.

$$\text{Density of Soil} = \frac{\text{Wt. of soil}}{\text{Volume of Soil}}$$

$$\text{Wet/Bulk Density of Soil, } \gamma_{wet} = \frac{\text{Wt. of wet soil}}{\text{Volume of Soil}}$$

Moisture Content: The moisture content of the soil is the weight of moisture present expressed as a percentage of the weight of dry soil.

$$\text{Moisture content, m\%} = \frac{\text{Wt. of water}}{\text{Wt. of Dry Soil}}$$

$$\text{Dry Density, } \gamma_{dry} = \frac{\gamma_{wet}}{1 + m/100}$$

Where, m is the moisture content in percentage

Moisture-Density Relationship: For a Particular compactive effort, the density of soil increases with increase in moisture content up to a certain Limit and then the density decreases as the moisture content is further increased. The water content at which the density is maximum is called the optimum water content (OMC) for that particular compactive effort.

In earthwork construction such as embankments, roads etc. it is required that the soil to be Compacted to maximum possible density. Knowledge of moisture-density relationship is therefore very important. The compaction test is used to establish the moisture density relationship for a particular soil and to determine optimum moisture content and maximum dry density.

Factors that Affect Compaction

For a particular type of soil, the factors that affect compaction are:

- Moisture content of the soil, and
- The compactive effort

Compactive effort is defined as the amount of energy imparted to the soil. With a soil of given moisture content, increasing amount of compaction results in closer packing of soil particles and increased dry density. For a particular compactive effort there is only one moisture content which gives the maximum dry density. The moisture content that gives maximum dry density is called

as the Optimum Moisture Content. If the compactive effort is increased, the maximum dry density also increases but the optimum moisture content decreases. The compactive effort means different types of roller e.g. vibratory roller, sheep-foot roller etc.

Measurement of Compaction

Compaction is measured quantitatively in terms of dry density of the soil. % compaction is the term used to compare the in-situ compacted density to the laboratory compacted density under standard condition. % compaction is expressed as

$$\% \text{ Compaction} = \frac{\text{Dry density of compacted field soil}}{\text{Maximum Laboratory Dry Density}} \times 100$$

% compaction may be more or less than 100%. For example, a particular project may specify that soil be compacted to 95%, another project may specify 105% relative compaction.

Field density is measured either by:

a) Core cutter method, or
b) Sand replacement method

Laboratory maximum density is measured by:

a) Standard proctor test, or
b) Modified proctor test

Testing

One of the main supervision tasks is to maintain quality of specified material of work. This is an important component in determining whether the material is acceptable or not and that the work has been carried out of the requirement standard. Test will be carried out at various stage of the work. These cover two elements-

1. The material to be used should be tested to meet the specification; the test shall be carried out prior to the material being laid
2. Earthwork should be sufficiently compacted. This carried out after the layer has been compacted and prior to the laying next layer

There are various types of test related to earthwork. These are - Liquid Limit, Plastic Limit, Plasticity Index, Sieve Analysis, CBR, Compaction etc.

3.0 Road Pavement Construction

Components of flexible road pavement

The structural components of flexible pavement are:

- Subgrade
- Improved Sub-grade (in case of poor sub-grade)
- Shoulder/Hard Shoulder

- Sub base Course
- Base Course
- Surfacing/Wearing Course
- Seal Coat

Sub-grade

The sub-grade is the foundation layer on which the pavement rests and to which the entire load of the structure as well as that of traffic plying on the surface above is ultimately transferred. The sub-grade on an embankment is the upper layer of the earthwork filling and in cut it is the original ground below the area of the road. It is thus the final load carrying part of the structure. A sub-grade must be able to resist the effects of both traffic and weather and therefore the sub-grade should be prepared properly before any subsequent layer over sub-grade is placed. The importance of sub-grade lies in the fact that if it fails, the performance of the whole road will be affected. The sub-grade should possess sufficient strength & stability under most adverse loading & climate condition.

Preparation of Sub-grade

The sub-grade shall be prepared after box cutting for pavement construction. The proper preparation of the sub-grade for any road is of utmost importance before the road structure is laid over it. The sub-grade shall be prepared after box cutting and the sub-grade material should be free from roots, sods or other deleterious material. The sub-grade shall be prepared over the full width of the embankment including shoulder, in lengths of not less than 100 metres and not more than 500 metres at any one time. Half width working may be allowed only with the prior written approval of the Engineer. When existing sub-grade compaction is found less than 95% STD, sub-grade material shall be excavated to a depth of 150mm and stocked piled and further 150mm should be scarified. The excavated top layer material shall then be spreads and compacted as specified. But if natural compaction of sub-grade is found 95% STD available, two or three pass of 3-5 ton vibratory roller or 6-8 (min) static rollers over natural sub-grade are specified. The compaction shall be done in a longitudinal direction along the embankment and generally begin at the outer edges and progress toward the centre in such a manner that each section receives equal compaction effort. The moisture content at the time of compaction shall be kept ± 5% of optimum moisture content. The CBR (soaked) of sub-grade material shall be tested and it would be comply with desired value.

Improved Sub-grade

It is an intermediate layer between weak sub-grade and the sub-base. In Bangladesh, the sub-grade strength is normally low and the provision of improved sub-grade will make the pavement more economical. Improved sub-grade should have CBR not less than 10%.

Improved Sub-grade material shall be of natural sand, free from vegetable mater, soft particles and excess clay with free draining properties. F.M of sand shall not be less than 0.5. The plasticity index (PI) of sand would be <6. The soaked CBR of sand would be >10% at 100% of MDD determined by standard proctor test.

Improved Sub-grade Construction

An improved sub-grade made of sand may be obtained by the following steps:

- The sub-grade shall be shaped and compacted properly at least for a length of 100 metres ahead of placing of the improved sub-grade material. Any damage to or deterioration of sub-grade shall be rectified before improved sub-grade is laid.
- Prior to spread of the improved materials, full width of shoulder shall be constructed to the elevation of the top of design pavement.
- Sand of F.M 0.5 shall be spread in layers with compacted thickness up to 150mm.
- Immediately after each layer has been spread and shaped to camber or super elevation satisfactorily, it shall be compacted thoroughly with mechanical compaction. Rolling operations shall begin from the outer edge of the roadbed towards the centre, gradually in a longitudinal direction, expect on super elevation curves, where rolling shall begin at the low side and progress toward the high side.
- The moisture content at rolling shall be optimum moisture content (standard compaction) ±3%.
- Each layer shall be compacted to at least 100% of the maximum dry density achieved from standard proctor test. If the density measurement falls below the specified density level the further compaction shall be required irrespective of the field compaction trial result.
- Before starting the compaction, the improve sub-grade material shall be tested for determining the moisture content in the sand, if moisture content found less than specified, the material has to be reworked and watered properly so that the moisture in the sand remain ±3% of the optimum moisture content.
- The finished improved sub-grade at any point neither shall nor vary more than 20mm above or below the planned grade or adjusted grade. The thickness of the finished improved sub-grade shall be on average not less than the required thickness at any point and the average of five thickness measurement in any 100 meters of road shall be not thinner than 15mm less than the required thickness.

Shoulder Construction

The shoulders form the essential part of the roadways for the following reasons:

- The vehicles can be parked for a while on this extra width in the case of an emergency e.g. for change of tyres or for minor repair works.
- The capacity of the highway is increased since there are better opportunities of overtaking
- Helps to reduce the chances of accidents.

- Spaces are available for erection /installation of roadway signs and signals, tree plantation etc.
- Improve the general appearance of highways and gives confidence on driving.
- Rain water is drained away from the pavement, this increases the life of the pavement.
- Sight distances are improved.
- Shoulder provides lateral support to edge of the road pavement structure this increases the life of the pavement.

Therefore, it is very important to have sufficient usual width of the shoulder. In rural road shoulder width vary from 1.25 m to 2.1m

Hard shoulder: The work consists of providing a hard wide strips of shoulders adjacent to the pavement on either side. The width of shoulder on either side of pavement is 600 to 900mm. Brick khoa and local sand blended in proportion of 1:1 may be used as hard shoulder material. The mix shall then be spread in layers of uniform thickness not exceeding 150mm, sprinkled with water and compacted. The compaction and CBR requirement of hard shoulder is 98% (standard) and 25% respectively.

Earth shoulder: Like hard shoulder, it is provided on either side of the pavement but the material for earth shoulder is same as that of sub-grade. The material shall be spread in layers of uniform thickness not exceeding 150mm and compacted to 95% (standard Proctor).

Construction procedure

a) Box cutting up to sub-grade level and compacting the sub-grade over the full width of carriageway and hard shoulder.

b) Laying the improved sub-grade layer over full width of carriage way (If no hard shoulder) and laying of soil in the portion of earthen shoulder. Then compact both the layers in carriage way & hard shoulder together.

c) Laying the sub base over carriageway and improved sub-grade material over hard shoulder (a separator may be used). Compact the layer over the carriageway and hard shoulder prepared in stepped at a time.

Sub-base Course

Sub base course is the layer immediately under the base course. Sub base course is provided to minimize the overall cost for pavement construction. It is the secondary load spreading layer of the pavement and load on the improved subgrade/subgrade is very much dependent on the strength of this layer.

The sub-base is composed of aggregate and sand, or sand-soil mixture or soil treated with binding agents. The construction of sub-base consists of laying and compacting the sub-base material on prepared subgrade or improved sub- grade (if any) in layers. Aggregate and sand shall be mixed in proportion 1:1 or as specified. Minimum F.M of sand shall be 0.5. Sand should be free from vegetable mater, soft particles and clay with free draining properties.

The thickness of each layer depends on the total thickness of sub-base. Thickness of each layer should not be more than 100mm loose. The CBR (soaked) of sub-base should not be less than 30% or as specified.

Sub-base construction

The work consists of providing, laying, and compacting sub- base material over improved subgrade to the lines, levels dimensions and cross-sections as required. The sub-base material shall consist of homogeneous mixture of brick aggregates or shingles and local sand. The brick aggregates may be obtained from crushed over-burnt, first class or picked Jhama bricks. The grading requirement of sub-base material shall conform to the grading curve as shown in Table below or as specified.

Table: Aggregate grading for Sub Base course:

Sieve Size	38 mm	20 mm	10 mm	4.75 mm	2.36 mm	600 micron	300 micron	75 micron
% passing	100	55-95	35-75	25-60	15-50	10-35	10-25	5-15

The other requirements of aggregates are:

- Water absorption shall not exceed 16%
- Los Angeles abrasion test (AASHTO Desination-T-99) with a percentage of wears not exceeding 40 at 500 revolutions.
- Flakiness Index (BS-812) 15%
- Aggregate Impact value of not more than 32% (BS-812)

The brick aggregates and sand shall be mixed thoroughly before placing it on improved sub-grade. The mixed material shall be spread uniformly upon the prepared improved sub-grade in such quantities that the thickness of the layer after compaction shall be 100mm. The relation- ship between the loose thickness and compacted thickness shall be determined from field trials and used in controlling the loose thickness at the time of spreading the mix. After spreading has been completed and the surface shaped according to the sectional requirements, rolling shall commence by mechanical means (8-10 ton roller). The rolling shall continue until the mix has attained the required compaction (98%) and CBR as specified.

Base Course

Base Course is the layer immediately under the surface course. It is the main road spreading layer of the pavement and the life of the road is very much dependent on the strength of this layer. The function of the base course is to withstand the high shearing stresses imparted by concentrated loads at the surface and to distribute these loads to underlying layers of the pavement. The base course thickness depends upon the nature of the traffic and the bearing capacity of the underlying layers (sub-grade, improved sub-grade, sub-base), so that the base is not over stressed.

Base course of bituminous pavement that normally practiced in LGED are Water Bond Macadam or Wet Mix Macadam.

Base Course / WBM Construction

Base course Material

The base course Material shall consists of crushed first class bricks and/or picked Jhama brick aggregates well-graded and of desired strength.

The broken bricks shall comply with the following requirement:

- Water absorption shall not exceed 16%
- Maximum nominal size of aggregates shall be 38mm according to ASTM-C-131
- Los Angeles abrasion test (AASHTO Desination-T-99) with a percentage of wears less than 40 at 500 revolutions.
- Flakiness Index (BS-812) 15%
- Aggregate Impact value of not more than 32% (BS-812)
- The socked CBR value not less than 40% for first layer of maximum 100mm compacted thickness and not less than 80% for second layer and third layer of maximum 100mm compacted thickness each
- Grading Requirements for Base Course

Sieve Size	38 mm	20 mm	10 mm	4.75 mm	2.36 mm	600 micron	300 micron	75 micron
% passing	100	60-80	40-60	25-45	15-32	10-20	-	0-15

The material shall be well graded meeting the gradation envelop having no excess or deficiency in any size.

Preparation of Base course/WBM

The material shall be spread in layers and the compacted thickness shall not exceed 100mm. Rolling should be done by 8-10 ton power roller. Rolling shall begin at the outer edge with the rear wheel overlapping the shoulder. When the broken aggregate become firm, the rolling will shifted to the opposite of the road and the operation will be repeated. After both edges rolled modestly firm, the roller will be gradually moved towards the center by overlapping 150mm of the rolled width until the entire base course thoroughly compacted. The base course shall be compacted in such a way that it achieved the value of CBR as specified. The field density shall be checked at least once every 100 linear metre of base course surface.

The finished surface of the base course shall in no place be more than ± 10mm from the designed level and the mean of five measurements of the thickness taken in any 200 metres long section shall be equal to or more than the required base course thickness.

WMM Base Course Construction

Brick aggregates of WMM base course will be 38mm downgraded aggregates as specified in the relevant item of LGED road design standard as in wet mix macadam specification that made of 1st class and picked bricks combining brick chips of different sizes (38mm downgraded and 19mm downgraded mixed with fine particles of same materials) to provide requisite grading and premixing the materials with water at OMC in mechanical mix plant at stack yard. Laying in uniform layers of specified loose thickness no more than 100mm with grader on well prepared surface maintaining camber, super elevation, gradient etc. And compacting with 8 to 10 tons vibratory road roller to attain minimum soaked CBR 80% or design CBR at a degree of minimum compaction 98% (Modified Proctor).

Surfacing/Wearing Course

The surfacing also known as wearing course forms the upper most layers in the road structure and receives the traffic load directly on its surface. It is also provides a good riding surface. The principal functions of the surfacing are

- To waterproof the base against the penetration of surface water and
- To resist the effects of abrasion and impact caused by the wheel load.

In other words, it act like a roof to shed a large portion of the rain water and thereby protect the lower layers of base courses and the sub-grade from getting wet and softening or swelling. There should not be any loss of surface materials due to abrasive action and suction effect of traffic. Surface courses are constructed of materials consistent with traffic needs and economy.

It is the riding surface of the road. The main function of this course is :

-to transmit the traffic load safely to the base course
-to act as an impervious layer (waterproof)
-to withstand abrasion etc.
Different types of Surfacing/Wearing Course commonly in use are -

o Surface dressing/Surface Treatment (SBST or DBST)
o Premixed seal coat
o Carpeting with seal coat
o Asphalt concrete surfacing etc.

Types of wearing courses practiced in LGED are –

(i) 15mm thick (minimum) compacted premixed bituminous surfacing
(ii) 25mm thick (minimum) compacted premixed bituminous carpeting (25mmBC)

(iii) 25mm thick (minimum) compacted premixed bituminous surfacing -wearing course (25mmDC)
(iv) 40mm thick (minimum) compacted premixed bituminous carpeting (40mmBC)
(v) 40mm thick (minimum) compacted premixed bituminous surfacing -wearing course (40mmDC)
(vi) 50mm thick (minimum) compacted premixed bituminous carpeting (50mmBC)
(vii) Premixed dense bituminous surfacing-wearing course as per design Job Mix Formula with hot mix plant and paver machine at specified compacted thickness (DCPM)

Bituminous surfacing also includes the following as well

- Prime coats
- Tack coats
- Seal Coats

Prime coat: When a bituminous wearing surface is to be placed upon a previously untreated compacted foundation layer, such as earth, sand-soil-aggregate, sand-aggregate, water-bound macadam, wet mix macadam or similar absorptive bases, the base is generally given a single application of liquid bituminous material called Prime coat. The bituminous material used for prime coats should have high penetrating qualities. Normally Prime coat shall provide @1.2liter/sqm with cut back bitumen to be prepared by cutting back 60/70 or 80/100 penetration grade straight run bitumen in the ratio of 100 parts by volume of bitumen to 40-60 parts by volume of kerosene depending on the porosity of the surface and will be decided by field trials, the correct quantity that will be completely absorbed within 24 hours. Spraying cut-back bitumen at a temperature from 100^{o}C to 120^{o}C.

Tack coat: Tack coat is a single initial application of bituminous material on surfaces which have previously been treated or prepared such as existing bituminous layer, cement concrete, etc. Simply to insure adhesion between the existing surface and the new bituminous surface. Normally tack coat shall provide @0.50 to 0.75 kg/sqm or as specified with 60/70 or 80/100 penetration grade straight run bitumen at a temperature between 175^{o}C to 185^{o}C.

Seal coat: Seal coat may be defined as a very thin surface treatment which is either applied as a final step in the construction of certain bituminous surfaces or to existing surfaces which have cracked or oxidized over a number of years and have begun to ravel. Purpose of seal coat are: To water proof or seal the surface and thereby prevent the deterioration of the surfacing from moisture and air. To protect the surfacing from abrasion caused by heavy traffic. It may also improve night visibility.

Premixed bituminous carpeting

The work consists of preparing and laying premix on the base course layer to the lines, levels, grades, dimensions and cross-section. The stone chips, fine aggregates and bitumen are used for carpeting. The bituminous material of 60/70 (Preferable) or 80/100 penetration grade are used as a binding material. The stone chips (16mm down graded) should be free from organic matter, clay or other deleterious material and LAA value not exceeding 35%. Natural sand, stone screening or combination of both may be used as fine aggregate. The grading requirement of carpeting is shown in Table below:

Table: Grading Requirement of Carpeting

Sieve Size	25 mm Dense Graded BC	40 mm Dense Graded BC	50/40 mm nominal BC	25 mm nominal BC
	% passing by weight	% passing by weight	% passing by weight	% passing by weight
25mm	100	100	100	-
20mm	100	75 – 100	75 – 100	100
16mm	100	-	-	-
12.5mm	75-100	60 -80	-	-
10mm	60-80	-	35 – 62	40 – 65
4.75mm	35-55	35 – 55	15 – 35	20 – 40
2.36mm	20-35	20 – 35	5 – 20	8 – 22
600 micron	10-20	6 – 18	-	-
75 micron	2-8	2 – 8	0 – 4	0 – 5

The bitumen and the aggregates shall be heated separately to the required temperature between 140oC to 160o C and 150oC to 170o C respectively before mixing at a separate place away from the fire. The bitumen in the mix shall be @4.5% to 5.5% by weight of the total mix or as determined by job mix design. The mixing operation will continue until a uniform colour is obtained and all aggregates are coated with bitumen. Before laying premixed carpet, a prime coat with cut-back (Bitumen that has been rendered liquid by fluxing it with a light volatile petroleum distillate. Upon exposure to atmospheric conditions the volatile distillate evaporates leaving the bitumen behind) shall be applied at a rate of 1.2 kg/sq.m to the clean ,washed and dried surface of base course. The cut-back bitumen may be prepared by mixing bitumen (80/100) and kerosene in the ratio of 60:40. The temperature of bitumen during mixing should be 80^{o}-90^{o}C.The purpose of application of prime coat are : waterproof the existing surface, promote adhesion between WBM soft aggregate base and bituminous layer to be supplied subsequently, plug the capillary thereby preventing the capillary rise of water, coats and blends dust and loose particles thereby hardening and toughening the surface. The prime coat should be spread along the length of the road and should be cured for 24 hours. The premix material shall then be laid to a uniform thickness in proper camber, grade, and super elevation only on the prepared and accepted base in a single appropriate layer to give the specified compacted thickness. After laying, the material shall be compacted with a Steel Drum Roller (3 to 5 tons) & pneumatic multiple tire roller (8/10 tons) to full compaction. The rolling temperature shall be maintained not less than 90^{o}C. The sections of newly finished work shall be protected from traffic of any kind for at least 6 hours.

Premix bituminous seal coat

The work consists of providing the premix seal coat over the carpeting. The materials to be used in the premix are – pea- gravel, sand and bitumen. The pea-gravels shall be 6.3mm downgraded and

free from any organic matter, clay or any other objectionable matter. The sand shall be non-plastic, clean, and free from any deleterious substances and have FM > 0.80. The bitumen of 60/70 (Preferable) or 80/100 penetration grade minimum @5.0% by weight of total mix or as determined by job mix design. The grading requirement of overall aggregates is shown in Table below.

Table- Aggregate Grading for Bituminous Seal Coat

Sieve Size	For 7 mm Seal Coat	For 12 mm Seal Coat
	% Passing by weight	% Passing by weight
10 mm	-	100
6.3 mm	100	80 – 100
4.75 mm	80-100	70 – 95
2.36 mm	70-95	20 – 50
600 micron	20-50	5 - 15
75 micron	5-15	2 – 10

Like carpeting, bitumen and aggregates shall be heated separately to a temperature between 140^{o}Cto 155^{o}Cand 150^{o}C to 170^{o}C respectively before mixing at a separate place away from the fire. The mixing operation will continue until a uniform colour is obtained and all aggregates are coated with bitumen. After laying a tack coat @ 0.75 kg of bitumen per square metre to the clean & dry carpeted surface, the pre-mix seal coat is laid uniformly and compacted to give the specified compacted thickness. After laying, the material shall be compacted with a Steel Drum Roller roller (3 to 5 tons) & pneumatic multiple tire roller (8/10 tons) to full compaction. The rolling temperature shall be maintained not less than 90^{o}C. The vehicle may be allowed on the surface after 6 hrs.of completion of seal coat.

Bituminous Surface Treatment (DBST or SBST)

This treatment is constructed by spraying hot bitumen on the base (WBM or WMM) and immediately covering it with stone chips of the specified size. The roller then pushes the stone chips into the bitumen so that they remain sticking to the road. The most important requirement is that rolling is carried out immediately after the stone chips are spread and in turn the stone chips must be spread immediately behind the tar spryer.

Rolling must start within 3 minutes of spraying bitumen. A pneumatic rubber tyred roller is most suitable but a steel wheeled dead weight roller can be used. The whole area should have 3-passes again from the outer edge to the centre and with an overlap of ½ roller width. At the end of the day a further 3 passes should be given. A second layer may be done in the some way after a week in which the traffic has been allowed to pass.

Heavy Equipment for road construction:

- Excavators
- Backhoe loader
- Bulldozer
- Grader
- Dump Truck
- Road Roller (Vibrating Roller, Dead weight steel roller)
- Rubber Tyred Roller
- Asphalt Pavers
- Truck loader
- Compactor

SESSION-5

Topic: Understanding of Drawings

Contents

1.0 General

2.0 Detailed Map;

3.0 Location Map/Site Plan and Lay out Plan

4.0 Reading of Working drawings of Culvert

5.0 Reading of working drawings of Bridge

Session Objective:

At the end of the session the participants will be able to understand and also explain to others the Master plan; Site Plan; Working drawing of Culverts and Working drawing of Bridges.

Time: 1hour

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out& Working drawings of Bridge & Culvert in A3 Sheet.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will present in details the standards and salient features of engineering drawings in general.	10min.
03.	Through a participatory approach, the facilitator will explain all the features of working drawings of a culvert.	15 min
04.	Through a participatory approach, the facilitator will explain all the features of working drawings of a bridge.	15 min
05	At this stage, the facilitator will give a class room task in groups (5 to 6 participants in one group) and introduce a specific questioner on Bridge and Culvert Working drawings (Annex-) where the participants are to be	10min

	answered the questionnaire following the set of bridge/culvert working drawings in Annex- .	
06	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Understanding of Drawings

1.0 General

Drawing: Drawing is an essential tool for supervision. Drawing provides various details such as length, width, height, depth, finished level, finished shape, orientation/position, views, working details of Formwork, Working details of cutting, bending and binding of reinforcement bars (Bar Schedule) and all interior and outer features to be provided. There are different types of drawing such as Plan, Elevation, the longitudinal profile, Horizontal and vertical cross section of the structure, layout etc.

Orientation: Orientation of structure means setting the plan of the structure and gives it particular direction. Fundamentals of orientation vary on site condition from structure to structure and place to place

2.0 Detailed Map

Detailed Map shows the details of the site where the structure is proposed to be built. When the tentative location of the project is identified the detailed map of the location can be prepared by field surveying, conveniently by taking offsets around by open traverse or by stadia surveying or by plane tabling. The detailed map is required to ascertain the final location and span/length of the structure to be built. In any type of surveying, the alignment of the road on which the structure is to be built may be taken as reference line. The bearing of the reference line with respect to the north line should be recorded on all survey maps.

3.0 Location Map/Site Plan and Lay out Plan

Site Plan (Annex-I) is required to be made to show the physical location of the structure on the alignment in relation to existing important features like roads, canals, markets, schools, agricultural fields etc. Location Map locates the proposed structure showing the starting and ending points on which the structure is to be built. Location map indicates the direction of flow of water, slope of the land, catchment area along with channel upstream and downstream of the proposed location of the structure.

Lay out plan (Annex-I) is required to set out the structure physically in the site before commencement of the excavations of foundation trenches. Lay out plan is fully dimensioned.

3.0 Working drawings of Culvert

A set of working drawings of a culvert is attached in **Annex-II** for details discussion and class room exercise by the participants. For this purpose the participants will be divided into groups, each group will have members of 5 to 6 participants.

Through a participatory approach, the facilitator will explain all the features of working drawings of the culvert. Latter, the facilitator will give a class room task in groups and introduce a specific questioner on Culvert Working drawings **(To be P\provided during group work)** where the participants are to be answered the questionnaire following the set of culvert working drawings in **Annex- II** .

At this stage the facilitator will assist each group and verify the misconception of participant's learning.

4.0 Working drawings of Bridge

A set of working drawings of a Bridge is attached in **Annex-III** for details discussion and class room exercise by the participants. For this purpose the participants will be divided into groups, each group will have members of 5 to 6 participants.

Through a participatory approach, the facilitator will explain all the features of working drawings of the bridge. Latter, the facilitator will give a class room task in groups and introduce a specific questioner on Bridge Working drawings shown at the end of this topic where the participants are to be answered the questionnaire following the set of bridge working drawings in **Annex- III** .

At this stage the facilitator will assist each group and verify the misconception of participant's learning.

Class room exercise on Understanding of Drawings
(Group work)

Read out the working drawings of the bridge attached in **Annex- III** and give answer of the following quarries:

1 Length of the bridge:
2 Girder length of mid span:
3 c/c distance of two abutment:
4 Total width of the bridge:
5 Width of carriage way:
6 Length of return wall:
7 Height of railing post:
8 Height of wheel guard from level of deck:
9 c/c distance of the railing post:
10 Size of railing post:
11 Thickness of deck Slab:
12 Thickness of wearing course:
13 Length of the girder of end span:
14 Width of the girder:
15 Depth of the pile cap of pier:
16 No. of piles in abutment:
17 Diameter of piles and length of abutment piles:
18 Length of pile in pier:
19 Diameter of main bar need in piles & pier:
20 Spacing of pitcher of spiral in piles of pier:
21 R.L level of bridge deck at centre:
22 Clear cover of pile and pile cap:
23 Diameter of pier column:
24 Width & depth of diaphragm:
25 c/c distance of girder:
26 Size of CC block:
27 c/c distance and diameter of deck drainage pipe:
28 Size and c/c distance of weep holes:
29 Depth of pier head:
30 Height of pier Colum:

SESSION-6

Topic: Briefing on Project Activities

Contents

1.0 Background of the project

2.0 Main Objectives of the project

3.0 Project Area

4.0 Project Components

5.0 Major activities of the component of the project

6.0 Implementation Modality

Session Objective:

At the end of the session the participants will get idea about the Objectives of the project, Project Area, Project Components and Major activities of the component of the project

Time: 1hour

Training Methodology

- Lecture /Discussion
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand outetc.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	10 min
02	Through a participatory approach, the facilitator will explain in briefthe Background of the project, Main Objectives of the project and Project Area	20 min.
03.	Through a participatory approach, the facilitator will explain in brief the Project Components and Major activities of the component of the project.	20 min
04	The facilitator will conclude the session by summarizing his/her presentation and asking about any queries of participants.	10 min

Overview
Briefing on Project Activities

Contents

1.0 Background of the project

2.0 Main Objectives of the project

3.0 Project Area

4.0 Project Components

5.0 Major activities of the component of the project

In this session, the project personnel of the respective project will explain in brief about his/her project in the light of contents as mentioned above through power point presentation. In that case, the project personnel of respective project will prepare the slides for power point presentation.

SESSION-7

Topic: Introduction to LGED Rate Schedule

Contents

1.0 Introduction

2.0 Chapter-1; General Information and Instruction to users of Rate Schedule

3.0 Introduction to Chapter- 2 to 5 of LGED Rate Schedule

4.0 Technical Sp. of Important Items of Chapter-2 to 5 with Rate break down (Rate analysis)

5.0 Introduction to Chapter- 6 to 13of LGED Rate Schedule

6.0 Technical Sp. of Important Items of Chapter-6 to 13 with Rate break down (Rate analysis

7.0 Introduction to Appendices of LGED Rate Schedule

Session Objective:

At the end of the session the participants will be familiar with the use of LGED Rate schedule and able to understand and also explain to others the technical specification of items of works as well as rate break down of those items of works as shown in the LGED Rate Schedule.

Time: 2 hours

Training Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out, Original copy of a LGED rate schedule etc.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will explain in details the General Information and Instruction to users of Rate Schedule.	15min.
03.	Through a participatory approach, the facilitator will explain the Technical Specification of Important Items of works of Chapter- 2 to 5 in the LGED Rate Schedule. In this stage the facilitator will show the Original copy of the LGED rate schedule to the participants.	20 min

04.	Through a participatory approach, the facilitator will explain the Technical Specification of Important Items of works of Chapter- 6 to 13 in the LGED Rate Schedule and Appendices of LGED Rate Schedule. In this stage the facilitator will show the Original copy of the LGED rate schedule to the participants.	30 min
05	The facilitator will conclude the session by getting feedback from the participants.	10 min

Overview
Introduction to LGED Rate Schedule

1.0 Introduction

Historically Local Government Engineering Department (LGED) publish its schedule of Rates (SOR) primarily aimed at providing the field offices of LGED with the unit prices of different construction works within the mandate of the LGED as reflected in the CPWA code. The SOR was last compiled in 2015 and science then prices of materials as well as labors has registered substantial increase. Besides the cost, there has been spurt of new construction techniques and materials. This has necessitated revision of the SOR-2015 to include the above changes. Although the SOR-2017 contains most of the items of the SOR-2015, the nomenclature of the existing items has been revised and updated wherever found necessary. Nevertheless 775 new items have been introduced and 411 items have been discarded together (in the respective chapter) as are felt not necessary or there is overlapping with the other existing items.

To make the SOR comprehensive, useful and fit for purpose, basic item prices were collected from 19 old districts. 'LGED Schedule of Rates Updating Committee' and '5 Sub-committees' have made relentless effort to collect, collate and compile current basic unit price of materials of major items among its field offices and the current market basic unit price of other supply and finished items were collected at the central level, Also the committee have compared prevailing unit rate of similar items of works with other Government Departments, specially Roads and Highways Department (RHD) and Public Works Department (PWD). Moreover, Bangladesh Bureau of Statistics (BBS) published rates and also used in the unit rate analysis, where applicable. All basic rates of materials and labor have been compared with previous year'sunit rate by LGED's own computerized software, assayed with the prevailing market prices, and have been rationalized to make them compatible with the existing situation. In addition, comparatively higher rates have been exclusive considered for the remote and isolated places to accommodate the transportation disadvantage and acute crisis of materials and skilled/semi-skilled labors anticipated there.

In order to facilitate wider user context SOR also includes,

- basic unit prices of different construction materials;
- labor; hire charge of equipment and machinery;
- gradation of aggregates;
- Item of works tests type, frequency and test fees;

- unit conversion;
- cross-sectional area of rebar;
- unit weight of different engineering materials;
- miscellaneous relations and standard drawings have been included as appendixes to this SOR.

The SOR is solely compiled as a basis for estimating and tendering of works for which the LGED is responsible. The SOR may not necessarily reflect the market values of materials/products/works as included in this SOR.

2.0 General Information and Instruction to users of Rate Schedule

Chapter 1 of LGED Rate Schedule contains '**General Information and Instruction to users'** of Rate Schedule as below**:**

1.1 This Schedule of Rates has been prepared using the standard analyzing formers with data input as provided by the field offices.

1.2 For use by the off-shore islands and inaccessible area (Hatia, Sandwip, Saint Martin, Moheshkhail, Kutubdia, Rangabali, Monpura, Sulla, Dharmapasha, Khaliajuri, Itna, Mithamoin, Ausdtagram, Barkol, Belaichari, Jurachari, langadu, Naniarchar, Ruma, Thanchi and Rowangchari), the unit rates of different items of works shall be computed by enhancing the rates shown in this book by an extra 5%.

1.3 All unit rates are inclusive of carriage of all materials and have been worked out so as to cover the full compensation of all materials, labor, equipment and machinery, tools and plants, overhead/incidentals, etc. necessary to complete the work in all respect required under the respective item. The unit rates are also inclusive of all duties and taxes and a certain amount of profit for the contractors. In the relevant cases, it has further taken into account the testing, installation and maintenance expense. However, in a few cases, the costs for some of the major construction materials have been itemized separately. For example, the cost of reinforcement has been taken out from the item on Reinforced Cement Concrete (R.C.C) and shown separately.

1.4 All items of works, contained in this book, have been described in a precise manner. The Tender Documents should accompany Technical Specifications detailing all procedures in addition to the short description of the Cost Estimates/BOQ and the features shown on the Drawings.

1.5 **Departmental supply of new construction materials is totally discouraged as restricted under the prevailing Government Rules.** However, some specific materials becoming scarce in this country occasionally necessitate their departmental supply. Such provisions may be kept in the Tender Documents as an exception clearly stating the corresponding price(s) for cost recovery. The delivery rate(s) for such material (s) should correlate the exact amount as considered against them in the Analysis of Rates. All costs of departmentally supplied material(s) shall be recovered from the Contractor(s) at this (ese) rate(s) for the entire supply.

1.6 **For the purpose of preparation of estimates in the cases where old materials would be re-**used/re-cycled, the damages should be assessed and grouped according to their extent. Such assessment should only be undertaking appropriate field survey works in terms of area and thickness/depth. Representative sampling of each group should be made and analyzed in order to assess the expected quantity of salvaged materials.

1.7 For the purpose of recording the quantity of the salvaged materials and to determine and specify their usage quantities, the old materials should be taken out, properly stacked, accurately measured and the measurements are entered in the Measurement Book (MB). The materials should be stacked in a manner that will allow for the Engineer-in-Charge (E-I-C) to hold random inspections and verification with regard to the quality and quantities of materials as salvaged. The E-I-C shall certify the salvaged materials according to his (her) inspection results. Inventory of the man trails shall then only be made and the material(s) be allowed for use in the work(s). The contractor shall agree with the quantity (ies) of material(s) salvaged and so certified by the I-C. **The material(s) shall, under no been properly entered into the permanent record.** The value of the material(s), so supplied, shall be recovered from the contractor strictly in accordance with the provisions made under paragraph 1.8 of this chapter. In the case the salvaged materials become more than the shown quantities of the Tender Document/BOQ, shall also be recovered.

Recover of such material(s) shall be made exactly at the same rate(s) as was (were) originally stipulated in the Tender **Document/BOQ, such provisions shall specifically be incorporated in the Tender Document**.

1.8 The expected quantities of the salvaged material(s) should specifically be shown in the Tender Documents along with rate(s) should specifically be shown in the Tender Documents along with the rate(s) at which its (their) cost recovery will be made from the Contractor(s). The rate for this item should also be determined by following the procedures as stated under paragraph 1.7 of this Chapter. The cost of recovery may also be shown as lump sum on the basis of approximation. Under no circumstance, the costs of the salvage material(s), shown in the BOQ/ Tender Documents, shall be changed even on the ground that it has been found short of the provisions of the BOQ/Tender Documents. **These provisions shall specifically be incorporated in the Tender Documents.**

1.9 In case of material(s) issued by the Department or material(s) salvaged from the existing structure(s), VAT and IT shall be deducted on the basis of the gross value payable to the Contractor(s) before any deduction is made on account of the departmental material(s) (new or salvaged). Rules circulated by the National Board of Revenue (NBR) in this respect shall strictly be followed, This condition shall specifically be incorporated in the Tender Documents.

1.10 The Contractor(s) is (are) also required to return to the Department any quantities of material that may remain unused from the supply given by the Department or salvaged. In case of default, instructions of this paragraph shall also apply. **These provisions shall specifically be incorporated in the Tender Documents**.

1.11 Otherwise Provisions are unless made in the Technical Specifications, every item of this Schedule of Rates shall also comprise the activities like activities like mobilization, de-mobilization and clearance of work site. Separate item should not be prepared for these activities unless any exception is allowed by the Authority. In the case of any exceptions, obtaining prior approval from the Chief Engineer, LGED shall be compulsory. These provisions shall specification be incorporated in the Tender Documents.

1.12 While black-topping the road pavement, no item of seal coat shall be considered over any dense bituminous carpet.

1.13 The Contractor(s) at this (their) own costs shall perform all Laboratory Tests required for the construction works in the LGED laboratories unless any different arrangement are incorporated in the tender Document on seeing assented by the Chief Engineer, LGED on any special circumstances. The testing facilities, not available with the LGED, may be performed from outside sources, if directed or allowed by the E-I-C. The E-I-C shall reserve the right to increase the frequency of testing on actual requirement. Fees for any tests performed in the LGED laboratory shall be realized at the prescribed rate(s) of the LGED form the immediate next bill of the concerned Contractor. Fees, so realized shall immediately be credited to the respective heads of account of the Government. Under no circumstance the money shall be kept in any intermediary Bank Account.

1.14 All the unit rates contained in this Schedule of Rates are inclusive of all duties and taxes as required under the law of the Country and the Contractor(s) shall remain liable to pay them all. The Contractor(s) shall include all these levies in his (their) tender prices for all items of works and no additional claim for payment of taxes and duties or any compensation to subsequent increase in the existing taxes, duties, etc. shall be entertained by the Authority unless approved by the Government otherwise. The Income Tax and VAT shall be deducted at source strictly in accordance with the Rules of the NBR and shall be created immediately to the respective heads of account of the Government.

In all circumstances, taxes shall be deducted on the gross amount of the Contractor's claims. In the case of re-used /re-cycled materials or materials used under departmental supply, these taxes shall also be levied on the value of the materials re-used/re-cycled or used through departmental supply. These provisions shall specifically by incorporated in the Tender Documents.

1.15 The field officer shall fully discourage entertainment of non-tendered items and major variations. It is required that the respective local office should prepare estimate for any works on making proper field investigations and undertaking appropriate survey works that will leave least scope for major variations subsequently. Performing any works outside the scope of the contract. if at all found unavoidable, shall require prior approval of the competent Authority before of any such works starts. **The Authority shall not accord any post-facto sanctions to this effect.**

1.16 In case of detection of ant errors of omission in the specifications during of prior to implementation of work, it should immediately be brought to the notice of the Authority for necessary correction or amendment. Under no circumstance, one shall be allowed to take advantage of such situations, The Chief Engineer, LGED, Would be the sole Authority to

decide any disputes arising from such errors or omissions. **His decision(s) shall be conclusive and final, which will be binding upon all parties concerned.**

1.17 The community-Service Organizations such as PIC, WMCA shall work on no-profit basis under the in-house and force –account working systems and procedures. For this reason, any works to be implemented by them shall be subject to a cost estimate reduced by a margin of 10%, which constitutes as profit. **The percentage should very exactly in the same ratio of any variation as and when take place in the Analysis of Rates. Amount accrued as VAT and IT will be realized from the works payment bills and the same will be credited immediately to the respective heads of account of the Government. Instructions, information and procedures stated under paragraphs 1.9, 1.14 and other relevant paragraphs of this chapter shall also apply in this regard.**

1.18 Local government Institutions and other organizations, using this Schedule of Rates for preparation of cost estimates, shall follow their prevailing rules and regulations, procedures and customs with regard to VAT, IT and profit.

1.19 Unit rates of this Book shall also apply for works to be carried out by the LCS under any Contracts. In a similar way as followed in the case of normal Contract. The LCS shall have to pay VAT and IT also at the same rates as are required in the case of normal Contract of LGED satisfying the prevailing rules of the NBR. **LGED Guidelines, categorically prepared and circulated on this subject, should however govern the entire procedures.**

1.20 The Executive Engineer of the District is the key-person of LGED for overall management and supervision of works supported by the Upazila Assistant Engineer (UAE) and the Sub-Assistant Engineer (SAE). It is their responsibility to ensure that the items of this Schedule of Rates are strictly implemented in the work(s) with all stipulations, specifications and details. Standard field/laboratory tests to be performed with random sampling of brick, cement, sand, M.S. bar and other construction materials. Random cylinder/cube tests for Cement Concrete shall be carried out at the specified frequency for all concrete structural elements in order to protect their requisite strength.

1.21 Road Design Standards that has been developed and circulated by the Government/LGED should be followed.

1.22 When under some specific circumstance use of sanitary wares of most sophisticated type/superior quality would be a necessity, approval of the Chief Engineer, LGED must be obtained prior to making such provisions in the cost estimate. The unite rate(S) of the requisite material(s)/item(s) shall have to be determined on the basis of the Prevailing market price(s) and the approval of the Chief Engineer, LGED shall be a mandatory requirement before of its (their) any use.

1.23 Instructions for Cost Estimating of Lump-Sum (L.S) Items in Bridge Works

1.23.1 Sub-soil investigation works (Item no4.02.03) will be carried out for all bridge. Number and depth of bore holes will be considered based on bridge length and bridge location and shall be decided in consultation with LGED Design Unite.

Reputed firm will be engaged for this work and rate may be determinate as per market rate.

1.23.2 Electronic Cone Penetration test (item no. 4.02.04) shall be carried out only for selected bridge s and will be decided in consultation with LGED Design Unit. Reputed firm will be engaged for this work and rate may be determined as per market.

1.23.3 Dynamic load test of pile [Pile Dynamic Analyzer (PDA) test] will be carried out only for selected bridges if instructed in the design/drawing or as per discussion LGED Design unit. Reputed firm will be engaged for this work and rate may be determined as per market rate.

1.23.4 Engineer's site office in bridge works may be considered only for only for large bridges. Cost of Engineer's site office will be determined based on the detailed estimate including cost of building civil works, electrical works, water supply and sanitation works, furniture, etc. of drawings enclosed in Appendix-06 of this book with the deduction of salvage amount @ 25%of estimated cost.

1.24 **Provisional Sum**

1.24.1 A general provision of physical contingencies (Quantity overruns) of for meeting other essential expenditures like utility relocation, physical services etc. beyond the coverage of BOQ items may be made by including a provisional sum in the Summery Bill of Quantities. Similarly, a contingency allowance for possible price increases/adjustment should be provided as a provisional sum in the Summary Bill of Quantities. The inclusion of such provisional sums often facilitates budgetary approval by avoiding the need to request periodic supplementary approval as the future needs arise.

1.24.2 The estimated cost of specialized work to be carried out, or of special goods to be supplied, by nominated Sub-Contractor(s) should be indicated in the relevant part of the Bill of Quantities as a particular provisional sum with an appropriate brief description. A separate procurement producer is normally carried out by the Procuring Entity to select such specialized Sub-Contractor(s).

1.24.3 Each item shall be mentioned in the Bill of Quantities with indicative cost as lump-sum. [The amount shall only be used, in whole or in part, in accordance with procuring entity's instructions]

1.25 In case of any of the foregoing instructions and stipulating of this chapter comes into any conflict with any of the Codal Rules, the Codal Rules shall prevail.

3.0 Introduction to Chapter- 2 (Earth Works) of LGED Rate Schedule

Chapter-2 of 'LGED Rate Schedule' contains technical specification of Earth Works in Road Embankment in precise manner; the tender document should accompany detailing of technical specifications and all procedures in addition to the short description of the Cost Estimates/BOQ and the features shown on the Drawings.

All items of works of Chapter-2 (Earth Works)have been shown in one section.

The item codes have been set following the identification of Chapter, Section, Item Sl. and Sub – item Sl. For example Item code 2.02.1.2 indicates Sub-item sl. 2 of Item Sl.1 of Section 2 of Chapter 2.

3.1 Technical Specification of Important Items of Earth Works in Road Embankment with Rate break down (Rate analysis)

Some important items of Chapter 2 of LGED Rate schedule are attached in **Annex- V** of this manual for discussion of technical specification of item of works in details as well as unit rate analysis of those items of work.

4.0 Introduction to Chapter- 3 (Road Works) of LGED Rate Schedule

Chapter-3of 'LGED Rate Schedule' contains technical specification of Road Works in precise manner; the tender document should accompany detailing of technical specifications and all procedures in addition to the short description of the Cost Estimates/BOQ and the features shown on the Drawings.

All items of works of Chapter-3 (Road Works) have been shown in the following sections:

Chapter 3	**3.00**	**Road Works**
	3.01	Box Cutting
	3.02	Improved Sub- Grade
	3.03	Sub- Base Course
	3.04	End Edging
	3.05	Base Course
	3.06	Surfacing Works
	3.07	Concrete Pavement
	3.08	Herring Bone Bond (HBB) Road
	3.09	Concrete Block Road
	3.10	Special Road Maintenance
	3.11	Protective Work
	3.12	Road Safety Works

All the item codes have been set following the identification of Chapter, Section, Item Sl. and Sub – item Sl. For example Item code 3.02.1.2 indicates Sub-item sl. 2 of Item Sl.1 of Section 2 of Chapter 3.

4.1Technical Specification of Important Items of Road Works (Chapter-3) with rate breaks down (Rate analysis)

Some important items of Chapter 3 of LGED Rate schedule are attached in **Annex- V** of this manual for discussion of technical specification of item of works in details as well as unit rate analysis of those items of work.

8.0 Introduction to Chapter- 4 (Bridge Works) of LGED Rate Schedule

Chapter-4of 'LGED Rate Schedule' contains technical specification of Bridge Works in precise manner; the tender document should accompany detailing of technical specifications and all procedures in addition to the short description of the Cost Estimates/BOQ and the features shown on the Drawings.

All items of works of Chapter-4 (Bridge Works) have been shown in the following sections:

Chapter 4	**4.00**	**Bridge Works**
	4.01	General, Site Facilities and Preparatory Work
	4.02	Topographical Survey, Geotechnical Investigation & Preparation of Report
	4.03	Temporary bamboo/wooden Bridge & Diversion road
	4.04	Bailey Bridge (PSB), Steel pontoon and Steel Bridge
	4.05	Excavation, Dewatering, Artificial Island & Cofferdam
	4.06	Sand Filing, Brick Soling, Plain Cement Concrete, Brick Work & Plaster
	4.07	Pile Work & Pile Test
	4.08	Well Foundation Work
	4.09	Reinforced Cement Concrete (RCC) Work
	4.10	Pre-stressed Concrete (PSC) Work, HT Stand and Anchorage
	4.11	MS Fabrication, Re-Bar Coupler, Bearing & Expansion Joint
	4.12	Chemical Admixture, Galvanizing and Curing Compound
	4.13	Wearing Course, Drainage Spouts, Back Filling & Weep Holes
	4.14	Slop Protective Work, Jute & Synthetic Geo-Textile
	4.15	Railing, Painting & Others Bridge Appurtenances
	4.16	Repair & Rehabilitation
	4.17	Precast Reinforced Concrete Pipes
	4.18	Destructive and Non-destructive Test (NDT) on Concrete
	4.19	Ground Reinforcement, Improvement and Treatment Techniques

All the item codes have been set following the identification of Chapter, Section, Item Sl. and Sub – item Sl. For example Item code 4.02.1.2 indicates Sub-item sl. 2 of Item Sl.1 of Section 2 of Chapter 4.

5.1Technical Specification of Important Items of Bridge Works (Chapter-4) with rate breaks down (Rate analysis)

Some important items of Chapter 4 of LGED Rate schedule are attached in **Annex-V** of this manual for discussion of technical specification of item of works in details as well as unit rate analysis of those items of work.

9.0 Introduction to Chapter- 5 (Building Works) of LGED Rate Schedule

Chapter-5of 'LGED Rate Schedule' contains technical specification of Building Works in precise manner; the tender document should accompany detailing of technical specifications and all procedures in addition to the short description of the Cost Estimates/BOQ and the features shown on the Drawings.

All items of works of Chapter-5 (Building Works) have been shown in the following sections:

Chapter 5	**5.00**	**Building Works**
	5.01	Preparatory Works
	5.02	Excavation, Filling, Site Development, Pal standing Works & Shore Protection
	5.03	Brick Soling, Cement Concrete & DPC etc.
	5.04	Brick Works & Fancy Screen Block Works
	5.05	Reinforcement Cement Concrete Works
	5.06	MS Road Fabrication, MS Clamp, Expansion Joint & Bearing Joint
	5.07	Wood Works in Door and Window Frames, Roof Truss & Railing
	5.08	Door & Window Shutter & Fly Proofs Wire Net Shutter, uPVC Door
	5.09	CI Sheet Roofing and Fiber Glass Sheet Roofing Work
	5.10	Window Grill & Verandah Grill Netting
	5.11	Aluminum Door, Window Frame, Tinted & Tempered Glass &
	5.12	Cement Plaster, Pointing Works, Lime Terracing, Roof Tiles & Concrete Screed
	5.13	Patent Stone Flooring
	5.14	Mosaic Works
	5.15	Clayed Tiles & Marbles Stone Work
	5.16	Washing, Painting, Distempering, Polishing and varnishing Works
	5.17	False Ceiling, Wall Paneling
	5.18	Collapsible Gate, MS Gate & Rolling Shutter
	5.19	Stair & Verandah Railing and Nosing
	5.20	Grill, Fencing, V-H Blinds & Barbed Wire Fencing
	5.21	Concrete Hollow Block & Paving Stone & Pipe
	5.22	Drain and Apron
	5.23	Pile
	5.24	Sub-soil Investigation
	5.25	Chemical admixture, Water-proofing membrane
	5.26	Arboriculture Work

All the item codes have been set following the identification of Chapter, Section, Item Sl. and Sub – item Sl. For example Item code 5.02.1.2 indicates Sub-item sl. 2 of Item Sl.1 of Section 2 of Chapter 5.

6.1Technical Specification of Important Items of Building Works (Chapter-5) with rate breaks down (Rate analysis)

Some important items of Chapter 5 of LGED Rate schedule are attached in **Annex- V** of this manual for discussion of technical specification of item of works in details as well as unit rate analysis of those items of work.

10.0 Introduction to Chapter- 6 to 13 of LGED Rate Schedule

Chapter-6 to 13of 'LGED Rate Schedule' contains technical specification& unit rate of items of works under the sections below:

Chapter 6	**6.00**	**Small Scale Water Resources Development Works**
	6.01	Earth Works
	6.02	Brick Works and Sand Filling Works
	6.03	Cement Concrete (C.C.), Cement Plaster and Painting Works
	6.04	Reinforced Cement Concrete Works
	6.05	MS Rod Fabrication, MS Embedded Parts and MS Works
	6.06	CC Block, Gunny Bag, Geo-textile Filter and Ferro-cement Works
	6.07	Sheet Pile, RCC Pile, Bamboo Pile Works and Driving
	6.08	Gate Works of Hydraulic Structure
	6.09	MS Pipe, GL Pipe, RCC pre-cast Pipe, Gate Valve and Pipe fitting
	6.10	uPVC Pipe and pipe fitting Works
	6.11	Rubber Bag and Fitting Works
	6.12	Dismantling Works
	6.13	De-Watering, Bailing out water, Ring Bundh and Miscellaneous
	6.14	Rubber Dam
Chapter 7	**7.00**	**Sanitary And Water Supply Works**
	7.01	Long Pan, Oriental Pan & Lowdown
	7.02	Commode & Lowdown, Seat Cover, Flushing Siphon
	7.03	Commode/ Lowdown & WH Basin/Pedestal set
	7.04	WH Basin, Pedestal set, Cabinet Basin & Sink
	7.05	Flat Urinal & Standing Urinal
	7.06	Bib cock, Pillar cock, Sink cock , Faucets, Basin Mixture, Stop cock,
	7.07	Looking Glass, Glass shelf, Towel rail, Soap case, Toilet Paper
	7.08	Pipe of uPVC, ABS,PVC,HCI,CI RCC etc for Rainwater, Water
	7.09	Water supply GI, MS Pipe& fittings
	7.10	Water Tank (PVC, Stain less steel, Fiber)
	7.11	Inspection Pit, Septic Tank & Soak Well
	7.12	Two pit Latrine
	7.13	Bathtub
	7.20	Fire Protection System (Extinguisher)
	7.21	Fire Protection System (Hydrant)
	7.22	Fire Detection & Alarm System (Conventional Type)

	7.23	Fire Detection & Alarm System (Conventional Addressable Type)
	7.24	Fire Rated Door
Chapter 8	**8.00**	**Electrical Works**
	8.01	Main and Sub- Main switches
	8.02	Distribution/ Sub-Distribution Board
	8.03	Energy Meter
	8.04	Circuit Breaker
	8.05	Electrical Wiring and Cable
	8.06	Switch Board, Switch and Socket
	8.07	Earthling and Thunder Protection
	8.08	Miscellaneous
	8.09	Ceiling and Exhaust Fan Fittings
	8.10	Light Fittings
	8.11	Electric Bulb/Lamp
	8.12	Electric Motor/ Pump
Chapter 9	9.00	Termite Treatment Works
Chapter 10	10.00	Tube well Works
Chapter 11	11.00	Furniture and Fixtures
Chapter 12	12.00	Electro- Mechanical [Air-Cooler(AC), Transformer, Voltage
Chapter 13	13.00	Mechanical Works

11.0 Introduction to Appendices of LGED Rate Schedule: 'LGED Rate Schedule' also contains technical specification & unit rate of items of works under the sections below:

Appendices:

Appendix 1	7.02	Basic Rates of Material, Labour and Equipment Rental
Appendix 2	7.02	Rates of Hire Charge of Equipment and Machinery per Unit Quality of the Work done
Appendix 3	7.02	Gradation of Aggregate
Appendix 4	7.02	Item of Work, Type of Test, Test Frequency and Testing Fees
Appendix 5	7.02	Unit Conversions, Cross Sectional Area & Mass of Round Bar, Wire and Sheet Metal Gages in Decimals of an Inch, Unit Weight of Different Engineering Materials and Measurement Relations
Appendix 6	7.02	Drawings

SESSION-8

Topic: Concrete Technology

Contents

1.0 Concrete

1.1 Factors affecting Concrete

1.2 Water Cement Ratio in Concrete

1.3 Workability of Concrete

1.4 Consistency of Concrete

1.5 Curing of Concrete

2.0 Types of Concrete used in LGED

3.0 Concrete Production

4.0 Quality Control of Concrete

4.1 Sampling and Testing of Concrete

4.2 Workability Test of Concrete

4.3 Strength Test of Concrete

Session Objective:

At the end of the session the participants will be able to understand and also will be able to explain to others about Concrete and factors affecting quality of concrete, production of good quality concrete and test of concrete.

Time: 1hr. 30 mins.

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD and Hand out

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02.	Through a participatory approach, the facilitator will explain in detail how good concrete can be produced and quality of concrete can be ensured.	45 min
03	The facilitator will demonstrate the procedure of workability and strength test of concrete.	20min
04.	Now by asking questions to the participants the facilitator will verify the conception and misconception of the participant's learning.	10 min
05.	At this stage, the facilitator will complement &repeat the week areas of the participant's learning.	5 min
06.	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Concrete Technology

1.0 Concrete

Concrete is a composite construction material composed of cement, aggregate and water(Often admixtures). Concrete solidifies and hardens after mixing with water due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a robust stone-like material.

Composition of Concrete:

a) Cement
b) Course Aggregate
c) Fine Aggregate
d) Water
e) Air

1.1 Factors Affecting Concrete

a) Soundness of aggregate
b) Cement-related parameters
c) Aggregate-paste bond
d) Water -Cement Ratio
e) Mixing Method
f) Mix proportion
g) Method of Concreting
h) Form Work
i) Curing

1.2 Water/Cement Ratio in Concrete

The proportion between the amount of water and cement by weight in a concrete mix is termed as the 'Water/Cement Ratio'. In practice the water/cement ratio is the largest single factor in the strength of fully compacted concrete.

$$\text{Water/Cement (W/C) Ratio} = \frac{\text{Weight of water}}{\text{Weight of Cement}}$$

- The strength of concrete is adversely and significantly affected by the presence of voids in the compacted mass, it is vital to achieve a maximum possible density.
- This requires sufficient workability for virtually full compaction to be possible using a reasonable amount of work under the given conditions.
- Presence of voids in concrete reduces the density and greatly reduces the strength: 5% of voids can lower the strength by as much as 30%.

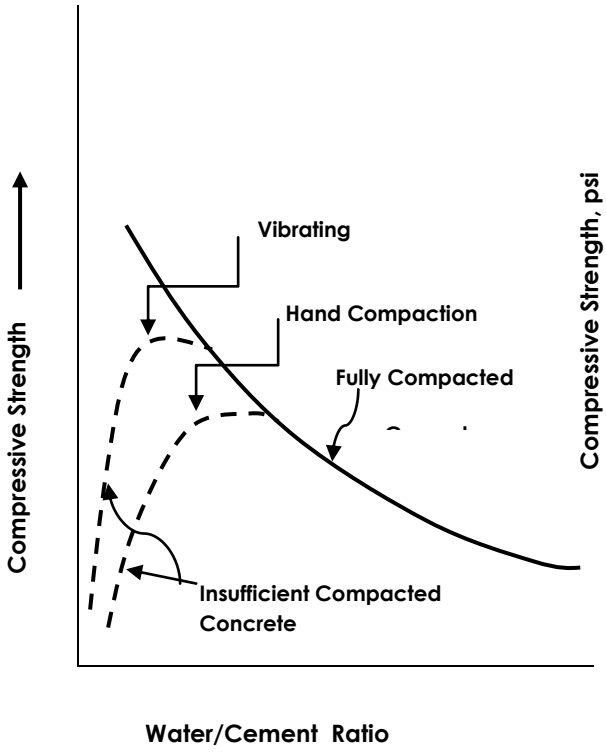
Water in concrete primarily does the three functions:

i. To wet the surfaces of the aggregates;

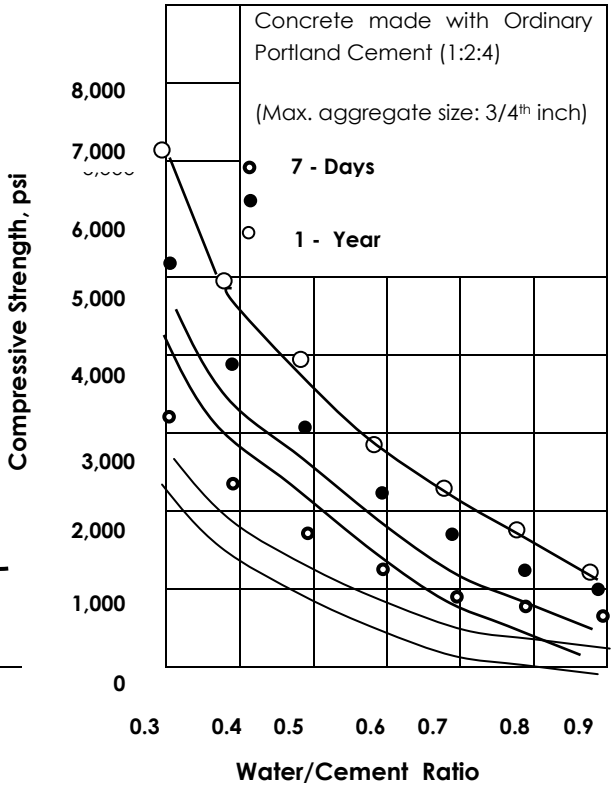
ii. To impart workability;

iii. To combine chemically with cement.

- When concrete is fully compacted its strength is taken to be inversely proportional to water/cement ratio.
- It may be recalled that the water/cement ratio determines the porosity of the hardened cement paste at any stage of hydration.
- Figure given below shows that; at the lower end of the scale the curve (Water/Cement Ratio vs. Compressive Strength) ceases to be followed when full compaction is no longer possible. The actual position of the point of departure in this curve depends on the means of compaction available.



The relation between Strength & Water/Cement Ratio of concrete



The relation between Strength & Water/Cement Ratio of Concrete

- Experiments have shown that the quantity of water in a mix determines its strength and there is a water/cement ratio which gives the maximum strength to the concrete.
- There is a certain percentage of water below which the water will not be sufficient to hydrate the cement.
- The use of less water than that required will not give workability and will produce porous and weak concrete.

- On the other hand if more water is used than that actually required, the concrete will be weak.
- The above Figure above shows the relationships between gain compressive strength and the water/cement ratio with time for the concrete (1:2:4) made with ordinary Portland cement.
- Water/cement ratio should be kept low even though strength requirements may be met with a higher value. Table A and Table B give limiting values of water/cement ratio for different level of strength and conditions.

Table A : Relationships between Water/Cement Ratio And Compressive Strength of Concrete

Cylinder Compressive Strength at 28 days		Water/Cement Ratio by weight
Kg/cm^2	psi	
350	4980	0.48
300	4270	0.55
250	3560	0.62
200	2850	0.70
150	2130	0.80

1.3 Workability of Concrete

- The strength of concrete of given mix proportions are very seriously affected by the degree of its compaction.
- It is vital, therefore, that the consistence of the mix be such that the concrete can be transported, placed and finished sufficiently easily and without segregation. A concrete satisfying above conditions is said to be workable.
- Furthermore, the desired workability in any particular case would depend on the means of compaction available. Likewise, workability suitable for mass concrete is not necessarily sufficient for thin, inaccessible, or heavily reinforced sections.
- For these reasons, workability should be defined as a physical property of concrete alone without reference to the circumstances of a particular type of construction.

Factors Affecting Workability:

i. Water-Cement ratio
ii. Amount and type of aggregates
iii. Amount and type of cement
iv. Weather condition (Temperature and wind)
v. Chemical admixtures
vi. Fine to coarse aggregate ratio

1.4 Consistency of Concrete

To describe the state of fresh concrete the word consistence is used. This refers to the firmness of form of a substance or to the ease with which it will flow. In the case of concrete, consistency is sometimes taken to mean the degree of wetness. Within limits, wet concrete are more workable than dry concrete, but concrete of the same consistency may vary in workability.

1.5 Curing of Concrete

Curing is the process of minimizing evaporation and loss of moisture from concrete mass at its early age, in order to retain sufficient water for the hydration of cement.

Curing methods:

- Water curing,
- Membrane curing,
- Application of heat,
- Miscellaneous.

Water Curing:

This is the best, cheap and widely used methods of curing as it satisfy all the requirements of curing, namely, promotion of hydration, elimination of shrinkage and absorption of heat of hydration. Water shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or together injurious substances. It is desirable to use potable water for curing of concrete.

Ways of Water Curing:

- Immersion: Immersion of concrete into the water.
- Spraying: Regular spraying and sprinkling of water either manual or by a pump.
- Wet covering: Covering the concrete surface with wet gunny bags, straw, damp burlap, etc.
- Formation of Ponds: Forming small ponds to enclose water on the surface of horizontal surfacing.

When to start curing and how long to cure?

The best practice is to keep the concrete under the wet gunny bag for 24 hours after concreting and commence water curing by way of ponding or spraying. Wet gunny bag or wet hessian cloth would be like that it does not drop water and at the same time, does not allow the concrete to dry.

The concrete cured for a long time will show superior strength and develop other good practice but long time curing is expensive. The curing period will vary for different structures, situations and different atmospheric temperature. For general guidance, it can be said that concrete must be cured not more than 28 days.

2.0 Types of Concrete used in LGED

The types of concrete and properties applicable to the concrete in various parts of structure shall be as specified in the following table:

Table: Types of Concrete used in LGED

Types of Concrete	28 days strength	Mix Ratio (By volume) (Only indicative)	Properties of ingredients
RCC-17BCCM	f'c=17MPa	1:2:4	Sand of Min^{m}F.M1.8; Coarse Aggregate 20mm downgraded crushed picked brick chips(LAA<=38); Max^{m}. w/c 0.45. Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N. Using Concrete Mixer
RCC-20SCCM	f'c=20MPa	1:2:4	Sand of Min^{m}F.M2.2; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=35); Maxm. w/c 0.40. Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N. Using Concrete Mixer
RCC-25SCCM	f'c=25MPa	1:1.5:3	Sand of Min^{m}F.M2.5; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=30); Maxm. w/c 0.40. Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N. Using Concrete Mixer
RCC-25SCBP	f'c=25MPa	1:1.5:3	Sand of Min^{m}F.M2.5; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=30); Maxm. w/c 0.40. Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N. Using Batching Plant, Transit Mixer& Concrete pump
RCC-30SCCM	f'c=30MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.5; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=30); Water Cement Ratio as per mix design (Dose of admixture to be fixed by the mix design). Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1. Using Concrete Mixter.

RCC-30SCBP	f'c=30MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.5; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=30); Water Cement Ratio as per mix design (Dose of admixture to be fixed by the mix design). Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1. Using Batching Plant, Transit Mixer& Concrete pump
RCC-35SCBP	f'c=35MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.8; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=25); Water Cement Ratio as per mix design (Dose of admixture to be fixed by the mix design). Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1. Using Batching Plant, Transit Mixer& Concrete pump
RCC-40SCBP	f'c=40MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.8; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=25); Water Cement Ratio as per mix design (Dose of admixture to be fixed by the mix design). Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1. Using Batching Plant, Transit Mixer& Concrete pump.
PSC-35SCCM	f'c=35MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.8; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=25); Water Cement Ratio as per mix design high range water reducing admixture of complying type F/G under ASTM 494 (Dose of admixture to be fixed by the mix design). Using Concrete Mixer.
PSC-35SCBP	f'c=35MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.8; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=25); Water Cement Ratio as per mix design . Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1,high range water reducing admixture of complying type F/G under ASTM 494 (Dose of admixture to be fixed by the mix design).Using Batching Plant, Transit Mixer& Concrete pump.

PSC-40SCRDM	f'c=40MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.8; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=25); Water Cement Ratio as per mix design. Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1, high range water reducing admixture of complying type F/G under ASTM 494 (Dose of admixture to be fixed by the mix design). Using Reversible Drum mixture / Batch Mix Plant.
PSC-40SCBP	f'c=40MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.8; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=25); Water Cement Ratio as per mix design. Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1, high range water reducing admixture of complying type F/G under ASTM 494 (Dose of admixture to be fixed by the mix design). Using Batching Plant, Transit Mixer& Concrete pump.
PSC-45SCBP	f'c=45MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.8; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=25); Water Cement Ratio as per mix design. Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1, silica fume conforming to ASTM C 1240, high range water reducing admixture of complying type F/G under ASTM 494 (Dose of admixture to be fixed by the mix design) Using Batching Plant, Transit Mixer& Concrete pump.
PSC-45SCBP	f'c=50MPa	Mix Ratio (By mix design)	Sand of Min^{m}F.M2.8; Coarse Aggregate 20mm downgraded crushed stone chips(LAA<=25); Water Cement Ratio as per mix design. Cement conforming to BDS EN 197-1: 2003 CEM-I 52.5N / ASTM C150 Type-1, silica fume conforming to ASTM C 1240, high range water reducing admixture of complying type F/G under ASTM 494 (Dose of admixture to be fixed by the mix design) Using Batching Plant, Transit Mixer & Concrete pump.

Structural Engineers generally specify the strength of concrete at different ages for the structural members. Then it is the responsibility of the Supervisory Engineer working at site to achieve the minimum target strength to fulfill the requirements of the specifications.

3.0 Concrete Production and Quality Control

3.1 Production of Concrete:

The stages of production of concrete are:

i. Batching
ii. Mixing
iii. Conveying,
iv. Handling and Placing
v. Compacting
vi. Finishing
vii. Curing.

i) Batching: Batching is the process to measure the materials for making concrete. Generally, for each batch mix, one bag of cement is used. The volume of one bag cement is 1.25 cubic feet (cft).

ii) Mixing of Concrete: 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 manufacture's plate showing the capacity of the drum in terms of mixed concrete and the speed or rotation of the mixing drum.

Mixing Time:

a) On a site, there is often a tendency to mix concrete as rapidly as possible, and it is, therefore, important to know what is the minimum mixing time necessary to produce a concrete uniform in composition and, as a result, of satisfactory strength.

b) This time varies with the type of mixer, and, strictly speaking, it is not the mixing time, but the number of revolutions of the mixer that is the criteria of adequate mixing. **Generally, about 20 revolutions are sufficient**.

The mixing time is reckoned from the time when all the solid materials have been put in the mixer, and it is usual to specify that all the water has to be added not later than after one quarter of the mixing time.

iii) Conveying of Concrete:

a) 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.

b) Conveying equipment shall be capable of providing a supply of concrete to the place of deposit without segregation of ingredients.

c) Remixing 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.

d) The intervals between deliveries of batches shall not be so long as to allow the concrete in place to harden partially and in no case such an interval shall exceed 30 minutes.

iv) Handling and Placing of Concrete:

a) In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed form the interior of formworks.

b) The concrete shall be placed in the position and sequences indicated on the drawings, and specifications. 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 item of mixing.

c) Concrete shall be placed in horizontal layers. 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.

d) Each layer shall be compact so as to avoid the formation of a construction joint with a preceding layer that has not taken the initial set.

e) 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 of formwork.

f) Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise provided.

g) Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon the reinforcement steel and the surfaces of forms shall be removed.

h) 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.

i) The concrete shall be well rammed and compacted to ensure that all cavities are filled.

j) Concrete shall not be dropped through a height greater than 1200mm.

k) 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.

l) 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.

m) After compaction the exposed concrete surface shall be struck off smooth with hand held steel floats.

n) No plastering of imperfect concrete faces will be allowed; any concrete that is defect in any way shall be cut out and replaced to such depth or be made good.

o) Construction joints shall be formed in the work where indicated on the drawings or as specified.

v. Compacting of Concrete

Concrete, during and immediately after depositing and placing, shall be thoroughly compacted. It is imperative that 100% compaction of concrete is one of the most important aim to be kept in mind in good concrete making practice.

The following methods are adopted for compact the concrete:

a. Hand compaction,
b. Compaction by vibration

a) Hand compaction: Hand compaction of concrete is adopted in case of unimportant concrete works of small magnitude. Hand compaction consists of rodding, ramming or tamping. The strength of hand compacted concrete will be low because of higher water cement ratio is required for full compaction.

b) Compaction by vibration: The compaction by vibration permits improvement in the quality of concrete or economy. The vibrated concrete will have many advantages (strength, low w/c ratio) over the hand compacted concrete.

The compaction by vibration shall be done by mechanical vibration subject to the flowing provisions:

- The vibration shall be internal, which is most commonly used.
- The poker is easily moved from place to place, and is applied at 0-5 to 1 m (or 2 to 3 ft) centres for 5 to 30 sec, depending on the consistency of the mix. With some mixes up to 2 min may be required. The actual completion of compaction can be judged by the appearance of the surface of the concrete, which should be neither honeycombed nor contain an excess of mortar.
- Vibrators must be operated by skilled workmen engaged / appointed mainly for this job.
- 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.

- Vibration shall not be applied directly or through the reinforcement or sections or layers of concrete. It shall not be used to make concrete flow in the forms over distances so long as to cause segregation.
- 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.

vi. Finishing

Finishing operation is the last operation in making concrete. Finishing in real sense does not apply to all concrete operations. For certain concreting, finishing may not be applicable, whereas for the concrete road pavement, airfield pavement or for the flooring of a domestic building, careful finishing is of great importance.

3.2 Quality Control of Concrete

The basic aim in the supervision of concrete preparation for construction in the field is to ensure that all the requirements of the design, which are embodied in the specification and working drawings, are achieved in the field.

For this purpose, the supervisor should ensure that the following records are maintained:

a) Details of reinforcing steel
b) Quality of concrete materials (the test results)
c) Details of mixing, placing and compaction of concrete.
d) General progress of work (with dates of casting of each section)

Concrete may be specified by the designer by one or both of the following two methods:

- Specification by required properties
- Specification by properties of ingredients

<u>Specification by Required Properties</u>

In this method, the designer specifies:

a) The strength of Concrete
b) The size and gradation of the aggregate
c) The required slump

<u>Specification by properties of ingredients</u>

In this method, the designer specifies:

a) The proportions of the ingredients
b) The methods of casting and placing etc. required to produce a concrete of desired properties.

4.0 Sampling and Testing of Concrete

Sampling and testing of concrete is necessary to ensure that the concrete proposed for use in the construction complies with the specified requirements. All testing of concrete should be carried out on representative samples. Fresh concrete may be sampled at the following locations:

i) At the discharge from the central or work site mixture;
ii) From concrete deposited in readiness for casting or deposited in the forms.

Sampling of the concrete of the forms will give a much better assessment of the quality of the concrete used in the structure than will sampling at the point of delivery.

Generally, slump tests should be performed immediately after collection of the sample but not later than 5 minutes after completion of mixing. Moulding of test cylinders should commence within 20 minutes after completion of mixing.

Strength test specimens are cast at the work site and sent to the laboratory for testing after initial curing at site. A minimum of three cylinders must be cast from each batch, whenever a strength test is specified. The following information should be recorded during sampling and included in the report:

a) Job Site
b) Batch number
c) Date and time of sampling
d) Sampling Location
e) Sampling Identification
f) Location of concrete batch after placement
g) Weather condition at the time of sampling
h) Name & signature of person responsible for sampling

4.1 Workability Test for Concrete

Measurement of workability:

Unfortunately, there is no acceptable test which will measure directly the workability as defined earlier. Numerous attempts have been made, however, to correlate workability with some easily determinable physical measurement, but none of these is fully satisfactory although they may provide useful information within a range of variation in workability. The Slump Test shall be carried out as frequently as required by the Engineer and not less than one per hour during placing of concrete.

Slump Test:

This is a test used extensively at the site all over the world. The slump test does not measure the workability of concrete, but is very useful in detecting variations in the uniformity of a mix of given nominal proportions.

- An increase in slump may mean, for instance, that the moisture content of aggregate has unexpectedly increased; another cause would be a change in the grading of the aggregate, such as a deficiency of sand.
- Too high or too low a slump gives immediate warning and enables the mixer operator to remedy the situation. This application of the slump test, as well as its simplicity, is responsible for its widespread use.

4.2 Strength Test for Concrete

Strength of Concrete is mainly tested for its Compressive Strength. The compressive strength of the concrete shall be determined by Cylinder Test. The Cylinder moulds shall be 150 mm in diameter and 300 mm long. Each class of concrete shall be represented by at least six Cylinders. Not less than one group of six test. Cylinders shall be made for each 30 cubic meter of structural concrete, but there shall be at least one group of six test Cylinders for each day's concrete work. For columns and girders, one set of test Cylinders would be made for each batch of concrete not exceeding one cubic meter. Samples from which compression test specimen are moulded, shall be obtained in accordance with the Method of Sampling Fresh Concrete (ASTM C 172). The concrete samples would be collected from a point just before final placement or as directed by the Engineer. Cylinders may be collected from any batch (load) including the first. Specimens made to check the adequacy of the proportions for strength of concrete or as a basis for acceptance of concrete shall be made and cured in accordance with methods and curing. Concrete compression and flexure test specimens in the field (ASTM C 31 or equal). Strength tests shall be made in accordance with the method of test for compressive strength of moulded concrete cylinders (ASTM C 39 or equal).

Six cylinders would form a set of sample for Strength determination. Three cylinders shall be tested at seven days and Three cylinders shall be tested at twenty-eight days. Each and every twenty-eight days cylinders shall attain the minimum specified compressive strength. The Contractor shall perform trial mix of his own to determine the characteristic strength or mean strength that has to be attained.

The twenty-eight days strength tests shall be used as a basis for acceptance of the concrete. Seven days tests are made to obtain advance information on the adequacy of strength development.

SESSION-9

Topic: Shuttering and Formworks

Contents

1.0 Formworks
2.0 Scaffolding
3.0 Materials for Formworks

Session Objective:

At the end of the session the participants will be able to name, understand and also explain to others aboutthe types of Shuttering and Formworks, Components of formworks and various Shuttering materials.

Time: 1 hr. 30 mins.

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD and Hand out

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	The facilitator will ask the participants about their concept regarding Types Formworks& Scaffolding and write their opinion in the white board/poster paper. Later the facilitator will discuss and give clear idea about Formworks& Scaffolding	30min.
03.	Through a participatory approach, the facilitator will explain various shuttering materials.	20 min
04	By asking questions to the participants the facilitator will verify the conception and misconception of the participant's learning.	15min
05	At this stage, the facilitator will complement &repeat the week areas of the participant's learning.	15 min
06	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Shuttering and Formworks

1.0 Formwork

General: Forms shall be used to confine the concrete and shape it to the required lines. Unless otherwise approved forms shall be designed and constructed by the Contractor in accordance with the appropriate Standard and shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete without excessive deflection of any part or surface and shall be maintained rigidly in position. The joints in the formwork should be tight against leakage of cement grout. The formwork should be rest on firm base. The contractor shall be solely responsible for the entire operations.

Materials: Forms shall be of wood, metal or of other approved material. Forms for exposed surfaces shall be lined with metal or plywood, or other approved material. Forms shall be sufficiently tight to prevent loss of mortar from the concrete. The engineer shall be informed in writing before the contractor strips off any formwork and its supports etc. The contactor shall remain fully responsible for the safety of structures from which he removes formwork and its supports etc. He should take all precautions taking structural concept of the whole structure in considerations. No plea in the event of any damage shall be accepted.

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

Treatment of Forms: Before forms are erected the surfaces of the forms shall be coated with an approved form-oil that shall effectively prevent sticking and shall not stain the concrete surface. The contractor shall submit, for approval, the proposed form-oil. When concrete to be placed, the surfaces of the forms shall be free from encrustations of mortar, grout, or other foreign material.

Removal of Forms: Except as directed or approved, forms shall be removed carefully as soon as the concrete has hardened sufficiently to prevent damage in order to facilitate satisfactory progress with the specified curing and enable the earliest practicable repair to imperfections on the surface of the concrete in accordance. Concrete curing shall be started immediately after the forms have been removed and curing only temporarily stopped in the actual locations where repairs are being carried out. Immediately after stripping off, the concrete forms to be reused shall be cleaned; the surface shall be repaired as necessary and oiled with form oil and shall be carefully stored in its true shape.

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 relive the contractor of his responsibilities regarding the safety of the structure. The Contractor shall be held responsible for any damages arising from removal of formwork.

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

Tolerances for concrete construction

Allowable deviations from plumb or level and from the alignment, profile, grades and dimensions shown on the drawings subject to the following tolerances unless otherwise specified in this document or Drawings or as directed by the Engineers.

Sectional dimension +/- 5mm

Plumb +/- 1 in 1000 of height

Levels =/- 3mm before any deflection has been taken place

Where tolerances are not stated in the Specification or shown on the Drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provisions in this document. The contractor shall be responsible for setting and maintaining concrete forms sufficiently within the tolerance limits and shall ensure that the work is completed within the tolerances specified. Concrete work that exceeds the tolerance limits specified in this Clause shall be remedied or removed and replaced by and at the expense of the contractor.

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 . Such forms shall be sufficiently rigid so that the undulation of the concrete surface shall not exceed 3mm when checked with a 1.5m long straight edge or template.

Unless otherwise stated on the Drawings, wrought formwork shall be used for all permanently visible concrete surfaces. Wrought form work 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 joint flushed with the surface. The formwork shall be formed with approved standard size panels. The panels shall be arranged in a uniform approved pattern, free from defects likely to be detected in the resulting concrete surface.

In all types of formwork to form finished exposed concrete, only non-staining mould oil shall be used as approved by the Engineer.

The repetitive usage of the same formwork to cast form- finished exposed concrete shall be as decided by the Engineer and in no case the formwork, not guaranteed to produce the required form-finish to the satisfaction of the Engineer, shall be used.

The exposed concrete shall have a uniform finish. The finish of the concrete, when shuttering and formwork are removed will generally be without any blemish and will be such as will not require touch up. Slight touch up for a small spot if necessary shall be carried out skillfully so as to be synonymous with the entire surfaces.

The finished surface shall be within the specified tolerances and full cover to the reinforcement steel shall be maintained.

Formwork for non-exposed concrete surfaces

Unless otherwise stated on the Drawings, rough formwork may be used for all surfaces, which are not permanently exposed. Rough formwork may be constructed of plain but joined sawn timber. But the Contractor shall ensure that all joints between boards shall be grout tight.

The finished surfaces shall be within the specified tolerances and full cover to the reinforcement steel shall be maintained.

2.0 Scaffolding

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 of scaffolding 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 together with all incidental dynamic effects caused by placing, vibrating and compacting the concrete. No harmful cracking should occur in the placed concrete. The Engineer may require the Contractor to employ screw jacks or hardwood wedges to take up any settlement in the formwork either before or during the placing of concrete.

All scaffolding, exceeding 20m or six stories in height, shall be constructed of noncombustible or fire-retardant materials.

Scaffolding shall be founded on a solid base, which is safe against undermining, protected from softening and capable of supporting the loads imposed on it. Scaffolding which cannot be founded on a satisfactory footing shall be supported on piling, which shall be spaced, driven and removed in a manner approved by the Engineer.

Horizontal and cross bracings shall be provided for posts higher than 3m. Spans of beam bottoms shall be supported by posts with maximum 1m apart when steel is used and instructions from the manufacturer/supplier shall be strictly followed. Spacing of the props under beams shall consider the increased load and shall be posted closer than those under the floor slab.

Scaffolding can, in certain cases, be supported on structures already constructed. In that case, the Contractor shall submit in due time to the Engineer in writing all information on the loading

from the scaffolding as requested. The Engineer shall consider the loading and submit his approval in writing.

Scaffolding shall be set to give the finished structure the camber shown on the Drawings or specified by the Engineer. If any weakness develops or the scaffolding shows undue settlement or distortion during construction, the work shall be stopped and any structure affected thereby shall be removed and the scaffolding shall be further strengthened before work is resumed. Suitable screw jacks, pairs of wages or other devices shall be used at each post to adjust scaffolding to grade.

All materials used in the construction of the scaffolding shall conform to the corresponding ASTM or BS Standards or any other equivalent International Standards. Material tests and certificates may be required by the Engineer. Examinations of welding may also be requested. Test loading of the scaffoldings may be requested for the determination of the flexibility and the strength. All expenses of the tests and examinations of scaffoldings shall be borne by the Contractor on non-reimbursable basis.

Scaffolds shall be made from strong bamboo poles, wooden posts, steel pipes or any other suitable materials. They shall be adequately tide 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 lies or guys of steel wire or rood not less than 6mm in diameter.

Good, sound and uniform bamboo shall be collected in sufficient quantities for providing scaffolding, propping, temporary staging, ramp etc. The bamboos shall be free from any defects, filmy ties to each other and joints made smooth. Joining members only with nails shall be prohibited. Bamboos for vertical support shall not be less than 75mm in diameter and shall be straight as far as possible. Bamboos may be used as vertical support for up to a height of4m, if horizontal bracings are provided at the center. Splicing shall be prohibited.

After stripping the formwork, the bamboo posts shall be cleaned and stacked vertically in shade protected from rain and sun. Defective or damaged bamboo posts shall be removed from the site.

Timber posts shall be used in supporting formwork up to 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 cross 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 color of the surrounding surface.

Triangular wooden wedges shall be put under the posts for easy dismantling of the members. Timber planks or steel sheets shall be placed at a time below the vertical or inclined posts covering several posts.

Materials and joints in scaffolding shall be inspected from time to time both before and after erection for the soundness, strength, damage due to weathering etc. Inspections shall be made for spillage of material or liquids, loose material lying on the gangways and proper access to the platform.

The scaffold shall be secured to the building at enough places; no ties shall be removed Warning sign, prohibiting the use of any defective or incomplete scaffold and working in bad weather and high wind, shall be posted in prominent place. Inspections shall be made for the observance of these requirements.

Steel or Tubular Scaffolding: 38 to 64mm diameter steel tubes and special type of steel couples or fittings are used for connecting different steel members. The steel tubes used for scaffolding for normal building construction work are of heavy class and of diameter vary from 40 to 60mm. In this type of scaffold the vertical tubes called uprights are spaced 2.5 to 3.0m apart which are welded to a base plate, square or circular, the base plate has holes so that it can be spiked to a timber or concrete base, thus forming rigid foundation for the scaffolding. The longitudinal tubes or ledgers connecting the vertical tubes are spaced at 1.8m vertically apart.

Tubular scaffolding has several advantages over the bamboo/timber scaffolding such as rapid erecting and dismantling, greater strength and durability and higher fire resisting qualities and salvage value and economical due to its increased number of reuses and hence it is being extensively used now a days.

Platform Gantry: This is needed for providing a working platform above ground level and leaving the space below free from obstruction. The gantry consists of vertical posts fixed to common sole piece at its base and to a head piece at the top. The entire frame is thoroughly braced dogged.

3.0 Materials for Formwork

Formwork can be made out of timber, plywood, steel, precast concrete or fiber glass, used separately or in combination. The type of material to be used for formwork depends upon the nature of construction as well as the availability and cost of material. In early stages, formwork was made up of timber alone. With the introduction of steel materials use of timber formwork is getting reduced specially in case of major construction projects and in situations where large number of re-uses of the same forms are possible. However, for small works involving less

number of re-uses, timber formwork proves economical. Fiber glass is used mainly for making moulds for respective castings of pre-cast concrete products. Moulds made up of pre-cast concrete, fiber glass and aluminum are used in cast-in-situ construction such as waffle slabs or members involving curved surfaces.

Timber Formwork

Timber used for the formwork should satisfy the following requirements:

(i) It should be well seasoned.
(ii) It should be light in weight.
(iii) It should be easily workable with nails without splitting.
(iv) It should be free from knots.

The sizes of timber section for different components of formwork depend upon the span of the slab or beam, floor to floor height and the centre to centre spacing of the centering supports.

The timber used for shuttering for exposed concrete work should have smooth and even surface on all faces which are to come in contact with concrete. In situations where concrete surfaces are not exposed, as in case of foundation etc., undressed timber can be used to effect economy. The timber planks for the shuttering should be joined by providing tongued and grooved joints so as to ensure adequate tightness against leakage of cement grout.

Plywood Formwork

Use of plywood instead of timber planks is getting popular these days. In this case resin bonded plywood sheets are attached to timber frames to make up panels of required sizes. The panels thus formed can be easily assembled by bolting in the form of shuttering. This type of shuttering ensures quality surface finish and is specially recommended in works where large exposed areas of the concrete are to be constructed such as floor slabs, faces of retaining walls.

Steel Formwork

This consists of panels fabricated out of thin steel plates stiffened along the edges by small steel angles. The panel units can be held together by two or more clamps or bolts provided along each edge and the shuttering can be assembled and kept in alignment by use of horizontal or vertical centering of timber or steel. The panels can be fabricated in large number in any desired modular shape or size. The usual size for wall or slab panel varies from 60cm X 60cm to 60 cm X120cm.

Steel forms are mostly used in large construction projects or in situations where large numbers of re-uses of the same shuttering are possible. Steel forms are extensively used in repetitive castings of pre-cast concrete products. This type of shuttering are considered most suitable for circular or curved shaped structures like large sewer, tunnels and retaining walls.

Although steel shuttering costs more initially but in view of its various advantages it may work out to be economical for a medium sized work in the long run.

Advantage of steel formwork over timber forms.

(1) Steel forms are stronger, more durable and have longer life as compared with timber forms.
(2) They can be put to sufficiently larger number of re-uses. For estimation purpose the number of re-uses can be assumed to vary from 100 to 120.
(3) Steel forms can be installed and dismantled with greater ease and speed which results in saving in labour cost for this item of work.
(4) The quality of exposed concrete surface obtained by use of steel forms is excellent and it needs no further treatment. On the other hand construction carried out by use of timber formwork invariably requires plastering to obtain desired finish of the concrete surface. Thus there is saving in the cost of finishing the surface by use of steel forms.
(5) There is no danger of the formwork absorbing water from the concrete and hence the chances of honeycombing are minimized.
(6) They are not liable to shrink or distort and hence it is possible to achieve better workmanship and higher degree of accuracy by use of steel forms.

SESSION-10

Topic: Bridge Culvert Construction

Contents

1.0 Types of Bridge and Culvert Constructed by LGED

2.0 Bridge Site Selection and Lay-out Plan

3.0 Different types of foundations practiced in LGED

4.0 Important Items of Bridge Construction

Session Objective:

At the end of the session the participants will be able to understand and also will be able to explain to others about Bridge and Culvert types which LGED constructed and able to explain the criteria of stable bridge site as well as how bridge lay-out can be set. Also able to name the important items of bridge construction with their technical specifications.

Time: 1 hour

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out and hard copy of a LGED 'Rate Schedule'.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02.	Through a participatory approach, the facilitator will explain in detail the types of Bridge and Culvert, Criteria of stable Bridge Site Selection and Lay-out setting, Different types of foundations and finally the Important Items of Bridge Construction with their technical specification	35 min
03.	Now by asking questions to the participants the facilitator will verify the conception and misconception of the participant's learning.	10 min
04.	At this stage, the facilitator will complement &repeat the week areas of the participant's learning.	5 min
05.	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Bridge/Culvert Construction

1.0 Types of Bridge and Culvert Constructed by LGED

Types of Culvert

a. Pipe Culvert
b. Box Culvert
c. Slab Culvert

Types of Bridges based on Traffic Load

a. Pedestrian Bridge
b. Light Traffic Bridge
c. Medium Traffic Bridge
d. All Traffic Bridge

The types of bridges which are common in LGED

a. Solid Slab Bridge
b. Simple Girder Bridge (T-girder)
c. Continuous Girder Bridge (T-girder)
d. Box Girder Bridge
e. PC Girder Bridge.

The choice of a particular type of bridge should be made so that it is most suitable to carry the desired traffic, adequately strong to support the design loads, economical and aesthetically pleasing along with some other influencing factors such as Large Navigational Clearance, Need to reduce the number of piers, Climate and Environmental Conditions, Topography and Soil Condition, Availability of funds, the type of traffic, Personal preference etc.

Prestressed Concrete Bridge

The application of the concept of Prestressing Concrete Bridge to bridge engineering has resulted in a wide number of bridge types and has enlarged the bridge span range possible with concrete.

Basically there are two types of Prestressing

(i) Pre-tensioning; and
(ii) Post-tensioning

In the pre-tensioning method, the steel tendons (wire or strands) are tensioned before the concrete is placed in the moulds. After the setting and hardening of the concrete , the tendons are released from the tensioning device.

In the Post-tensioning method, the Prestressing tendon is assembled in a flexible metal sheath and anchor fittings are attached to its end. The tendon assembling is placed in the form and tied in place, along with other untensioned and auxiliary reinforcement. Concrete is placed in the form

and allowed to cure to the specified strength, the tendon are stressed to computed extent and anchored. The space around the tendon within the sheath is grouted under pressure with cement grout.

2.0 Bridge Site Selection and Lay-out

Bridge Site Selection

Usually road structure such as culverts and bridges will be built across gaps along roads. Such gaps may be due to canals and streams or bare opening left for water to pass from one side of the road to the other. For structural stability, safety and cost effective construction a site should be selected as follows

a. to be situated on a straight reach of the stream/cannel,
b. to be so far away from the confluence of large tributaries as to be beyond their disturbing influence,
c. should have well defined bank,
d. approach road to be straight, and
e. offers a square crossing as far as practicable

Foundation Lay-out

Before giving lay-out in the practical situation, it is convenient to plot a map of the proposed bridge location and superimpose on it a scaled plan of the proposed structure. A number of reference points including bench mark should be marked on the map and located in the ground. It is necessary to know the dimension and overall geometry of the excavation trenches. These should also be located in the map. Such map also helpful to locate areas over which excavated materials will be dumped and construction materials are to be stored. For all structures a main reference line should be chosen. All other distances and offsets are to be measured from this main reference line. The centre line of the abutment, set out accurately may form such a reference line. Similarly a permanent bench mark should be installed. All other levels to be established from the permanent bench mark.

3.0 Different Types of Foundations Practiced in LGED

Foundations can be broadly classified into two groups (i) Deep Foundation and (ii) Shallow Foundation.

The object of deep foundation is to transfer the loads of the structure in strata of good bearing capacity is not available near the ground, the foundation of the structure has to be taken deep with the purpose of attaining the bearing capacity which is suitable in all respect. In addition there may be many other conditions which may require deep foundations for ensuring stability and durability of a structure. For example, the foundation for a bridge pier must be placed below the scour depth, although suitable bearing stratum may exist at a higher level. The most common forms of deep foundations practiced in LGED are *(i) Pile Foundation and (ii) Well Foundation.*

In general, pile foundation provides a common solution to all difficult foundation site problems. Depending upon functions or use, piles may be classified into the following types:

(i) Bearing Piles
(ii) Friction Piles
(iii) Batter Piles
(iv) Fender Piles
(v) Anchor Piles
(vi) Sheet Piles
(vii) Compaction Piles

Depending upon the material used in their manufacture, piles can be broadly classified as:

(a) Concrete Piles
(b) Steel Piles
(c) Composite Piles
(d) Timber Piles

Concrete piles are classified as:

(i) Pre-cast piles
(ii) Cast in place or Cast-in-situ piles
(iii) Prestressed Concrete piles

When the foundation is placed immediately beneath the lowest part of the super structure, it is termed as shallow foundation. The object of this type of foundation is to distribute the structural loads over a wide horizontal area at shallow depth below the ground level. The various types of shallow foundations which practiced in LGED are:

1. Spread footings (Wall footings, Independent footings etc.)
2. Mat or Raft footings
3. Combined footings
4. Eccentrically loaded footings

4.0 Important Items of Bridge Construction

All items of works related to the Bridge Construction have been described in the LGED's 'SCHEDULE OF RATE' in a precise form. The Tender document should accompany Technical Specifications detailing and all procedures in addition and the features shown in the design and drawings. Important items of bridge construction as described in the 'SCHEDULE OF RATE' are:

Excavation, Dewatering, Artificial Island & Cofferdam
Item Code:

4.05.01 Earth work in excavation of foundation of structures by mechanical(Hydraulic excavation – Long Boom)/ manual means in all sports of soil up to specified depth in accordance with requirements of lines, grades, cross sections and elevation as

shown in the drawing including setting out, removal of stumps, logs, boulders and other deleterious materials, providing necessary tools and plants, construction of shoring and bracing, cleaning the excavation materials to a safe distance out of the site premises, cut to a firm surface including pumping/bailing out water, removal of spoils to a safe distance, dressing of sides and bottom and backfilling of trenches up to original level with approved material etc. all complete as per approval of E-I-C. Contractor shall get acquainted with site conditions, nature of soil and adopt suitable adequate dewatering system as deemed fit for the nature of soil and prevailing water table to get the surface reasonable dry for laying PCC at the time of execution so that execution will not be hampered or delayed. Back filled materials shall be compacted to a density comparable with the adjacent undisturbed material.

Pile Work & Pile Test

Item Code

4.07.01 BCIS: Boring of cast-in-situ piles up to the required depth and specified diameter with driving temporary steel casing (shall be 8mm thick with necessary stiffener bands and sharp edge at bottom and provided up to non-collapsible strata from the existing ground level but not less than 4.0m) in all types of soils including min. 2-chamber slurry tank, drilling with bentonite circulation (Dry Bentonite powder of liquid limit of minimum 350 shall be mixed with water @ minimum 4% by weight to make the fresh drilling fluid of viscosity between 32-50 seconds and density less than 1.1gm/cc), maintaining fluid level inside casting at all time at least 2 m higher than outside the casings, washing bore hole by air lift cleanup method with fresh bentonite slurry until the slurry from bore hole bottom have density less than 1.15gm/cc and sand content is less than 4%, make the bore hole ready for concreting including disposal/removal of all bored material, hire charge of mechanical winch machine/skid mounted mechanical table drive rotary/hydraulic rotary boring equipment, derrick, trimie pipe, cost of fuel, lubricant, mobilization, demobilization, spares, insurance coverage, water electricity and other charges all complete as per design, drawing, specification and direction of E-I-C. Contractor shall submit the methodology of cast-in-situ pile work including information on boring equipment, sequence of boring & casting, quality control, disposal of spoils, test result of materials to the E-I-C for approval before commencing any boring operation. Boring and excavation for a pile shall not commence unit 24 hours after completion of any pile within radius of 6 meters c/c. Cost of collecting, conveying, loading, transportation of spoils/mud accumulated during boring in cast-in-situ pile with all lifts and lead is included in this unit rate. The spoils must be dumped in an unobjectionable place outside the site premises with minimum traffic disruption and the procuring entity will not be responsible for any irregularities by the party regarding dumping of the spoils.

Note: Boring method shall be selected as per instruction given in the drawing.

Reinforced Cement Concrete (RCC) Works

Item Code

4.09.01 RCC-17 BCCM: Reinforced cement concrete work with minimum cement content relates to nominal mix ratio 1:2:4 and maximum water cement ratio 0.45 having minimum required average strength, for= 24 MPa and satisfying a compressive strength f 'c = 17 MPa at 28 days on standard cylinders as per standard practice of Code AASHTO/ASTM and cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V?W 42.5N, sand of minimum FM 1.8 and 20mm down well graded crushed picked brick chips (LAA value & maximum water absorption not exceeding 38 & 15% respectively) conforming to gradation requirement as per ASTM C 33 including screening chips through proper sieves, cleaning, placing shutter in position, making shutter water- tight properly, placing reinforcement in position, maxing in standard mixture machine with hoper, fed by standard measuring boxes, maintaining allowable slump of 50mm to 100mm, casting in forms, compacting by mechanical vibrator machine, curing for 28 days, removing centering- shuttering after approved specified time period, other incidental charges, etc. all complete as per drawing, specification & direction of the E-1-C. the cost of reinforcement and it's fabrication, welding, coupling, placing, binding etc. is not included in this unit rate. Additional quantity of cement to be added if required to attain the specified strength at the contractor's own cost.

Note: Using Concrete Mixer

Pre- Stressed Concrete (PSC) Work, HT Strand and Steel Anchorage

Item Code

4.10.01 PSC-35SCCM: Providing and laying Cement Concrete in Pre- Stressed Concrete works with minimum cement content and maximum water cement ratio as specified by the laboratory through mix design having minimum required average compressive strength, for = 45 MPa and satisfying a specified compressive strength, f 'c= 35 MPa at 28 days on standard cylinder as per standard practice of Code AASHTO/ ASTM and cement conforming to BDS EN 197-1:2003 CEM-1 52. 5 N/ASTM C150 Type-1, high range water reducing admixture of complying Type F/G under ASTM C494 (Doses of admixture to be fixed by the mix design) for smart dynamic concrete (i.e. Low fines self-compacting concrete), sand of minimum FM 2.80 and 20mm down well graded crushed stone chips broken from boulders (LAA value not exceeding 25) conforming to ASTM C 33, including breaking stone boulders into chips, screening through proper sieves, making and placing shutter in position, making shutter water -tight properly, placing non prestressing reinforcement, HT Strand, sheath, anchorage in position, mixing in standard mixture machine with hoper, maintaining allowable slump of 75mm to 100mm, casting in forms, compacting by mechanical vibrator machine, curing at least for 28 days,

removing shutter after specified time period, finishing, launching, shifting & placing in position etc. including cost of water, electricity, other incidental charges etc. all complete as per design, drawing, specification & direction of E-I-C. The cost of non Prestressing, reinforcement, HT strand and it's fabrication, binding, welding and placing in not include but the cost of admixture is included in the unit rate. The mix Design shall have to be approved by Central Quality Control Laboratory (CQCL), LGED or any other reputed laboratory approved by the competent authority before execution of the work.

Note: Using Concrete Mixture

MS Fabrication, Re-Bar Coupler, Bearing & Expansion Joints

Item Code

4.11.01 Supplying and fabrication of Ribbed or deformed bar reinforcement for all type of RCC work including straightening, removing ruts, cleaning, cutting, hooking, bending, lapping and/or welding wherever required as directed, placing in position, tieing with 22 BWG black annealed binding wire (PVC coated in case of FBEC rebar) double fold, cost of binding wire and anchoring to the adjoining members wherever necessary, supplying and placing with proper cover blocks (1:1), supports, chairs, spacers, splices or laps etc. including cost of all materials, cost of labour, cost of equipment & machinery, loading and unloading, transportation, all other incidental charges and work at all leads and lifts etc. to complete the work as per design, drawing, specifications and direction of the E-I-C. Measurement relating to nominal mass, dimensions and tolerances of various types of steel shall conform to relevant BDS/ASTM codes. Reinforcement shall be measured only in lengths of bar as actually placed in position on standard weight i.e. 7850 kg/m3 (BNBC Table 6.2.1) basis. No separate payment shall be allowed for chairs of any shape & profile, space bar of any shape & profile, lap/slice unless otherwise shown in the drawing, wastages, binding wire, concrete cover blocks etc. as the cost of these is included in the unit rate.

Note: Tests for reinforcing bars shall be conducted at LGED/BUET/CUET/KUET/RUET

Slope Protective Work, Jute & Synthetic Geo-textile

Item Code

4.14.01 Manufacturing and supplying Plain Concrete (PCC) Blocks with cement conforming to BDs EN 197-1 2003 CEM-II/AL/M/V/W 42.SN, sand of Minimum FM.1.5 and mm down well graded shingles to attain a minimum 28 days cylinder strength of 9.00 MP a (suggested mix proportion 1:3:6) including grading, washings shingles mixing laying in forms, consolidating, curing for at least 21 days, including preparation of platform, shuttering and stacking in measurable stack, cost of all materials, labour, equipment and machinery, work at all leads and lifts, loading and unloading, transportation and all other incidental charges etc. all complete as per drawing, specification & direction of the E-I-C. Steel shutter shall be used to perform the job.

[Payment shall be done after laying of PCC Blocks]

Precast Reinforced Concrete Pipes

Item Code

4.17.01 Supplying and laying machine made pre-cast RCC pipes with collars of different diameter, length & thickness including screening, grading and washing aggregates with clear water, water, mixing laying in steel forms, placing re-bars in position, consolidating, curing for at least 14days consolidating the cost of formwork, lifting loading and unloading from factory/ yard, laying in position etc including tools, plants, testing etc. all complete as per direction of the E-I-C. The collars shall be of 200mm wide made by RCC and having the same strength as the pipes to be jointed. The spirals shall end in a complete ting/term at both the ends of pipes and collars. The cost of reinforcement and it's fabrication, welding, coupling, placing, binding etc. is included in this unit rate.

SESSION-11

Topic: Bridge Culvert Construction (Contd,)

Contents

1.0 Bridge Components

2.0 Pile Foundations

3.0 Pre-cast Piles Construction Technique

4.0 Bored Cast in situ Piles Construction Technique

5.0 Pile Load Test

6.0 Pile Integrity Test (PIT)

Session Objective:

At the end of the session the participants will be able to name, understand and also explain to others about the Bridge components, types of Pile foundations and Choice of pile foundations and Construction technique of Pre-cast Piles and Bored Cast in situ Piles including test of piles.

Time: 2 hours

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD and Hand out

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will ask the participants for listing bridge components from their idea. The facilitator will then write the participant's answers in a poster paper and will discard the irrelevant with the consent of the participants and explain.	30min.
03.	Through a participatory approach, the facilitator will explain in detail the Pre-cast Piles Construction Technique.	15 min
04.	Through a participatory approach, the facilitator will explain in detail the bored Cast-in-situ Piles Construction Technique including Pile Test	40 min
05	Now by asking questions to the participants the facilitator will verify the conception and misconception of the participant's learning.	10min
06.	At this stage, the facilitator will complement &repeat the week areas of the participant's learning.	15 min
07	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Bridge/Culvert Construction (Contd.)

1.0 Bridge Components (Discuss along with Bridge Drawings)

The bridge structure comprises the following parts

- Decking, consisting of a slab, girder and railings;
- Bearing for the decking;
- Abutment and piers;
- Wing walls and returns;
- Foundation for the abutments, piers, wing walls and returns;
- River Training Works, like slope protection at abutments, wing walls, returns, aprons at bed level etc. and
- Approach to the bridge to connect the bridge proper to the roads on either sides.

The components above the levels of the bearings are grouped as *superstructure* and the parts below the bearing level are classed as *sub-structure*.

a. Traffic Railings

Traffic railings have been provided at the edge of the structures for the protection of traffic and pedestrians. Total height of the railing has been fixed normally at 0.75m over a curb of 0.25m high from the top of the bridge way. The railings have been provided with vertical posts at suitable spacing.

b. Diaphragm/Cross Girder

To furnish lateral support to the girders, diaphragm have been provided between the girders at either end of the bridge and also at the centre of the span when the bridge span exceeds 10metres.

c. Bridge Seat

Provision has been made in the designs to accommodate the changes in length that result from temperature variation. The girder have been placed over the seat in such a way that one end is fixed against horizontal movement and the other end is allowed to displace.

d. Bridge Abutments

Bridge abutments are used to transmit the load from the superstructures to the foundation. These are also used to act as retaining walls to hold back the earth fill behind them. Various component of cantilever abutment includes Bridge Seat, Breast Wall, Wing wall and Footing.

In soils having low values of bearing capacity, it is expected that the stress in the soil under an abutment footing will exceed the bearing capacity value of the soil. In such cases, the abutment should be supported on pile foundations.

Proper drainage of backfill is essential for stability as well as for economic design of abutments. Drainage of the backfill can be provided most efficiently by a continuous back drain consisting of a layer of gravel or brick aggregates covering the entire rear face of the wall with discharge at the ends through drainage tubes in the form of weep holes.

e. Pier

The pier usually is composed of one or combination of columns with a cap at the top to support the superstructure. This structure, however, is not designed to retain approach road soil and hence is normally used as intermediate supports. In the design of pier bearing capacity of soil and settlement characteristics of the foundation is required to know.

f. Girder

The girders have been designed for the load coming as a reaction force from the slab. The girder has been taken as the centre to centre distance between the supports. Girder may be T-beam type and Box girder type. The T-girder bridge is most commonly used in LGED.

2. Pile Foundations

The different types of piling have been devised to suit different ground conditions. The nature of the ground where piling operation is to be carried out, determines to a large extent the choice of type of pile to be used. In addition, the other important factors which must be considered are:

(i) The nature of the structure
(ii) Loading conditions
(iii) Elevation of the ground level with respect to the pile cap.
(iv) Probable length of pile required
(v) Factors which may cause deterioration of pile quality
(vi) Probable cost of pile

3.0 Pile Construction Technique

3.1 Pre-cast Concrete Driven Piles

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

Concrete: Pre-cast concrete piles shall be constructed in accordance with the details shown on the drawings, of concrete class, proportioned, mixed and placed in accordance with the section 3.0 of Session-8. All cement used shall be as specified and approved quality and proportioning

should be as per specification of RCC work mentioned. The cross sectional dimension of the pile shall be not less than those specified and shall not exceed them by more than 1 cm. Any face of a pile shall not deviate by more than 6mm from a straight edge of 3m long laid on the face, and the center of any cross section of the pile shall not deviate by more than 1/1000 of the length of the pile from the straight line connecting the center the end faces of the pile.

Formwork: the formwork for square pre-cast concrete piles shall comply with the general requirement for concrete formwork as described in section 1.0 of Session-9. The head of each square pile shall be square to the longitudinal axis. The comers of the head and the comers of the pile shaft for a distance of 30mm from the head shall be chamfered 25mm.

Reinforcement: Reinforcement shall be in accordance with the provisions set out in section 2.5 of session 2 topic of this manual and positioned as shown on the drawings.

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

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

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

Marking of piles: After a pile has been cast, the date of casting reference number, length shall be clearly inscribed on the outer surface of the pile. In addition, each pile shall be marked at intervals of 25mm along the top 3m of its length before being driven.

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

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

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

Leaders and Trestles: At all stages during driving and unit incorporation in the superstructure the pile shall be adequately supported and restrained by means of leaders, or other guide arrangements to maintain position.

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

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

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

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

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

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

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

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

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

and alignment and to prevent bulking. these arrangement shall be such that damage to the pile does not occur leaders shall be of sufficient length to make the use of following unnecessary.

3.2 Bored Cast-in-situ Piles

Annex-III shows the set of pile drawings for discussion in details. The facilitator will explain in details all the features in drawings along with the discussion below.

Cast-in-situ piles are those piles which are cast in position inside the ground. This work shall comprise of boring and construction of bored cast in place piles for foundation of the bridge structures in accordance with the specifications, in conformity with the requirements of the drawings and design.

Piles through the water and soft upper soil layers shall be provided with permanent steel casing. The pile boring shall be carried out using a temporary steel casing driven up to the pile toe or to a level approved by the Engineer. The temporary casing shall be withdrawn. Concrete and

reinforcement of the piles shall be strong enough to resist pile loads and horizontal forces on the pile cap.

Accessories for Pile Construction

Temporary Steel Casing

- Temporary steel casing pipe shall be used at least for the upper 6m from the ground Level
- Diameter of the casing pipe shall not more than 10mm than that of the pile shaft.

Permanent Steel Casing

- 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.
- Casing pipes may be transported to the site in pieces and shall be welded to the design length.
- Two coats of anti-corrosive tar type paint shall be given to the outside surface of the casing for a maximum depth of 5mfrom the underside of the pile cap

Tremie pipe

A tremie having a diameter of not less than 150mm, sufficiently long to reach the end of pile bottom and additional 500mm. The tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work so as to permit rapid lowering when necessary to retard or stop the flow of concrete.

Drilling Fluid / Bentonite Slurry

- Prevent borehole from collapsing
- Controlling Parameter- Density
- Remove of Cutting
- Controlling Parameter- Viscosity, Gel Strength
- Borehole Cleaning/ Borehole Flashing
- Controlling Parameter- Viscosity, Gel Strength and Type of Flow

Characteristics for Bentonite Slurry

CHARACTERISTICS FOR BENTONITE SLURRY					
Property	**Units**	**Stages**			**Test equipment**
		Fresh	**Ready for re-use**	**Before concreting**	
Density	g/ml	< 1.10	< 1.25	< 1.15	Mud balance
Marsh viscosity	sec	32 to	32 to 60	32 to 50	Marsh funnel
Fluid loss (30	ml	< 30	< 50	n.a.	Filter press
pH		7 to 11	7 to 12	n.a.	pH meter
Sand content	%	n.a.	n.a.	< 4	Sand content set

Slurry Usage Calculation

Diameter		US Gallons per foot depth	Litter Per Meter Depth
Feet	Inch		
0	3	0.37	4.59
0	6	1.50	18.63
0	9	3.37	41.85
1	0	5.91	73.39
1	3	9.35	116.11
1	6	13.24	164.41
1	9	18.18	225.76
2	0	23.49	291.70
2	3	29.99	372.41
2	6	36.73	456.11
2	9	44.73	555.45
3	0	52.88	656.66
3	3	62.38	774.63
3	6	71.96	893.59
3	9	83.03	1031.06
4	0	93.95	1166.66
4	3	106.59	1323.62
4	6	118.93	1476.86
4	9	133.07	1652.45
5	0	146.83	1823.32
5	3	162.47	2017.54
5	6	177.65	2206.04
5	9	194.78	2418.76
6	0	211.38	2624.90
6	3	230.08	2857.11
6	6	248.11	3081.01
6	9	268.31	3331.85
7	0	287.76	3573.37
7	3	309.52	3843.59
7	6	330.32	4101.88
7	9	353.58	4390.72
8	0	375.80	4666.65
8	3	400.63	4974.98
8	6	424.27	5268.54
8	9	450.60	5595.51

Diameter		US Gallons per foot depth	Litter Per Meter Depth
Feet	Inch		
9	0	475.65	5906.57
9	3	503.48	6252.16
9	6	529.96	6580.99
9	9	559.35	6945.95
10	0	587.18	7291.54
10	3	618.15	7676.12
10	6	647.39	8039.22
10	9	679.86	8442.43
11	0	710.53	8823.29
11	3	744.48	9244.88
11	6	776.57	9643.37
11	9	812.03	10083.71
12	0	845.54	10499.83
12	3	882.57	10959.67
12	6	917.50	11393.42
12	9	956.02	11871.76
13	0	992.37	12323.15
13	3	1032.39	12820.12
13	6	1070.16	13289.14
13	9	1111.75	13805.60
14	0	1150.87	14291.39
14	3	1194.03	14827.35
14	6	1234.57	15330.77
14	9	1279.23	15885.35
15	0	1321.19	16406.41
15	3	1367.34	16979.49
15	6	1410.73	17518.30
15	9	1458.45	18110.89
16	0	1503.18	18666.34
16	3	1552.40	19277.55
16	6	1598.63	19851.63
16	9	1649.34	20481.34

Materials for Pile Construction

Concrete

- The concrete for bored cast-in-place piles shall conform all requirements as described under the Section on '**Concrete Work** 'of ***LGED Technical Specifications for Bridges.***
- 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.
- Reasonable calculated delays shall be secured by a **design mix** (including the necessary retarders and plasticizers)
- All relevant concrete properties such as slump, time of setting, temperature and strength shall be measured on the **trial mixes.**
- Slump measured at the time of discharge into the pile boring shall be minimum 100mm and maximum 150mm. Plasticizers /super plasticizers (e.g. DARACEM 100 @ 400-1200L/100kg cement may be added to increase workability)
- 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 LGED Technical Specifications for Bridges.
- 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 the size and classification number recommended by the manufacturer.

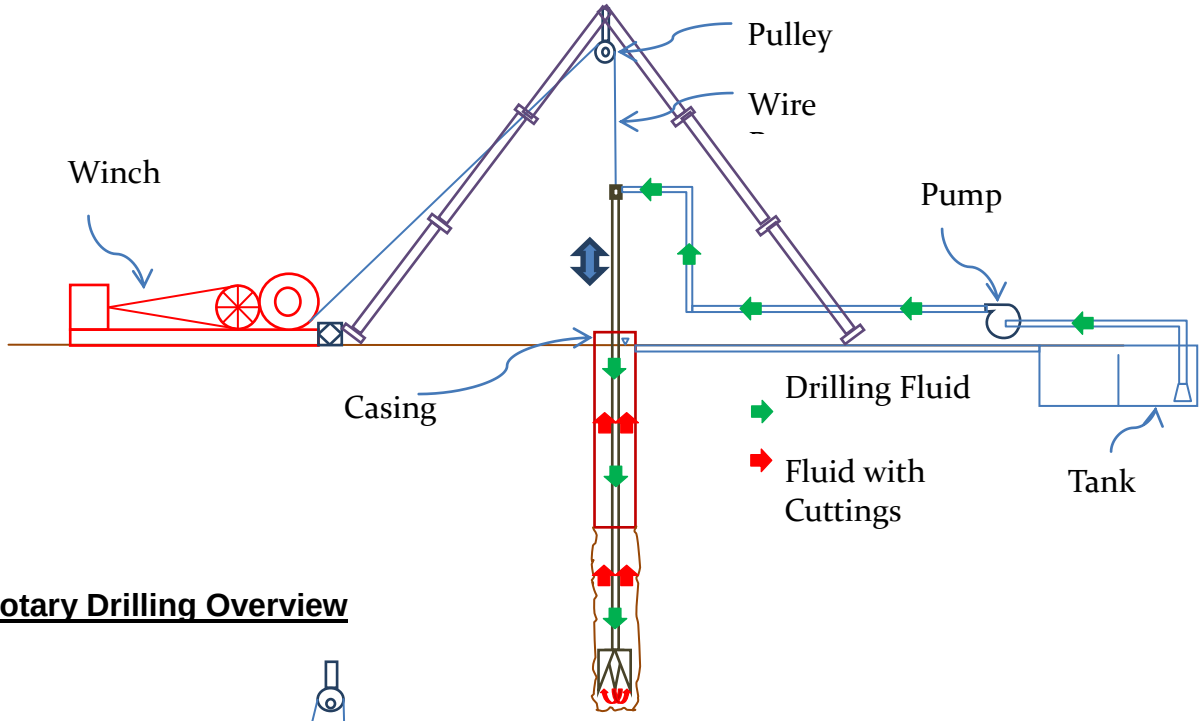
Bridge and Pile Layout Plan

- The Engineer shall carefully study the Hydrology and Morphology report and examine the recommendation on the sequence of the work to be implemented.
- The contractor shall provide 3 TBM pillar near the site with reference to the nearest SOB BM pillar and mark the 3 GPS coordinates (Longitude, Latitude and Elevation) with the help of Professional GPS and Total Station Machine.
- The contractor provide the location (longitude and Latitude) of centerlines of all Abutments (as suggested in the Hydrological and Morphological Study report) and Piers with the help of Total Station Machine
- The Contractor shall submit the Bridge layout plan for approval of the Engineer.
- The contractor shall submit the pile layout plan for approval of the Engineer
- The Engineer shall obtain the BIWTA certificate for horizontal and vertical clearance and verify the same with the drawing and the information of HFL from local interview

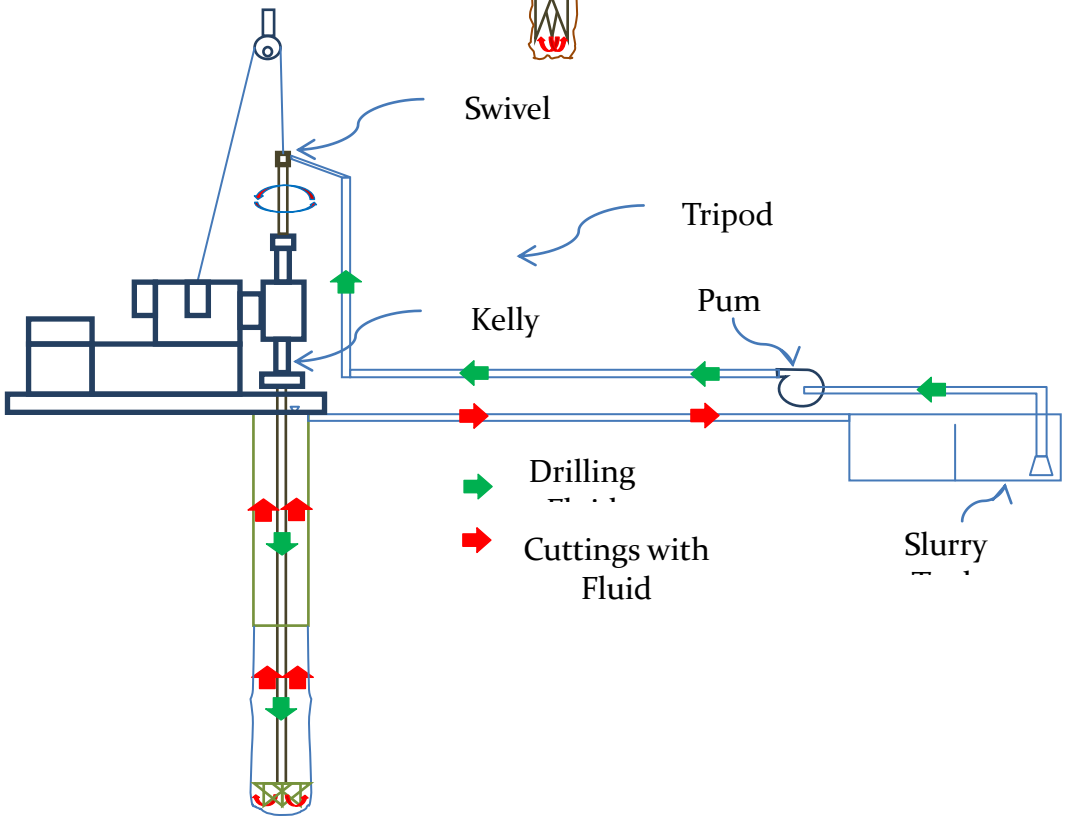
Drilling Professionals and Equipment

- At least one standby for each running drilling equipment shall be made available at the site.
- All Running and Standby equipment shall be of proven quality and shall have adequate power (HP and RPM).
- The essential equipment are Winch Machine with wire cable, Winch Operating Engine, Drilling fluid pumping Engine, Concrete Pump, Mixture Machine, Vibrator Machine, Welding Machine, Betonies mixing machine, Drill bit, etc.
- Tromie pipe of minimum internal diameter shall be 150mm for concrete made with 25mm aggregates and 200mm for 32mm aggregates

Percussion Drilling Overview



Rotary Drilling Overview



Placing Reinforcement & Preparation for Concreting

- Lower and place rebar case in position with cover block
- Lower and place tremie pipe as close as possible to bottom (0.3m above bottom)
- Use jute, coir or cotton rope with grease to seal joint of tremie
- Apply Air lift pumping by using compressed air through tremie
- Flash the borehole by reverse mud flow through tremie using compressed air
- During reverse flashing tremie to be moved around entire bottom
- Make tremie concrete (Slump 150-175mm) adding water reducing Admixture (DARACEM-100)
- Start pouring concrete just after removing air lift accessories

Pile Concreting

- Determine volume of 1st batch so that at least 500mm of tremie to be immersed into the concrete after 1st batch
- Use separator to avoid mixing concrete with mud inside tremie
- Place a valve in the bottom of the funnel
- Place a rubber ball below the 1st batch concrete to separate mud with concrete
- Pour & pack concrete into the funnel and open the valve
- Sudden opening of the valve will push the mud towards bottom vigorously and huge surge will clean the borehole bottom
- Not to lift tremie after 1st batch poured until tremie sufficiently embedded into concrete
- After enough concrete has been poured to fill the hole for 6 meters, 3 meters of tremie may be removed.

Pile Construction Records

- 1st RING FILE shall be made for each Abutment and Pier. The 1st page of the ring file is the pile construction sequence sheet. The ring file shall contain several sub-files. Each sub-file shall various records for each pile and these includes the pile driving log, Laboratory report of fresh concrete (Slump, Setting time of concrete etc.) and hardened concrete (Cylinder strength etc.), Bentonite suspension test report (Density, Viscosity, Sand content test etc), ID numbers of materials used for construction. Each sub-file shall be separated by colored page separator.
- The 2nd RING FILE shall contain the Laboratory test report of construction materials (Cement, Aggregates, and Reinforcement etc.), Bentonite Powder test report (Liquid Limit, moisture content etc), Admixture test report, Mix Design report, Trial Mix report. All new materials shall be tested before use. Materials shall be stocked properly and marked with Peg and Tag (ID Number) and test reports shall be kept sequentially for each material with arrival date and quantity procured. Colored Page separator shall be used for each material type
- The 3rd RING FILE shall contain all test report related to the Test Pile
- Site Order Book

- Measurement Book (MB)
- 24 hours Duty Roster signed by supervising LGED staff, Consultant and Contractor with date and time

TROUBLE SHOOTING-BULGING

- Bulging may occur when borehole wall collapses within a certain depth resulting in enlarged diameter. Common caused of borehole wall collapse is drilling fluid unable to hold the integrity of the borehole wall or inadequate length of casing in sandy strata.
- To avoid such problem soil profile should be carefully studied and adequate density of drilling fluid and casing must be maintained.
- Necking may occur in soil when drilling fluid pressure cannot hold the hole open resulting in reduced diameter. Necking may occur due to lower density of drilling fluid or inadequate length of casing
- To avoid such problem soil profile should be carefully studied and adequate density of drilling fluid and casing must be maintained.

TROUBLE SHOOTING-DISCONTINUTY

- Discontinuity may occur for inadequate length of tremie in fresh concrete.
- When concrete is placed inside the fresh concrete, the concrete column rises thru the hole and slurry is displaced.
- However, if concrete is placed above fresh concrete then debris and mud may get trapped between concrete, creating a separation.
- To avoid such problems, tremie must be always placed in concrete at least 3 meters.

TROUBLE SHOOTING-DEFORMATION

- Casing maybe withdrawn after concreting if above conditions stated earlier are met.
- Casing should be withdrawn as soon as concreting is complete.
- When withdrawing, casing should be withdrawn slowly and verticality must be maintained.
- Otherwise, pile head may be damaged due to deformed shape, loss of clear cover, damaged to the rebar.

5.0 Pile Load Test (Static)

Pile Load Test:

It is a test conducted physically on piling site to test the magnitude of the pile foundation strength against the civil engineers' load factor.

Objectives of Pile Load Test:

- The pile load test involves the direct measurement of pile head displacement in the response to a physically applied test load.
- Load testing is the most accurate way to determine the ultimate compression and tension capacity of the deep foundation.

Necessity of pile load test:

- To determine the proof/ultimate load carrying capacity of pile;
- To ascertain the actual factor of safety against the design load of pile;
- To check or compare the theoretical design load with the actual pile capacity;
- To determine the load settlement behavior of a pile;
- To increase or reduce the designed pile length;
- To determine of the structural soundness of pile.

Types of Load Test on Pile:

- Compression Load Test : to determine the vertical load carrying capacity of pile;
- Lateral Load Test : to determine the lateral load carrying capacity of pile;
- Uplift test : to determine the uplift or tension capacity of Pile.

Categories of piles for testing:

Two categories of piles are taken for test:

i. Pilot pile test / Initial test
   - This test is carried out on pile / test piles which may or may not be incorporated in the work;

ii. Service pile test / Routine tests
   - This test shall be carried out as a check on working piles.

Test frequency:

- The number of initial and routine tests on pile is determined depending upon the number of foundation type of super structure and uncertainties of foundation strata;
- Normally the initial load test shall not be less than 2 (IRC), and routine test shall not be less than 2% of total nos. of pile or not less than 2.

Preparation of pile to be tested:

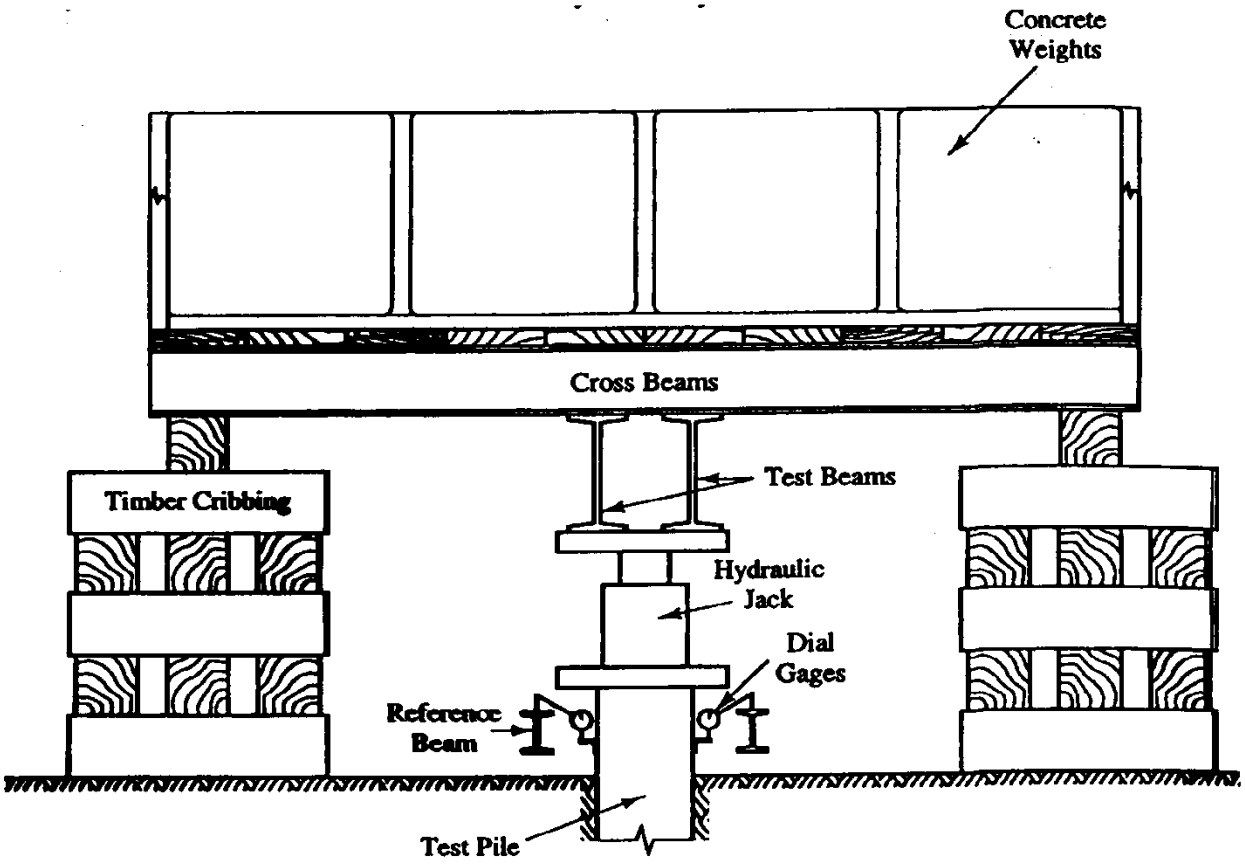
i. A pile shall not be tested until the curing period is over;
ii. In case of driven pile, the period shall not be earlier than 72 hours after the driving is completed;
iii. The head of the test pile shall be cut-off leveled and chapped with a steel plate to produce a level bearing surface;

iv. Pile head to be adequately reinforced or protected to prevent damage from the concentrated application of load.

Necessary check list prior to Testing:

a) Weight of Kentledge (Min.1.25 times the test load);
b) Platform stability (Particularly height of Kentledge);
c) Adequacy of reaction beam (For Anchor pile system);
d) Calibration of the pressure/load dial gauge;
e) Jack efficiency/ Jack calibration;
f) Capacity of Jack;
g) Ram diameter of Jack (ID);
h) Accuracy of deflection meter;

Fig.Load Test



Office Order of LGED:

এলজিইডি'র আওতায় বিভিন্ন প্রকল্পে নির্মানাধিন ব্রীজের পাইলের Static Load Test এর প্রস্তুতি গ্রহণ কালে সংশ্লিষ্ট ঠিকাদারকে নিম্নলিখিত বিষয়দি নিশ্চিত করতে হবে।

১। অভিজ্ঞতা সম্পন্নSub Contractor দ্বারা লোড টেষ্ট এর কাজ সম্পাদন করতে হবে। Sub Contractor নিয়োগে প্রকল্প পরিচালক/নির্বাহী প্রকৌশলীর পূর্বানুমতি গ্রহণ করতে হবে।

২। Pressure Gauge এর ID No এবং Pressure Gauge এর Capacity কমপক্ষে 700kg/cm2 থাকতে হবে।

৩। Pressure Gauge এর Calibration BUET থেকে Test কওে সিলগাল অবস্থায় সাইটে রাখতে হবে।

৪ ।Hydraulic Jack এর Ram dia কমপক্ষে 450mm (18") হতে হবে।

৫। Hydraulic Jack এর catalog এবং Hydraulic Jack এর efflciency test করা থাকতে হবে।

৬। কমপক্ষে ২টি Electric Hydraulic pump সাইটে রাখতে হবে।

৭। Recker beam or Reaction girder কমপক্ষে ৫ ফুট লম্বা এবং Heavy Plate (Min.40mm) দ্বারা তৈরী হতে হবে।

৮ ।Main girder (Joist) কমপক্ষে ৭টি এবং প্রত্যেকটি ২০ ফুট লম্বা (Size:350mmx175mmx15mm) থাকতেহবে।

৯। Cross-girder (Joist) কমপক্ষে ৩৬টি এবং প্রতিটি ২০ ফুট লম্বা (Size:350mmx150mmx6mm) থাকতে হবে।

১০। (Reference pipe or Angle ২টি এবং প্রতিটি কমপক্ষে ২০ ফুট লম্বা থাকতে হবে।

১১। Dial Gauge ২টি Dial Gaugeএর Capacity কমপক্ষে 70mm থাকতে হবে।

১২। Kent ledge এর লোড Test load থেকে ২০% বেশী থাকতে হবে।

এ বিষয়ে প্রয়োজনে এলজিইডি'র ডিজাইন/মাননিয়ন্ত্রন ইউনিটের পরামর্শ গ্রহণ সহ প্রয়োজনে সাইট পরিদর্শনের ব্যবস্থা নিতে হবে।

Record of Pile Load Test		
General Information:		
Project Name:		Contact No.
Pile Type: Pre-cast/ Cast-in-situ	Date of Driving / Casting of Pile:	Design/ Service Load:
Test Type: Pilot Pile/Service Pile	Date of Test Started:	Test/Proof Load:
Pile Location:	Date of Test Ended:	Jack Ram Area:
Pile Size/ Diameter:	Pile Length:	Jack Efficiency:

Load & Settlement Record:

Date	Time of Load Applied	Observed Gauge Reading	Actual Gauge Reading	Actual Applied Load	Settlement (mm)			Remarks
					M1	M2	M3	

Contractor's Representative Consultant's Representative Client's Representative

6.0 Pile Integrity Test (PIT)

Introduction to Pile Integrity Test (PIT):

Pile Integrity Test (PIT) is a non-destructive testing technique, involves applying low strain pulse to pile shaft using small hand held hammer for striking.

Main purposes of the Low Strain Pile Integrity Tester PIT testing system are to identify pile with major defects which can lead a pile to structural failure.

Objectives of Pile Integrity Test :

- ❖ PIT is a tool for investigating pile integrity;
- ❖ PIT is intended to locate major defects in pile shaft;
- ❖ Measuring qualitative dimension of pile shaft;
- ❖ Detecting changes in pile shaft properties.

Types of Pile Integrity Testing Method:

The experienced test engineer can choose method of tests from the followings:

i) **Pulse Echo Method (PEM)** – is the simplest method and pile top velocity records as a function of time.

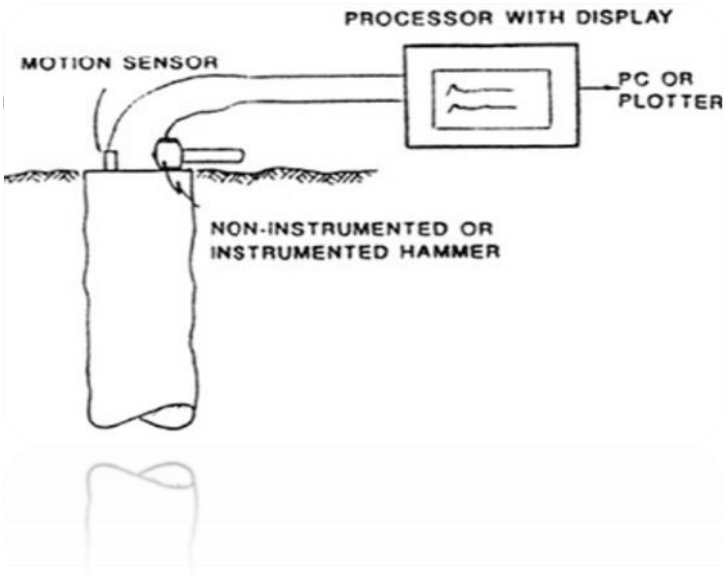
ii) **Transient Response Method (TRM**) – displays mobility, pile top velocity divided by force, as a function of frequency.

iii) **Combination of PEM & TRM Method:** A combination of PEM and TRM which displays the velocity in both time and frequency domain.

iv) **Profile Analysis:** The profile analysis which determines an approximate shape of the pile based the pile top velocity.

Basic Concept of PIT:

PIT is developed based on theory of weave propagation in concrete material. Compression stress weave generates when a pile top is struck by a hand held small hammer. Stress weave travels down to the toe and come back to top of the pile at weave speed ranging from 3000 to 4500 m/s.



SESSION-12

Topic: Estimate Preparation (Road)

Contents

1.0 Introduction

2.0 Discussion on use of RSEPS and procedure of use.

3.0 Discussion on working drawings of Road Works in the light of estimate preparation.

4.0 Preparation of estimate of Road Works using RSEPS

Session Objective:

At the end of the session the participants will be able to understand how to use RSEPS for estimation and costing of a Road work. .

Time: 1hr 30 mins.

Methodology

- Lecture /Discussion
- Demonstration
- Practice by doing an exercise

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out, Working drawings of Road in A3 Sheet and one computer with RSEPS software for each participant.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will discuss in details the use of RSEPS Software and procedure of use.	20min.
03.	Through a participatory approach, the facilitator will explain all the features of working drawings of a road works in the light of estimate preparation.	10 min
05	At this stage, the facilitator will give an assignment to participants individually for estimation and costing of a road works using RSEPS software. One computer and a set of working drawings of road works will be provided to every participant. .	45min
06	The facilitator will conclude the session by getting feedback from the participants.	10 min

Overview
Estimate Preparation (Road)

5.0 Introduction

এলজিইডি কর্তৃক গ্রহীত বিভিন্ন উন্নয়ন মূলক কাজ সুষ্ঠু ভাবে বাস্তবায়নের লক্ষ্যে কাজের বিভিন্ন আইটেম (Item of Works) সমূহকে Standardization এবং একক দর বিশ্লেষণ (Unit Cost Analysis) করা হয়েছে। যে কোন Item of Work এর দরের Unit Cost Analysis -এর জন্য ঐ Item of Work এ ব্যবহৃত Basic Material (যেমনঃ ইট, সিমেন্ট, বালি, শ্রমিক, ইত্যাদি) এর পরিমান ও তাদের বাজার দর এবং সরকার কর্তৃক নির্ধারিত VAT, IT ব্যবহার করা হয়েছে।

Basic Material সমূহের বাজার দরের মূল্য হ্রাস/বৃদ্ধির সাথে Item of Work এর দরের সমন্বয় রাখার জন্য প্রায় প্রতিবছর এলজিইডির সদর দপ্তর হতে Unit Cost Analysis ব্যবহার কওে প্রতিটি Item of Work এর জন্যই ১৭টি জোন অনুযায়ী আলাদা আলাদা দর নির্ধারন করা হয়ে থাকে। এছাড়া এলজিইডির সদর দপ্তর, জেলা ও উপজেলা অফিসসমূহে প্রতিনিয়ত নির্মাণ/মেরামত কাজের প্রচুর প্রাক্কলন (Estimate), সংশোধিত প্রাক্কলন (Revised Estimate), কাজের সিডিউল (Schedule of Works) তৈরি করতে হয় এবং দরপত্র দাতাদের দরপত্র সমূহ মূল্যায়ন করতে হয়। উল্লেখিত কার্যক্রমের ধরন থেকেই প্রতিয়মান হয় যে, কাজ গুলি Manually সম্পাদন করা অত্যন্ত কঠিন, শ্রমসাধ্য ও সময় সাপেক্ষ ব্যাপার। তদুপরি ভুলের সম্ভাবনাও থাকে প্রতিনিয়ত।

উপরোক্ত কাজ সমূহ নির্ভুল ভাবে সম্পাদন, সহজতর করা এবং জেলা ও উপজেলা পর্যায়ের এলজিইডির অফিসে কম্পিউটার ব্যবহার সম্প্রসারণের লক্ষ্যে Rate Schedule & Estimate Preparation System (RSEPS) নামক Software টিপ্রস্তুত করা হয়েছে। উক্ত Software টি ব্যবহার করে খুব সহজে নির্ভুল ভাবে এবং সময় সাশ্রয় কওে Schedule of Rates হাল নাগাদ করণ, Rate Analysis তৈরি, কাজের প্রাক্কলন (Estimate), সংশোধিত প্রাক্কলন (Revised Estimate), সিডিউল তৈরি (Schedule of Works), দরপত্র দাতাদের দরপত্র সমূহ মূল্যায়ন ইত্যাদি কাজ করা সম্ভব। RSEPS Software টি Microsoft Access Database এবংVisual Basic for Application এরসমন্বয়ে তৈরি করা হয়েছে। Software টিতে তথ্য উপাত্ত সমূহ সংরক্ষণে রজন্য ১টি Database File (RSEPS_ Front/MDE) এবং উক্ত Database File টিকে Link কওে কার্য সম্পাদনের জন্য ১টি আলাদা Interface (RSEPS _Front/MDE) তৈরিকরা হয়েছে। যারফলে Software টি Client-Server environment এ ব্যবহার করা সম্ভব।

Software ব্যবহার করার জন্য নিম্নলিখিত Software /Hardware environment প্রয়োজনঃ

- Software environment:
  Operating System (OS): Windows family

(Windows 95/98, Windows NT, Windows 2000/xp

Application Software : MS Access 97/2000

- Hardware environment:

CPU : Pentium-I or above

RAM : 64 MB or above (depending on OS)

6.0 Discussion on use of RSEPS and procedure of use.

Annex- VII of this manual contains procedural document of RSEPS. This procedural document will guide facilitator for discussion on use of RSEPS software. In this stage the participants will practice RSEPS software with the guidance of this procedural document and facilitator will assist them.

7.0 Discussion on working drawings of Road Works in the light of estimate preparation.

A set of working drawings of Road Works is attached in **Annex- IV** for details discussion in the light of estimate preparation and assignment of estimate of Road Works by the participants using RSEPS Software.

Through a participatory approach, the facilitator will explain all the features of working drawings of the Road Works in the light of estimate preparation.

8.0 Preparation of estimate of a Road Works using RSEPS

At this stage, the facilitator will give an assignment to participants individually for estimation and costing of Road Works using RSEPS software. One computer and a set of working drawings of Road Works will be provided to every participant.

The facilitator will assist every participant for preparation of estimate and will verify the misconception of participant's learning.

SESSION-13

Topic: Estimate Preparation (Bridge/Culvert)

Contents

1.0 Introduction

2.0 Discussion on use of RSEPS and procedure of use.

3.0 Discussion on working drawings of Bridge/Culvert in the light of estimate preparation.

4.0 Preparation of estimate of a Bridge/Culvert using RSEPS

Session Objective:

At the end of the session the participants will be able to understand how to use RSEPS for estimation and costing of Bridge and Culvert. .

Time: 1hr 30 mins.

Methodology

- Lecture /Discussion
- Demonstration
- Practice by doing an exercise

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out, Working drawings of Culvert and Bridge in A3 Sheet and one computer with RSEPS software for each participant.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will discuss in details the use of RSEPS Software and procedure of use for preparation of estimate of Bridge and Culvert.	20min.
03.	Through a participatory approach, the facilitator will explain all the features of working drawings of bridge & culvert in the light of estimate preparation.	10 min
05	At this stage, the facilitator will give an assignment to participants individually for estimation and costing of a bridge using RSEPS software. One computer and a set of working drawings of bridge will be provided to every participant. .	45min
06	The facilitator will conclude the session by getting feedback from the participants.	10 min

Overview
Estimate Preparation (Bridge/Culvert)

5.0 Introduction

এলজিইডি কর্তৃক গ্রহীত বিভিন্ন উন্নয়ন মূলক কাজ সুষ্ঠুভাবে বাস্তবায়নের লক্ষ্যে কাজের বিভিন্ন আইটেম (Item of Works) সমূহকে Standardization এবং একক দর বিশ্লেষণ (Unit Cost Analysis) করা হয়েছে। যে কোনা tem of Work এর দরের Unit Cost Analysis - এরজন্য ঐ Item of Work এ ব্যবহৃত Basic Material (যেমনঃ ইট, সিমেন্ট, বালিশ্রমিক, ইত্যাদি) এর পরিমান ও তাদের বাজার দর এবং সরকার কর্তৃক নির্ধারিত VAT, IT ব্যবহার করা হয়েছে।

Basic Material সমূহের বাজার দরের মূল্য হ্রাস/বৃদ্ধির সাথে Item of Work এর দরের সমন্বয় রাখার জন্য প্রায় প্রতি বছর এলজিইডির সদর দপ্তরহতে Unit Cost Analysis ব্যবহার কওে প্রতিটি Item of Work এর জন্যই ১৭টি জোন অনুযায়ী আলাদা আলাদা দর নির্ধারন করা হয়ে থাকে। এছাড়া এলজিইডির সদর দপ্তর, জেলা ও উপজেলা অফিস সমূহে প্রতিনিয়ত নির্মাণ/মেরামত কাজের প্রচুর প্রাক্কলন (Estimate), সংশোধিত প্রাক্কলন (Revised Estimate), কাজের সিডিউল (Schedule of Works) তৈরি করতে হয় এবং দরপত্র দাতাদের দরপত্র সমূহ মূল্যায়ন করতে হয়। উল্লেখিত কার্যক্রমের ধরন থেকেই প্রতিয়মান হয় যে, কাজ গুলি Manually সম্পাদন করা অত্যন্ত কঠিন, শ্রমসাধ্য ও সময় সাপেক্ষ ব্যাপার। তদুপরি ভুলের সম্ভাবনাও থাকে প্রতিনিয়ত।

উপরোক্ত কাজ সমূহ নির্ভুলভাবে সম্পাদন, সহজতর করা এবং জেলা ও উপজেলা পর্যায়ের এলজিইডির অফিসে কম্পিউটার ব্যবহার সম্প্রসারণের লক্ষ্যে Rate Schedule & Estimate Preparation System (RSEPS) নামক Software টি প্রস্তুত করা হয়েছে। উক্ত Software টি ব্যবহার করে খুব সহজে নির্ভুল ভাবে এবং সময় সাশ্রয় কওে Schedule of Rates হালনাগাদ করণ, Rate Analysis তৈরি, কাজের প্রাক্কলন(Estimate), সংশোধিত প্রাক্কলন (Revised Estimate), সিডিউল তৈরি (Schedule of Works), দরপত্র দাতাদের দরপত্র সমূহ মূল্যায়ন ইত্যাদি কাজ করা সম্ভব।

RSEPS Software টি Microsoft Access Database এবং Visual Basic for Application এর সমন্বয়ে তৈরিকরা হয়েছে। Software টিতে তথ্য উপাত্ত সমূহ সংরক্ষণের জন্য ১টি Database File (RSEPS_Front/MDE) এবং উক্ত Database File টিকে Link কওে কার্য সম্পাদনের জন্য ১টি আলাদা Interface (RSEPS_Front/MDE) তৈরি করা হয়েছে। যারফলে Software টি Client-Server environment এ ব্যবহার করা সম্ভব।

Software ব্যবহার করার জন্য নিম্নলিখিত Software /Hardware environment প্রয়োজনঃ

- Software environment:
  Operating System (OS): Windows family
  (Windows 95/98, Windows NT, Windows 2000/xp
  Application Software : MS Access 97/2000

- Hardware environment:

  CPU : Pentium-I or above

  RAM : 64 MB or above (depending on OS)

6.0 Discussion on use of RSEPS and procedure of use.

Annex-VII of this manual contains procedural document of RSEPS. This procedural document will guide facilitator for discussion on use of RSEPS software in the light of estimate preparation of a Bridge. In this stage the participants will practice RSEPS software with the guidance of this procedural document and facilitator will assist them.

7.0 Discussion on working drawings of Bridge and Culvert in the light of estimate preparation.

A set of working drawings of Bridge attached in **Annex- III** and a set of Culvert attached in **Annex-II** for details discussion in the light of estimate preparation and assignment of estimate of a Bridge by the participants using RSEPS Software.

Through a participatory approach, the facilitator will explain all the features of working drawings in the light of estimate preparation.

8.0 Preparation of estimate of a Road Works using RSEPS

At this stage, the facilitator will give an assignment to participants individually for estimation and costing of a Bridge or Culvert using RSEPS software. One computer and a set of working drawings of Bridge or Culvert will be provided to every participant.

The facilitator will assist every participant and verify the misconception of participant's learning.

SESSION-14

Topic: Surveying

Contents

1.0 Types of surveying practiced in LGED

2.0 Level Surveying

3.0 Plane Table Surveying

4.0 Use of Theodolite

5.0 Introduction to Total Station Equipment

Session Objective:

At the end of the session the participants will be able to know the types of survey practiced in LGED, understand level survey and plain table survey and also will receive preliminary idea on Total Station equipment.

Time: 1 hr. 30 mins.

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials:

White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will present in details the various types of surveying practiced in LGED	10min.
03.	Through a participatory approach, the facilitator will explain use of level surveying in LGED and operational procedure of leveling survey in the real situation.	25 min
04.	Through a participatory approach, the facilitator will explain use of plane table surveying in LGED and operational procedure of plain table surveying in the real situation.	25 min
05.	Through a participatory approach, the facilitator will introduce the Total station equipment to the participant	20 min
06	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Surveying

1.0 Types of surveying practiced in LGED

Surveying is of vital importance in any engineering project. Nobody can think of a project like Road project, Irrigation project, Buildings project etc. without proper surveying. There are various types of surveying. In LGED the following types of surveying are normally in practice:

(a) Level Surveying
(b) Plane Table Surveying
(c) Stadia Surveying
(d) Topographical Surveying
(e) Photographic Surveying
(f) Cadastral Surveying
(g) Hydrographic Surveying

Level Surveying: It is a type of surveying in which the relative elevations of different points on the earth's surface are determined.

Plane Table Surveying: It is a method of surveying in which observations and plotting are done simultaneously.

Stadia Surveying: It is a type of surveying in which vertical and horizontal distances are computed from stadia readings.

Topographical Surveying: To determine the positions both in plan and elevation of the different artificial and natural features of a terrain and representing them by measure of conventional symbols upon map.

Photographic Surveying: This is a method of surveying in which maps are prepared from photographs.

Cadastral Surveying: To determine boundaries of fields, houses, etc.

Hydrographic Surveying: To determine the shore lines, soundings, navigational depth, channel X-section etc.

2.0 Level Surveying

Before proceeding with level surveying the following terms should be clearly understood.

Bench Mark (B.M): A bench mark is a fixed point on the ground of known elevation. There are generally four kinds of bench marks. (i) G.T.S (Great Trigonometrical Survey) (ii) Permanent (iii) Arbitrary and (iv)Temporary.

Arbitrary bench marks are the reference point whose elevations are assumed arbitrarily for small leveling works. **Temporary bench marks** are the reference points which are generally established at the break of any leveling work on some permanent objects.

Height of Instrument (H.I): The elevation of line of collimation above datum is termed as the height of the instrument. This is also known as the R.L of the line of collimation.

Station: A station is a point whose elevation is to be determined. It is a point where staff reading is taken but not the point where the level is set up.

Change Point: It is an intermediate stations on which two reading are taken while the position of the instrument is shifted.

Back, Inter and Fore Reading: In any set up of the leveling instrument, the first staff reading on a station is termed as back reading (B.R) and the last staff reading on a station is termed as the fore reading (F.R) and the reading on the intermediate station is termed as the inter reading (I.R)

Purpose of leveling: This is performed to know the undulation of the ground along and across the alignment of a route such as roads, railway, irrigation, canals, water and sewer lines etc. so as to determine the volume of earthwork in filling or cutting in an embankment. It also determines the area from contour maps (such as reservoir area, catchment area etc.) This helps in setting out the formation levels of roads, canals, sewer lines etc.

Procedure of Leveling Operation:

A level is an instrument by which the relative heights of different points on the surface of the earth are determined. Leveling is the process of determining and recording the difference in elevation of various points. The main instruments that are essential in carrying out a leveling operation are i) a level machine with a tripod stand and ii) a leveling staff graduated in feet or in meters and a fraction of a meter.

It is essential to check the adjustments of the instrument before carrying out leveling. In the case of a dumpy level, the permanent adjustments of the bubble tube and the line of collimation are required to be checked to avoid errors in leveling. The vertical axis of the instrument is at right angle to the bubble tube if the bubble tube at the centre of its run remains at the centre when the level is turned 180^{O}. The line of collimation may be checked by the two peg test. The test describes that the difference in level of two pegs obtained by two sets of readings, one taken on the pegs from equal distance and the other taken from unequal distances, shall be equal. If test criteria are not satisfied, the level needs permanent adjustment.

The procedure for leveling is as follows:

(i) Fix the level on stand properly and set the 3 legs of the stand firmly on ground keeping the base of the instrument nearly horizontal.

(ii) Rotate the telescope until the bubble tube becomes parallel to two foot screws. Turn both the screws simultaneously inward or outward to bring the bubble at the center of its run.

(iii) Rotate the telescope through 90^{0} and bring the bubble to the center of its run with the help of the two screws previously used for adjustment.

(iv) Repeat steps (ii) and (iii) until the bubble is always at the centre of its run for any position of the telescope.

(v) Focus the staff by turning the focusing screw until the image is clear. If cross-hairs are not distinct, focus them by moving the eye-piece in or out while looking at sky or a distant light object.

(vi) Check the verticality of the staff by tilting the staff backwards, forwards and sideways. At vertical position the staff reading is the minimum.

(vii) Take the staff readings, enter the values in a level book and calculate the reduced levels.

Fly Leveling

Fly or differential leveling is the process of determining the difference in elevations of two distant points by taking back and fore readings without measuring distances between the stations. This method is needed to carry the Reduced Level (R.L.) from a bench mark (B.M.) to appoint near the proposed work. Fly leveling may also be used to transfer the High Flood Level (HFL.), if the HFL mark is not available near the project site. The transfer of B.M. and HFL by fly leveling is required.

Cross-sectional Leveling

Cross-sections of relatively shallow channels can be determined in the dry season by leveling. The leveling work was carried out along the cross-section of the channel from B.M. established. The readings obtained in two set ups of the instrument have been entered in the page of a level book. The cross-section of the channel can now be reproduced from the data in the table book

Sounding

The measurement of depth below the water surface is known as sounding. The objective of sounding is to take cross-section or the longitudinal section of the channel. Sounding is a good method for examination of the bed profile and determination of channel cross-sectional area at HFL or any other water levels. .

The field procedure for sounding is as follows:

i) Drive two poles on opposite banks of the channel

ii) Tie the ends of a string securely to both poles so that the tie is horizontal and stretched enough to avoid sag. The horizontality of strain can be ensured by a hand level or by fixing the tie-points on poles at the same elevation by using a level or maintaining the string parallel to water level.

iii) Divide the width of the channel into equal divisions (1m) and mark the divisions on the string line by visible colour or any other indicator. Smaller divisions in highly irregular bed will produce a more representative bed profile.

iv) Measure the water depth at the mark with the help of leveling staff, graduated poles or string with plumb bob and record the ordinates OO, O1, O2 . . . on a rough sketch of the channel.

v) If the desired highest flood level does not exist during measurement, coordinates may be measured with respect to the string and difference in level between the string and highest flood may be added or subtracted to obtain the actual ordinates at HFL.

vi) Draw the bed profile of the channel taking HFL as the reference line. R.L. of the bed profile at the ordinate points can be obtained subtracting the ordinates from HFL.

3.0 Plane Table Surveying

It is a method of surveying in which observations and plotting are done simultaneously. This type of surveying is very suitable in plotting the interior details like buildings, trees, roads, electric post or any other permanent objects. This is particularly used in small scale mapping and allows the work to be done very quickly. Since the observations and plotting are done simultaneously, so there is less possibility of any mistake.

Instruments: Instruments required for this type of surveying are (a) a drawing board (b) tripod stand (c) alidade (d) trough compass (e) plum bob (f) U-fork (g) sprit level (h) tape or chain (drawing sheet with board pins or clips.

Procedure:

Either the radial or the intersection method can be used for plane tabling the site of a road structure project.

The procedure for plane tabling is as follows:

(i) Select a station on the ground and fix it with peg and set the plane table on the station with the help of a plumb bob in such a way that the point representing the station on the plane table is directly above the peg.

(ii) Level table with the help of a sprite level and draw the north line with the help of a trough compass.

(iii) Sight the features through the alidade keeping its edge on the station and draw rays along the edge.

(iv) Measure the distances between the station and the adjacent features and plot them to an appropriate scale along the rays drawn sighting these features. For features whose distances are too great to be measured conveniently by type and chain, the method if intersection should be used for plotting.

(v) Fix another station from which the distant features sighted from this station this station are also visible and draw a ray sighting that station. Measure the distance between the station and plot the new station to scale on the ray.

(vi) Shift the plane table to the station already plotted on the map and set the table with the help of plumb of the bob and orient it by rotation the table until the trough compass placed along the north line indicates north. Check the orientation by back sighting towards the previous station.

(vii) Draw rays sighting the distant object already sighted from the previous station and plot the features at the points of intersection.

(viii) Plot the features around the station by the method of radiation as stated in (iv) and draw rays sighting new features which were not visible from the previous station.

(ix) Shift the table to a third station and onwards to cover all the features required to be plotted.

The type of surveying to be selected for the preparation of detailed map is dependent on the type of instrument available in the upazila and the field condition. Traverse surveying is possible only when all the features to be located in the map are easily accessible and the reference lines as well as the perpendicular distance between the objects and the reference lines can be directly measured by chain and tape. In stadia and plane table surveying, direct measurement of distance except the measurement of base or reference line can be avoided. Hence these methods are suitable for locating inaccessible visible features. If all the instruments are available, in many cases, a combination of two or three methods may be found most suitable for the preparation of detailed map.

4.0 Use of Theodolite

It is one of the complicated instruments used in surveying but accurate instrument with which both horizontal and vertical angles can be measured. This is also used for locating points, establishing slope, extending lines, finding difference in elevation, ranging curves and traversing. Theodolite also can be used as a leveling instrument. Theodolites are of three types (i) Transit (ii) Wye and (iii) Everest. Transit type theodolite is used in most of the works. There are different sizes of theodolite. The diameter of the graduated circle on the lower plate defines its size. In engineering works, generally 4" to 6" theodolites are used.

5.0 Total Station

Introduction to Total Station

Total Station is an electronic device, which can determine the coordinate of a target point in a digital form. It transmits beam of infrared light towards the target (reflector) & receive the reflected beam from the prism & calculate the distance, bearing & 3D coordinate of that target point with respect to the reference point.

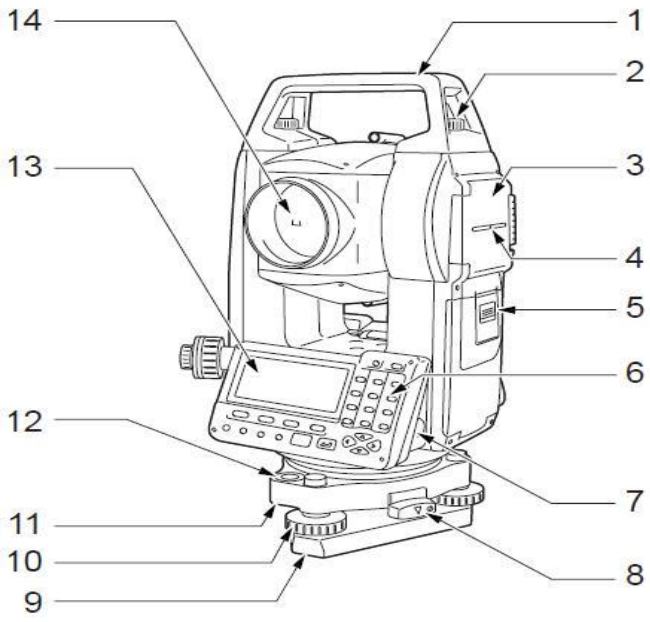
Total Station is combination of

- Distance & Level (Traditional Survey Equipment)
- Bearing / Angle (Traditional Survey Equipment)&
- Co-Ordinate (GPS)

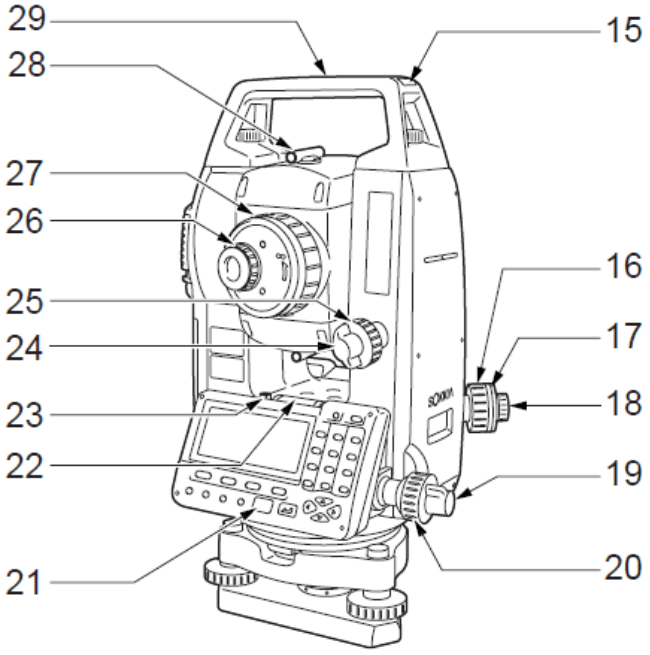
Application/Data Collection

- Distance and Angle Measurement
- Angle Measurement
- Area Calculation
- Remote Elevation Measurement (REM)
- 3-D Coordinates Measurement
- Resection
- Set-out
- Point Projection
- Traverse Adjustment

Parts of Total Station



1 Handle
2 Handle securing screw
3 External interface hatch
SD card slot
USB port
4 Instrument height mark
5 Battery cover
6 Operation panel
7 Data input/output connector (SET350X/550X/650X)
8 Tribrach clamp
9 Base plate
10 Levelling foot screw
11 Circular level adjusting screws
12 Circular level
13 Display
14 Objective lens



15 Tubular compass slot
16 Optical plummet focussing ring
17 Optical plummet reticle cover
18 Optical plummet eyepiece (16-18: Not included on instruments with optional laser plummet)
19 Horizontal clamp
20 Horizontal fine motion screw
21 Beam detector for wireless keyboard
(Not included on SET650X)
22 Plate level
23 Plate level adjusting screw
24 Vertical clamp
25 Vertical fine motion screw
26 Telescope eyepiece screw
27 Telescope focussing ring
28 Peep sight
29 Instrument center mark

SESSION-15

Topic: Earth Work Volume Calculation

Contents

0.0 Cross Sectional Leveling, Level Book Writing and R.L Calculation
1.0 Earthworks Volume Calculation using software

Session Objective:

At the end of the session the participants will be familiar with Level Book and able to calculate R.L from Level Book data. Also the participants will be able to know the operation of Software for Earthworks Volume Calculation using software.

Time: 1hr. 30 mins.

Methodology

- Lecture /Discussion
- Demonstration
- Practice

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out& Software for Earthworks Volume Calculation.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will explain in details the leveling of Road X-section, Level Book Writing and R.L calculation.	20 min.
04.	At this stage, the facilitator will discuss in details the operational procedure of EVCS Software **(Annex VIII).** Later, the facilitator will give an assignment to participants individually for Earthworks Volume Calculation using EVCS software	60 min
06	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Earth Work Volume Calculation

1.0 Cross Sectional Leveling, Level Book Writing and R.L Calculation

The leveling work for Road cross section is carried out along the cross section of the road from established B.M. The reading can be taken from set ups of the instrument at one or more station. The readings (staff reading) are entered in the page of a level book in the Table below. The R.L at different location of the cross section can now be calculated from the data in the level book. Also the cross section can now be reproduced from the data in the level book using EVCS software as well as earth volume can be calculated.

Table: Level Book Writing for a Road Cross-section

Staff Station	Distance (m)	Staff Reading			Ht. of Instrument	Reduced Level	Remark
		Back	Inter	Fore			
Section at Ch. 0 m							
BM						10.0m	B.M
L1							
L2							
L3							
L4							
CL							
R4							
R3							
R2							
R1							
Section at Ch. 50 m							
L1							
L2							
L3							
L4							
CL							
R4							
R3							
R2							
R1							

Arithmetical Check: Sum of BS – Sum of FS = Last RL-1st RL

The participants will be assigned with the level book in the table above along with staff reading (Facilitator will assist participants to write the staff reading). The participants will do this for two cross sections and accordingly will calculate R.L and use this two cross-sections at 50m apart for Earthworks Volume Calculation using EVCS software as mentioned in Art.2 below. (Assume R.L of TBM is 10.0m and Formation level of the Road is 9.80m)

2.0 Earthworks Volume Calculation using software

সড়ক উন্নয়ন ও প্রশস্ত করণের লক্ষ্যে প্রতি বছর এলজিইডি'র বিভিন্ন প্রকল্প/কর্মসূচীর আওতায় অসংখ্য মাটির কাজের স্কীম নেওয়া হয়ে থাকে। এসকল স্কীমের জন্য প্রযোজ্য মাটির Volume Manually Calculate করা অত্যন্ত কঠিন, শ্রমসাধ্য ও সময় সাপেক্ষ ব্যাপার। তদুপরি Calculation -এ ভুলের সম্ভাবনাও থাকে প্রতিনিয়ত। এ জাতীয় কাজ সহজীকরণের নিমিত্তে Earth Volume Calculation System (EVCS) Software টি Develop করা হয়েছে।

EVCS অন্যান্য Window base application (যেমনঃ MS-Word, MS-Excel) এরমত ১টি User Friendly Software, যেখানে Manu/Tool bar এর মাধ্যমে Software টির সকল কার্যক্রম পরিচালিত হয়ে থাকে। এছাড়া এখানে Mouse এর Right Button Click কওে কিছু নির্দিষ্ট Command সম্বলিত Pop-up Menu পাওয়া যার মাধ্যমে Manu/Tool bar এর কার্যক্রম পরিচালনা করা যাবে।

Software-টির মাধ্যমে খুব সহজেই Survey-কৃত ..Data Input/Edit করা যায় যেখানে Software টি নিজেই প্রয়োজনীয় ..Data সমূহের Validation Check করে এবং একই সাথে ভুল তথ্য সংশোধন প্রয়োজনীয় তথ্য প্রদানের জন্য ব্যবহারকারীকে অবহিত করে।এছাড়া ব্যবহারকারী Input -কৃত তথ্য Save করতে ভুলে গেলেও Auto Save প্রক্রিয়ায় Software-টি নিজেই তথ্য Save করে থাকে।

Software-টি মাটির Volume, Allied Item সম্বলিত Summary Sheet, Wheat Sheet/Taka Sheet-এর পাশাপাশি Cross Section, Longitudinal Profile এর গ্রাফও প্রদান করে থাকে যেখানে প্রয়োজন বোধে গ্রাফের Presentation Formate ব্যবহারকারী Customize করে নিতে পারে।

এছাড়া Software-টিতে Security পদ্ধতি প্রয়োগ করা হয়েছে যার ফলে অযাচিত ব্যবহার রোধসহ কিছু Resticted অংশে যেমনঃ Rate Upload) সাধারন ব্যবহারকারীদের অনুপ্রবেশ রোধ করা সম্ভব।

EVCS Software -টি 32-bit Windows Operating System -এ ব্যবহারের লক্ষ্যে তৈরি করা হয়েছে। Programming Language Visual Basic 6.0 দ্বারা EVCS Software-টি তৈরি করা হয়েছে যেখানে Reporting Tool হিসেবে Crystal Report ব্যবহার করা হয়েছে।

তথ্য/উপাত্তসমূহ সংরক্ষণের জন্যMicrosoft Jet Database Engine ব্যবহার করা হয়েছে তবে ব্যবহারকারীর Computer-এ Microsoft Access থাকাবাঞ্জনীয় নয়। Database File টিকে Serverএ রেখে Software টি Client-Server environment এ ব্যবহার করা সম্ভব।Software ব্যবহার করার হন্য নিম্নলিখিত Software/Hardware environment প্রয়োজনঃ

- Software Environment :
  Operating System (OS) : Window family
  (Windows 98, Windows NT, Windows 2000/XP

- Software Environment :
  CPU : Pentium-I or above
  RAM : 64 MB or above (Depending on OS)

At this stage, the facilitator will discuss in details the operational procedure of EVCS Software **(Annex VIII).** Later, the facilitator will give an assignment to participants individually for Earthworks Volume Calculation using EVCS software. The facilitator will guide the participants in this regard and clear the misconception of participant's learning.

SESSION-16

Topic: Brick Masonry Works

Contents

1.0 Materials and Tools of Brick Work

2.0 Principles of Brick masonry construction

3.0 Bonds in Brick Work

4.0 Tee-Junctions & Squint Junction

5.0 Cement Concrete Masonry

Session Objective:

At the end of the session the participants will be able to understand and also explain to others the properties of good quality materials for Brick masonry and Construction principles of brick masonry. Also able to understand Bonds in Brick Work, Tee-Junctions & Squint Junction and Cement Concrete Masonry

Time: 1hour

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out etc.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will explain in details the Materials and Tools of Brick Work and Construction principle of Brick Masonry works.	20 min.
03.	Through a participatory approach, the facilitator will explain brick bonding and joints of brick masonry.	20 min
04.	Through a participatory approach, the facilitator will explain all the features of Cement Concrete Masonry	10 min
05	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Brick Masonry Work

1.0 Materials and Tools of Brick Work

Construction of brick units bonded together with mortar is termed as brick masonry. Materials used in brick masonry are:

Brick: Brick shall be of first Class in Quality with the requirements as stated under the topic- Engineering Materials.

Types of Bricks other than normal bricks

Fire Bricks: Fire bricks are made of fire clay or refractory clay, burnt at a high temperature in special kiln. Fire bricks are generally of a white or yellowish white colour. Fire bricks are used for the lining of furnaces, boilers, combustion chamber and chimney flues where great heat is developed.

Terra-cotta: Terra-cotta is a kind of earthenware which is generally used as a substitute for stone in the ornamental parts of building.

Hollow Clay Bricks/Hollow concrete blocks: Use for non-load bearing partition wall. Each brick should contain a proportion of solid metal not less than one half of the gross overall volume. Hollow blocks have certain advantages over ordinary bricks, they are less weight. They have the advantage of hollow walls as regards insulation against heat and sound.

Cement: Cement used in the work shall be ordinary Portland cement complying with the requirements of ASTM C 150 Type 1 or BDS 232 or equivalent standard and those stated under the topic- Engineering Materials

Sand: Sand **(**Fine aggregates) shall consist of natural sand conforming to the requirements of ASTM C 144 and ASTM C 33 or BDS 243.Sand shall be completely non-saline, non-plastic and free from all clay, roots and all organic impaired for a specific work. Minimum F.M. of sand for any type of brickwork shall normally be 1.5 unless otherwise required for a specific work. All other properties of sand shall be the same as have been described under the topic- Engineering Materials

Water: Water shall be clean, free from injurious quantities of oil, alkali, salts and organic materials or other deleterious substance and shall not contain any visibly solid materials. All requirements shall be similar to what have been stated under the topic- Engineering. The contractor shall get the water tested by comparing with water of known satisfactory quality, if requested by the Engineer.

Soaking of bricks: Before use in works, all bricks shall be soaked in clear water for a minimum period of 24hours. Soaking shall be discontinued 2 hours before use so that at the time of laying they are skin dry. Such soaked bricks shall be stacked on a clean place where they shall not be spoiled by dirt or any other objectionable materials.

Preparation of mortar: Cement mortar for brick masonry works shall generally consists by volume of one part Ordinary Portland Cement and four parts screened sand or one part Ordinary

Portland cement and six parts screened and unless otherwise required by the specifications or instructed by the Engineer. In each mortar, just enough water shall be added the components mixed and thoroughly incorporated together to give workability appropriates to its use. Mortar shall be used whilst freshly mixed and no softening or re-tampering will be allowed.

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

Only a sufficient quantity of sand and cement shall mixed with water that can be used within 30 minutes from the time of addition of water at the time of initial mixing.

Finishing of surfaces

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 above.

The faces of brick masonry works shall be cleaned to remove any splash of mortar during the course of raising the brick masonry.

For pointing, the joints shall be squarely raked out to a depth of 15mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing shall then be finished to proper type given on the Drawing or as required under the BOQ and/or as directed by the Engineer.

If type of pointing is not mentioned on the Drawings or BOQ, flush pointing shall be used. For groove pointing, after the mortar has been filled and pressed into the joints and finished with the edges of the bricks, it shall be grooved along the center with a half round tool of such width as may be specified by the Engineer. Such works shall only be carried out within the period that the mortar remains green. The excess mortar shall then be cut off from the edges of the lines and the surfaces of the masonry shall also be cleaned of all mortars.

Tools for Brick Masonry work: Tools used for brick masonry construction are:

1) Hammer
2) Line and pins
3) Brick axe
4) Sprit level
5) Plumb rule
6) Mason’s square
7) Trowel
8) Two foot four fold rule etc.

Laboratory Test Requirement for Brick Masonry:

Materials	Tests	Test Frequency
Bricks, Sand and Cement	Compressive Strength of Brick	1 No. Test Per 300 m^3
	Water Absorption of Brick	1 No. Test Per 300 m^3
	F.M Test of Sand	1 No. Test Per 300 m^3
	Test of Cement (Compressive Strength) and Setting Time	1 No. Test Per 300 m^3
	Efflorescence of Bricks	1 No. Test Per 300 m^3

2.0 Principles of Brick masonry construction

The strength of masonry work however depends very much upon the type of materials used, nature of the workmanship and supervision. Bad workmanship may lead to very unsound construction in spite of the materials used being of the best possible type.

The following are the general principles to be followed in order to ensure strong and durable brick masonry work:

i) Only good, well-burnt bricks of regular shape and size, graded as A in BDS 208, should be used. They should have no cracks or flaws, grit or lumps etc.
ii) Bricks should be thoroughly soaked in clear water before they are used in masonry. A minimum of 24 hours of soaking is desirable.
iii) The bricks should be laid on a full bed of mortar. They should be slightly pressed into the bed of mortar while laying so as to ensure proper adhesion.
iv) Bricks should be bonded well in wall by one of the standard methods such as English bond, Flemish bend, etc. These bonds ensure that no two vertical joints come one over the other, in any two consecutive layers.
v) All the joints should be properly flushed and filled with mortar so that no cavity is left in between.
vi) Only specified mortar of a good quality should be used in the work, taking care that uniform mortar joint is obtained throughout the construction.
vii) The faces of masonry walls should be constructed truly vertical or true to any other batter, if this is specified. Plumb rule and wooden templates should be used to ensure this.
viii) The masonry in the entire length of wall should be raised uniformed. However, if it is necessary to raise any part of a wall in advance, proper tooting must be formed by giving projections to bind it to the wall to be built later.
ix) Good quality sand-cement mortar of appropriate consistency should only be used. The proportions as specified should be followed and should be adhered to strictly.
x) The work should be kept wet until the mortar sets and becomes hard. The curing period varies from 14 to 21 days.
xi) Mortar of uniform thickness varying between 6 and 13 mm should be used. All the joints and gaps in a layer must be filled up before laying another layer.

xii) Joints are usually the weak points in masonry and on exposed faces they should be protected by proper pointing with mortar.

xiii) The brick masonry should not be raised more than 1 m in a day. The weight of a high wall may disturb the mortar and the masonry if it is constructed too rapidly.

xiv) Iron fixtures like pipes, hold-fasts of doors and windows etc. which are to be fixed in the brick wall should be embedded in cement mortar or in cement concrete.

xv) Plastering should be done after about 28 days of completion of brick masonry. This permits adequate time for shrinkage in masonry and concrete.

xvi) In works where plastering or pointing is not desired, the mortar joints should be struck flush and finished at the time of laying.\

xvii) When it is desired to increase the length of the wall under construction at a future date, the wall is stopped with a toothed end. This is necessary to ensure continuous bonding between the old and the new work.

3.0 Bonds in Brick Work

Bonding is essential to eliminate continuous vertical joints both in the body as well as in the fact of wall thereby imparting strength to masonry. A wall having defecting arrangement of bricks, reduce the strength and stability of the structure. A wall having continuous vertical joint does not act as a homogeneous mass to distribute the superimposed load. On the other hand, it may be assumed to be consisting of small columns and when a particular column of this wall comes under the load, it fails on account of its inability to distribute the load to the portion of wall on either side of it. The different types of bonds commonly adopted are given bellow:

English Bond

This bond consists of alternate course of headers and stretches. In this arrangement, vertical joints in the header course come over each other and vertical joints in the stretcher course are also in the same line. For the breaking of vertical joints in the successive course it is essential to place queen closer, after the first header in each heading course, The following additional points should be noted in English bond construction:

(1) A heading course should never start with a queen closer as it is liable to get displaced in this position.

(2) In the stretcher course, the stretchers should have a minimum lap of $1/4^{th}$ their length over the headers.

(3) Walls having their thickness equal to an even number of half bricks, i.e., one brick thick wall, 2 brick thick wall, 3 brick thick wall and so on, present the same appearance on both the faces, i. e. a course consisting of headers on front face will show headers on the back face also.

(4) In walls having their thickness equal to an odd number of half bricks, i.e., $1^1/_2$ brick thick walls or $2^1/_2$ brick thick wall and so on, the same course will show stretcher on one face and headers on the other.

(5) In thick walls the middle portion is entirely filled with header to prevent the formation of vertical joints in the body of the wall.

(6) Since the number of vertical joints in the header course is twice the number of joints in the stretcher course, the joints in the header course are made thinner than those in the stretcher course. Alternate course of even and odd number of half brick thick walls are shown in Figs below

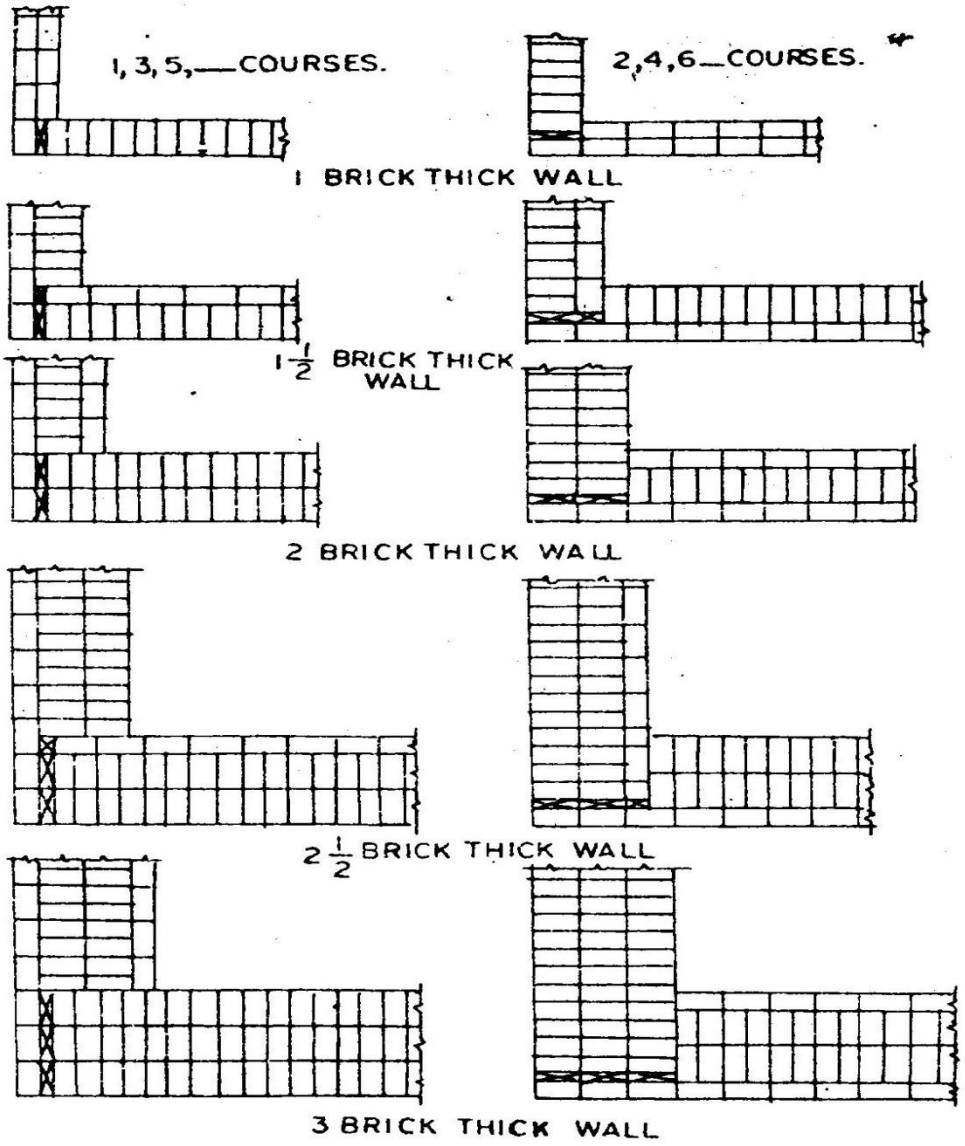


Fig. 94 — 98

Plans showing alternate courses of brick walls in different thickness in English Bond

Flemish Bond

In this arrangement of bonding brick work, each course consists of alternate headers and stretchers. The alternate headers of each course are centered over the stretchers in the course below. Every alternate course starts with a header at the corner. For the breaking of vertical joints in the successive courses, closers are inserted in alternate courses next to the quoin header. In walls having their thickness equal to odd number of half bricks, bats are essentially used to achieve the bond.

Flemish bond is further divided into two different viz. Single Flemish bond and Double Flemish bond.

Single Flemish Bond: This bond is a combination of English and Flemish bond. In this work the facing of the wall consists of Flemish bond and the backing consists of English bond in each course. This type of bonding cannot be adopted in walls less than one and a half brick in thickness. This bond is adopted to present the attractive appearance of Flemish bond with an effort to ensure full strength in the brick work. The alternate courses of brick walls of various thickness in Single Flemish bond are shown in Figs. .

Double Flemish bond: In this system of bonding, each course presents the appearance both in the front and back elevations. Every course consists of header and stretcher laid alternately. This type of bond is best suited from considerations of economy and appearance. It enables the one brick wall to have flush and uniform faces on both the sides.

Other Types of Bonds

Stretching bond. In this arrangement of bonding, all the bricks are laid as stretchers. The overlap, which is usually of half brick, is obtained by commencing each alternate course with a half brick bat. Stretching bond is used for half brick wall only. This bond is also termed as running bond and is commonly adopted in the construction of half brick thick leaves of cavity walls partition walls, etc.

Heading bond. In this type of bonding all the bricks are laid as headers on the faces. The overlap, which is usually of half the width of the brick, is obtained by introducing a three-quarter bat in each alternate at quoins. This bond permits better alignment and as such it is used for walls curved on plan. This is chiefly used for footing in foundation for better transverse distribution of load.

Herring-bone bond. This type of bond is best suited for very thick walls usually not less than four bricks thick. In this arrangement of brick work, bricks are laid in course inclined at 45^0 in two directions from the center. This bond is also commonly used for brick pavings.

Zig-Zag bond. This is similar to herring-bone bond with the only difference that in this case the bricks are laid in a zig-zag fashion.

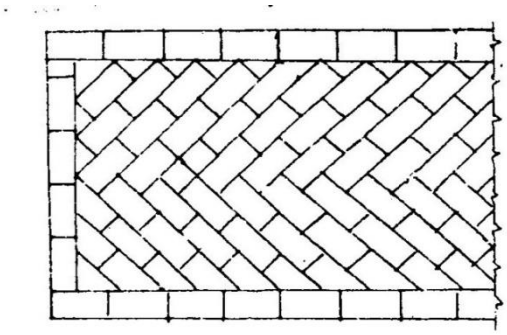


Fig. 922
Plan showing arrangement of bricks in Herring-bone bond.

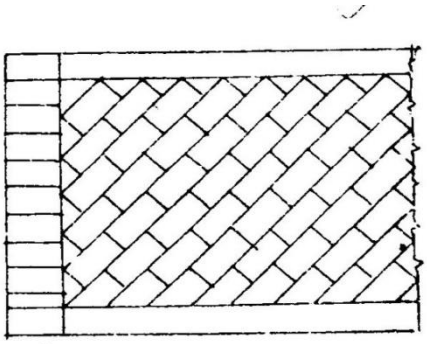


Fig. 923
Plan showing arrangement of bricks in Diagonal bond

4.0 Tee-Junctions & Squint Junction

A Tee junction is formed when two walls meet each other at right angles forming the letter `T' in plan. T-junction may be formed in different bonds described earlier. Fig. show the isometric views of T-junction between walls of various thickness.

A squint junction is formed when two walls meet each other at an angle other than a right angle without forming a quoin. The junctions may be in English or Flemish bond. Great difficulty is experienced in forming the junction accurately and that is why they are rarely adopted.

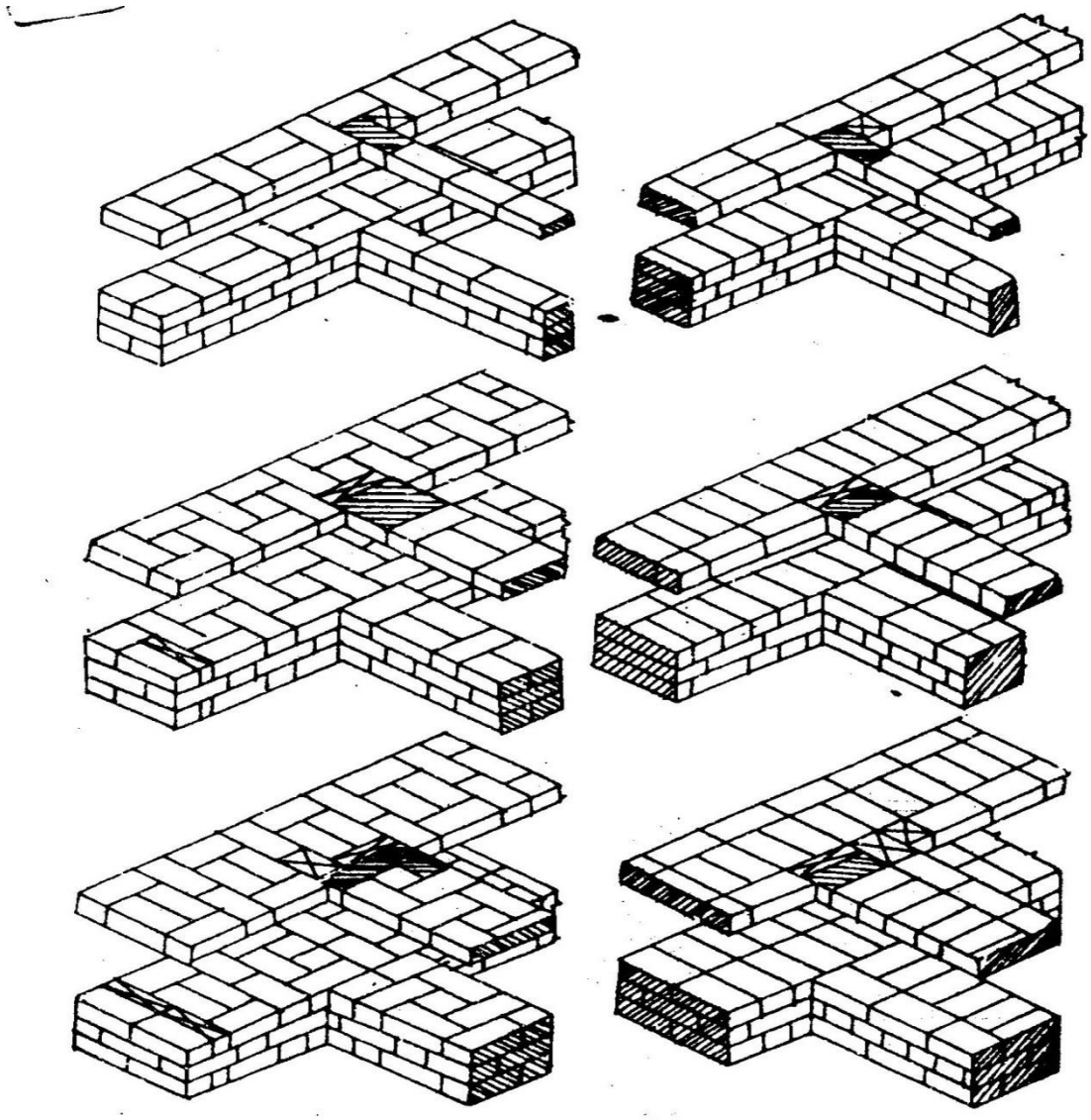


Fig. 928—930
Isometric view of T-junctions in English bond

931—933
Isometric view of T-junctions in Flemish bond

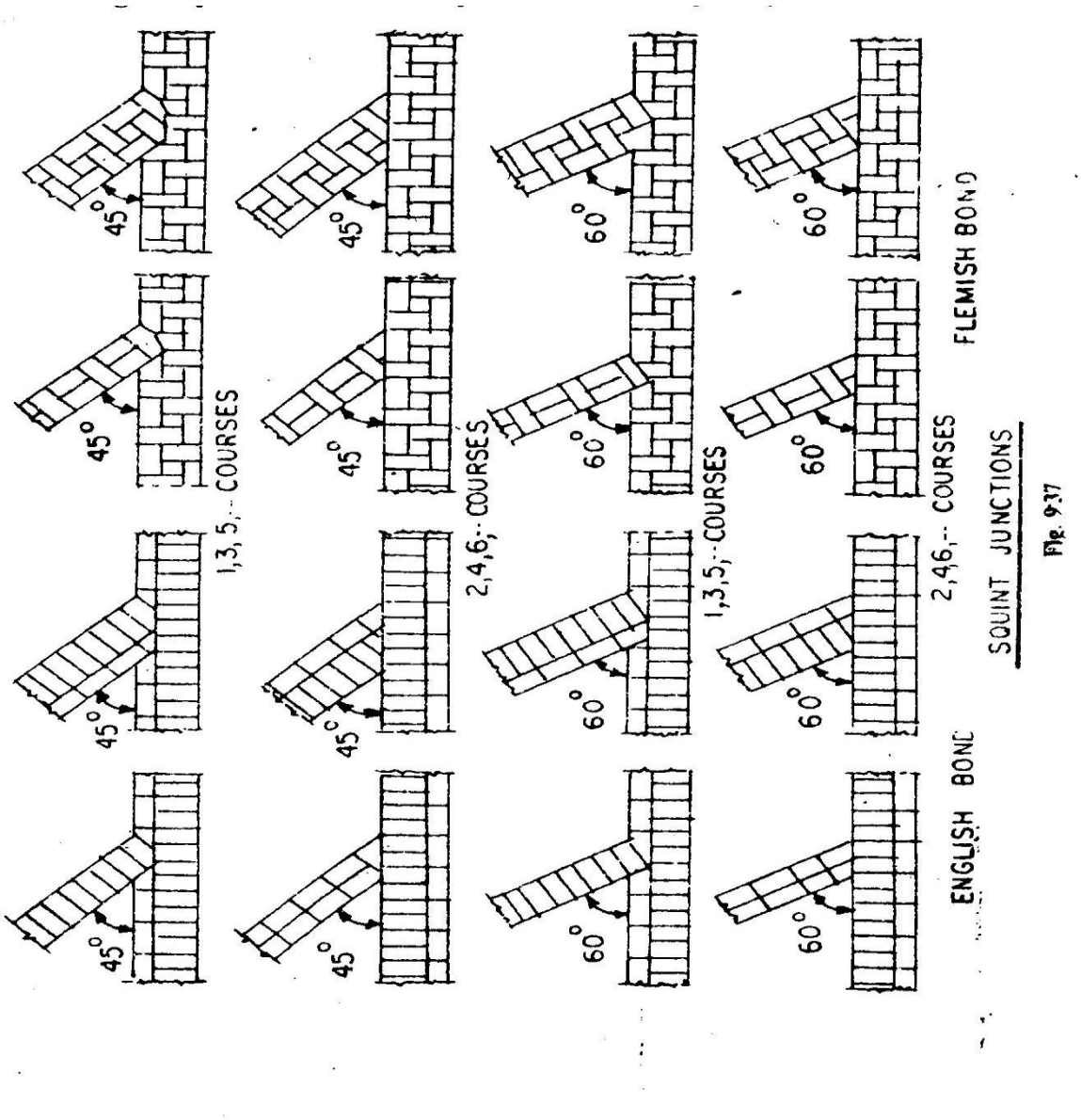


Fig. 9.17

5.0 Cement Concrete Masonry

Cement Concrete is largely used for construction purposes on account of its numerous advantages over the other building materials. Cement concrete may be used in the form of pre-cast concrete blocks, plain concrete slabs or reinforced concrete slabs. Hollow units may be defined as those units having core void areas greater than 25% of their gross area. The blocks may have one or multi core design to suit the choice of manufacturer. The various advantages of hollow concrete block masonry are described below:

(1) On account of their regular and uniform size and less weight, concrete blocks afford great facility in masonry construction which ultimately results in rapid execution of work.

(2) Hollow blocks of concrete permit adoption of thinner walls thereby achieving increased floor area and hence saving of space.

(3) There is a great saving of material on accounts of the blocks being hollow from inside. The air space (hollow space) in concrete blocks varies from 20 to 40 percent of their volume

(4) On account of the large size of concrete blocks, the number of joints in a work are lesser and hence there is saving of mortar in this type of masonry

(5) The hollow space in the blocks enables the masonry to have good insulating properties against sound, heat and dampness.

(6) On account of good properties of concrete, hollow concrete blocks masonry can safely withstand the atmospheric action and it requires no protective covering as is necessary in case of brick work.

(7) The rough surface of the concrete blocks makes plastering (if needed) easier.

SESSION-17
Topic: Works Supervision

Contents

1.0 Techniques of works supervision

2.0 Area of Supervision (Check list)

3.0 Bridge/Culvert Site supervision

4.0 Report writing& Presentation

Session Objective:

At the end of the session the participants will be able to understand the technique of effective supervision of works and also will be able to write Field visit of an ongoing construction site of bridge or culvert.

Time: 2 hours

Methodology

- Lecture /Discussion
- Demonstration
- Site visit

Teaching Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD and Hand out

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will explain in details the Techniques of works supervision and Check list to be followed.	30min.
03.	In this stage, the facilitator will demonstrate the total construction sequences (from lay-out setting) and quality control of works at all the important stages of Bridge Construction works. Later, the facilitator will give assignment in group (5 to 6 members in one group) for writing of Field visit Report based on visit of ongoing bridge construction site. The participants in group will prepare their presentation in the poster paper.	45 min
04	The participants will present their field visit report. The facilitator will check and clear the misconception of participant's learning.	35min
05	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Works Supervision

1.0 Techniques of works supervision

Supervision is a term, which assists to accomplish the successful implementation of project/scheme with desired quality and progress in allotted period of time. The quality of work depends directly on the intensity of supervision. Achievement of desired quality and progress need intensive supervision. On the other hand, less supervision creates poor quality and progress. During supervision many mistake are found which can be rectified instantly. It has to be remembering that the object of supervision is not only to find the mistake or wrong work. Some time it is found that the work could not complete correctly even having a good plan and management for lacking of proper supervision.

Supervision has important role in the successful implementation of project. The staff and officers should have adequate knowledge on drawing, specification, working procedure, methods, material, test requirement etc for better supervision and providing quick and correct decision. Supervision is needed in every steps/phases of project/scheme such as planning of scheme, selection of scheme, design and preparation construction and maintenance phase. Also the supervisor supervises the work of their sub-ordinate.

The objective and need of supervision are to:

- Involve oneself in every stage of work of the scheme
- Assist to maintain the quality of work
- Complete the work within the allotted time
- Identify the cause if less progress and find the solution
- Assist the staff so that they can supervise the scheme correctly
- Receive constructive advise from the sub-ordinate
- Create congenial environment to develop good working relation among all staffs
- Provide instant decision on complex situation and work

Aids/Tools for Scheme Supervision

A contract is made between construction agency and implementation for the implementation of the scheme. Under this contract, the contractor implement the scheme and technical staff of LGED supervises the construction work. The supervisor should have sufficient knowledge on the following document:

- Tender Notice
- Condition of contract
- Specification of works
- The drawing
- Bill of quantity
- Work plan

- Site Diary
- Testing requirement
- List of plants and personals.

2.0 Areas of Supervision (Check List)

The following are the key areas where supervisors should put due attention while inspection of **earthwork:**

- Check the type of soil that are being used in earthwork
- Check the moisture content of soil. The water content of soil should be within#2% of OMC
- Soil should be placed in layers.
- The soil layer should have clove clods of size less than 2" size
- Thickness of earth filling should be uniform
- Earthwork should be compacted in layers of 150mm thick
- Scarify the layer while placing successive top layers

The following are the key areas where supervisors should put due attention while inspection of **brickwork:**

- Well socked bricks to be used
- Brick will be well burnt, uniform color, shape and size
- Clean bricks to be used
- Brick is tested for compressive strength at laboratory
- Uniform thickness of the mortar to be placed
- Gaps between bricks must be filled in with mortar

Good Mortar for Brick Work:

- Cleaned mixing place to be selected
- Correct Proportion of cement and sand to be used
- Required quantity of drinkable water to be used during mixing
- Frequent adding of water to the mortar should be avoided
- Mixing continued till uniform colour
- Sand and cement to be mixed in dry condition first and then water to be poured

3.0 Bridge/ Culvert site supervision

The following activates need to address during construction of **Bridge/culver:**

- Layout of bridge/culverts
- Setting up reference line
- Fixation of formation level
- Fixation of bench mark, alignment, angular distance
- Collection of specified material
- Foundation trenches
- Removal of rubbish, debris and vegetation

- Laying of brick flat soling
- Maintaining quality concrete
- Vibration the fresh concrete and removing of shuttering,
- Constriction of abutment, wing wall and pier
- Fixing shuttering as per level and line
- Trench filling around abutment, wing wall.
- Maintain quality of filling earth,
- Construction of approach road pavement.
- Material collection, placement, compaction, thickness checked and quality control.
- Construction of railing and parapet.

Following note keep in mind at the time of **reinforcement** checking:

- Appropriate diameter of reinforcement
- All MS rod should be clean and rust free.
- All rods should be straight.
- Appropriate crank in rods is placed at proper place.
- Length of lapping of rods is provided as per requirement.
- MS rods as per drawing are placed.
- For maintaining of clear cover chair/space bar provided.
- Actual size of rods is used.

4.0 Report Writing and Presentation

In this stage, the facilitator will demonstrate the total construction sequences (from lay-out setting) and quality control of works at all the important stages of a Bridge Construction works. Later, the facilitator will give assignment in group (5 to 6 members in one group) for writing of Field visit Report based on visit of ongoing bridge construction site. The participants in group will prepare their presentation in the poster paper and will present.

Site visit report writing guidelines:

- Name the works visited
- Make a comments on the general management of the site giving consideration on Site office, Labour shed, toilet, store, register maintenance, sign board at site,work plan, inspection book, site order book, safety measures, tube well.
- Perform field tests of construction materials and make comments on the quality of construction works
- Observe the works that have already been performed and make comments on the quality of works.
- Make comments on the progress of work with respect to plan
- Identify the good practices and the areas of improvement.

Finally the participants will present their report in group.

SESSION-18

Topic: Measurement Book (MB) Writing Technique

Contents

1.0 Notes on Measurement Book

2.0 Entry of Running Work Measurement to MB

3.0 Entry of Final measurement of completed works to MB

4.0 Discussion on BOQ for Bridge/Road/Building and prepare BOQ using RSEPS Software

Session Objective:

At the end of the session the participants will be familiar with the Measurement Book (MB) and able to understand and also know how to take final measurements of completed works as well as entry to MB. The participants will also be able to know the operation of Software for Earthworks Volume Calculation using software

Time: 1hr. 30 mins.

Methodology

- Lecture /Discussion
- Demonstration
- Practice

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out& Software for Earthworks Volume Calculation.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will present in details the guidelines (Notes on MB) on MB writing and will discuss entry of measurement to MB (Entry of Running works measurement & Entry of final measurement of completed works). See **Annex X** for sample MB	30 min.
03.	Through a participatory approach, the facilitator will explain all the features of Detailed Estimate of Bridge/Culvert/Building and prepare BOQ using RSEPS software.	50 min
06	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Measurement Book (MB) Writing Technique

1.0 Notes on Measurement Book

Reference to PW. Code, Vol, 1, 8th Edition
Chapter Xl, Paras, 1111-1119

1. The measurement book is the basis of all accounts of quantities whether of works done by daily labour or by piecework or by Contract or of materials received which have to be counted or measured, and should be so kept up that the transactions may be readily traceable into the accounts- by the entry of the number and date of bill in this book, when the bill has been prepared and the entry of the number and page of the measurement book on the bill. The measurements affected should then be cancelled by cross red lines being drawn across the page or pages.
2. All measurements are to be neatly taken down in this book and in no others. The description of the situation of work must be lucid so as to admit of easy identification and check.
3. The entries in the measurement book should if possible be made in ink, but when this is not possible and entries have to be made in pencil, the pencil entries should not be inked over but left untouched. The “contents or area’’ should however be invariably inked in by the Officer who has taken the measurements. No page of the book should on any account be torn out. No entry should be erased or effaced so as to be illegible. No erasures are allowed. If a mistake is made, it should be corrected by drawing the pen through the incorrect entry and entering the correct one in red ink between, the lines. Every such correction should be initialed. A reliable record is the object to be aimed at as it may have to be produced as evidence in a Court of law.
4. For large works, a separate measurement book may be specially set apart, or if found convenient, even two or more books may be set apart for different classes of works.
5. The measurement books, must be looked upon as important records, they should be carefully checked by the Executive Engineer to see that they are properly kept up and measurements duly recorded, and that they are complete records of each kind of work done for which certificates have been granted. The eventual return of all books to the Executive Engineer/Upazila Engineer for record should be insisted upon. They must be carefully preserved for 20 years.
6. Whenever an Upazila Engineer is required to submit his measurement book with his accounts to the Executive Engineer, it will be necessary to provide a second book for his use.
7. It will be found convenient so far as possible to keep the measurement relating to one group together and to effect this the number of pages likely to be wanted for a work or sub- head should be estimated and set apart for the purpose or recording the measurements consecutively.

8. Before detailing the measurements relating to work the following information should invariably be given at the top of the first page of such measurements:

   (1) Name of work ----------
   ---
   (2) Situation of work
   (3) Agency by which work is executed
   (4) Date of written order to commence work or supplies
   (5) Date of actual completion of work or supplies covered by the contract
   (6) Date of measurement

   Note- Items (4) and (5) need not be filled up in the case of piece-work agreements in K-2 form.

9. For facility of reference, and to assist in carrying out the instruction given in paragraph 7 above, and Index has been provided for.

2.0 Entry of Running Works Measurement to MB

Through a participatory approach, the facilitator will present in details the guidelines (Notes on MB) on MB writing technique and will discuss entry of item wise measurement in MB. In this stage, the discussion will be exclusively on entry of item wise measurement of **ongoing works for running bill preparation.** The discussion will be guided by the Measurement Book (MB) attached in **Annex- X** of this manual.

3.0 Entry of Final measurement of completed works to MB

Through a participatory approach, the facilitator will present in details the guidelines (Notes on MB) on MB writing technique and will discuss entry of item wise measurement in MB. In this stage, the discussion will be exclusively on entry of item wise measurement of **completed works for final bill preparation**. The discussion will be guided by the Measurement Book (MB)attached in **Annex-X** of this manual.

4.0 Discussion on BOQ for Bridge/Road/Building

In this stage, discussion will be on preparation of detailed estimate and Engineering Estimate that will support to prepare BOQ and the facilitator will discuss all the features of BOQ and preparation of BOQ using RSEPS software.

SESSION-19

Topic: Site Management

Contents

1.0 Site Management issues

2.0 Job Lay-out

3.0 Facilities for labour

4.0 Work Plan (Bar Chart)

5.0 Management Meeting with Contractor

6.0 Site Order Book

Session Objective:

At the end of the session the participants will be able to understand and also explain to others the issues of site management and also able to understand Job Lay-out & Work Plan.

Time: 1hr. 30mins.

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD & Hand out etc.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will present in details the Site Management issues	15min.
03.	Through a participatory approach, the facilitator will explain Job Lay-out & Work Plan so that the participants can prepare Job Lay out & Work Plan.	30 min
04.	Through a participatory approach, the facilitator will explain issues of management meeting with contractor.	20 min
05	Through a participatory approach, the facilitator will explain the use of Site Order Book.	15min
06	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Site Management

1.0 Site Management Issues

For successful implementation of project activities on time, efficient site management is one of the vital factors. Issues of site management that to be guided and observed are-

- Job Lay-out
- Selection of labour/workers
- Facilities of Labour/workers
- Health and Safety of labour/workers and staffs
- Water and electricity
- Store and stack yard for materials
- Availability of necessary equipment and tools and their functions.
- Availability of up to date and approved drawings with specifications, estimates etc.
- Updating of working drawing
- Site order book in the site.
- Statement of materials available at site and test report of materials.
- Work Plan/ Bar chart and updating of progress in the bar chat.

2.0 Job Lay out

Efficient site management should have ideal Job Lay out Plan that to be followed on the basis of availability of land size and sequence of construction works.

Job Lay out plan should include location of

- Entry to the site
- Temporary structure (Site Office, Labour Shed, Toilet, Tube well etc.)
- Water and Electricity supply
- Store and Stack yard for materials
- Equipment and tools yard
- Shuttering materials preparation and stacking etc.

3.0 Facilities for Labour

The reality is that the labour forces are the key personnel for successful completion of project activities, they are not just the tools for production, and they are human being. Contractor will ensure following facilities for labour/workers:

- Accommodation
- Safe Drinking Water
- Hygiene Toilet
- Safety and Security in the working areas
- First aid facilities in the site etc.

4.0 Work Plan / Bar Chart

Work Plan

The work plan is graphical presentation of a project/scheme showing proposed starting and completion times of each activities of the project/scheme. The contractor responsible for preparation of the work plan. All construction activities to be shown sequentially in the work plan. Plants and equipment to be needed for implementation of work are also provided in the work plan. The main purposes of the work plan are:

- Splitting of total work into small activities.
- Determination of proposed starting and completion date of each activity.
- Before starting the work ensure necessary construction material, manpower, equipment etc. for completion of every activity.
- Review the progress and prepare revise work plan if necessary

Bar Chart and Critical Path Method (CPM)

CPM Bar chart are very effective tools for construction planning. In our country bar chart is used widely. Contractor is responsible for preparation of bar chart. Contractor submits bar chart during dropping the tender document and afterward that bar chart are generally revised depending on the ground situation. The advantage and the benefit of a bar chart are:

- Act as a time keeper
- Indicate when what activities will start and finish
- Provide logical sequences of activities
- Create awareness on when what activities has to be done
- Identify what a activities could be delayed without delaying the completion date of the project
- Help in completion the project as early as possible through effective utilization of labour, material and equipment
- Act as an indicator of progress monitoring
- Facilitate to collect material before starting the actual work.
- Provide an understanding on when money will be needed and when payment of the bill has to be given.

A sample Bar Chart is shown below:

Sl. No	Activity	Quantity	Duration in Week											
			1	2	3	4	5	6	7	8	9	10	11	12
1.	E/W in excavation to foundation trenches	660m^3												
2.	Brick Flat Soling	340m^2												
3.	Lean Cement Concrete	310m^2												
4.	Reinforcement, shuttering works & Concreting	22000Kg/ 820m^3												
5.	Brick Works	190m^3												
6.	Cement Plaster	780m^2												

5.0 Management Meeting with Contractor

Site meeting

Site meetings are an important part of the successful management of development project activities. Regular **site meetings** between the different stakeholders on a project can help to facilitate better communication and a shared sense of purpose making it more likely that the project is completed successfully. Project failures are often attributed to inadequate management, with a key factor being a lack of proper communication.

Meetings should be regular and formerly scheduled, perhaps on a weekly or monthly basis depending on the parties involved, although the size and complexity of the project may necessitate a more regular schedule. They are used as a means of reporting progress, enabling discussion of any problems or issues, and allowing the proposal of solutions. They provide a good opportunity for two-way discussions of any issues that have arisen or that are anticipated.

Holding meetings on site enables the stakeholders to see progress for themselves (rather than relying on a report for another party) and to look at problem areas, discuss quality issues, assess mock-ups and so on.

Construction progress meetings are a specific sort of site meeting during which the contract administrator receives progress reports from the contractor and consultant team, and other more specific information such as sub-contractor reports, progress photos and so on.

In order to be able to provide the correct information at construction progress meetings, the contractor may previously hold a progress meeting with sub-contractors sometimes called a production meeting.

Meeting minutes should be prepared, with a requirement that any disagreement with the items recorded in the minutes is raised within a pre-defined period. Progress meetings may also result in the preparation of a construction progress report for the client.

Other meetings held on site might include safety briefings and toolbox talks which are held to ensure that workers properly consider health and safety issues on site.

Construction progress meeting

During the construction stage, the contract administrator holds regular (often monthly) construction progress meetings attended by the contractor and if necessary members of the consultant team.

The client, client representative or project manager may also wish to attend these meetings. Construction progress meetings may require decisions to be made and so it is important that they are attended by sufficiently senior individuals.

Construction progress meetings are an opportunity to:

- Receive progress reports from the contractor (the contractor may hold a progress meeting, sometimes called a production meeting, with sub-contractors prior to the **construction progress meeting**).
- Receive progress reports from the consultant team.
- Receive records of sub-contractors and labor on site.
- Receive progress photos.

There are also opportunities to discuss major issues raised, such as:

- Any special circumstances which may affect the contract at any stage.
- Testing regimes.
- Mock-ups.
- Quality issues.
- Weather reports.
- Issues that may impact on costs.
- Health and safety issues.
- Issues with neighbors (such as noise, dust, vibrations, rights of light, access, safety, etc.).
- Off-site fabrication and off-site payments.
- Design issues.
- Warranties.
- Look ahead to the next period

Meeting minutes should be prepared, with a requirement that any disagreement with the items recorded in the minutes is raised within a pre-defined period (perhaps one week). The progress meetings will also result in the preparation of a construction progress report for the client.

6.0 Site Order Book

Site order book is a register (Annex---) containing some pages for writing the comments, suggestions and remarks about ongoing works. The contractor and supervising staff must follow the instructions, decision and suggestions written in the Site Order Book. In addition to Site Order Book others registers are also required to make available at site. Such as:

- Attendance Register of Labour
- Stock register of materials at site
- Register and file for testing report of materials
- Register for equipment etc.

These register should be maintain by the contractor and to be checked by the supervisor.
Purpose of Site Order Book:

- Recording the instruction given for the contractor and site supervising staff
- Act as an evidence of the presence/visit of supervisor.
- Acting as a different against the bad approach of the contractor.

The contents of the site order book are :

- Record of the detail of daily accomplished work (Quality of materials, Workmanship, Work procedure, Quality test etc.)
- Stock of materials at the site
- Test performed each day
- Instruction for the contractor
- Manpower available at site
- Equipment available at site
- Safety of the site
- Facilities for labour in the site

All these area to be covered during site visit / inspection and to be recorded in the site order book (particularly the non-compl

iance issues).

পরিদর্শনকারীকর্মকর্তা/কর্মচারীদের জন্য সাধারণনির্দেশাবলী

১. পরিদর্শনকারী কর্মকর্তা/কর্মচারী পূর্বে কার পরিদর্শনকারী কর্মকর্তা ও কর্মচারীদের পূর্বের পরিদর্শন মন্তব্য অবশ্যই পড়বেন।
২. সাইট পরিদর্শনের পরে পরিদর্শনকারী কর্মকর্তা/কর্মচারী অবশ্যই পরিদর্শনকারীর মন্তব্য সাইট অর্ডার বইয়ে লিপিবদ্ধ করবেন।
৩. পরিদর্শনকারী কর্মকর্তা/কর্মচারী কাজের গুনগতমান বজায় রাখার স্বার্থে করণীয় বিষয়ে সুস্পষ্ট মতামত লিপিবদ্ধ করবেন।
৪. উর্ধ্বতন পরিদর্শনকারী কর্মকর্তা কর্তৃক প্রতিবেদন মন্তব্যে যদি কোন আইটেমের কাজের ক্ষেত্রে কমবেশী হয়
৫. তবে সংশ্লিষ্ট কর্মকর্তাগণ তার ফটোকপি সংরক্ষণ পূর্বক পরবর্তী প্রয়োজনীয় ব্যবস্থা গ্রহণ করবেন।
৬. যে কোন চলতি বিল পরিশোধের ক্ষেত্রে সংশ্লিষ্ট কর্মকর্তাগণ সাইট অর্ডার বই পূঙ্খানুপূঙ্খভাবে পরীক্ষা করবেন এবং বিরূপ মন্তব্যের বিষয়ে পরীক্ষা/নিরীক্ষা পূর্বক যথোপযুক্ত কর্তৃপক্ষের মাধ্যমে বিরূপ মন্তব্যের কাজ সঠিক করে প্রত্যয়ন গ্রহণপূর্বক বিল তৈরী করবেন।
৭. চূড়ান্ত বিল পরিমাপের পূর্বে মূল সাইট অর্ডার বই নিয়ন্ত্রনকারী অফিসারদের তত্ত্বাবধানে সংরক্ষনের ব্যবস্থা নিশ্চিত করে চূড়ান্ত বিল পরিশোধ করবেন।

বাস্ত্মবায়নকারী প্রতিষ্ঠান/ঠিকাদারদের প্রতিকরণীয় সাধারণ নির্দেশাবলী

১. প্রকল্প কাজ চলাকালীন সময়ে সাইট অর্ডার বইটি সাইট অফিসে সংরক্ষণ করতে হবে।
২. সাইট অর্ডার বইটি পরিদর্শনকারী যে কোন কর্মকর্তা/কর্মচারীর পরিদর্শন কালীন মন্তব্য লিপিবদ্ধ করার জন্য সব সময় অবশ্যই সাইটে রাখতে হবে।
৩. প্রথম ইস্যুকৃত সাইট অর্ডার বই সমাপ্তির পূর্বেই প্রয়োজনে আরো একটি সাইট অর্ডার বই সংগ্রহের প্রচলিত প্রক্রিয়ায় সংগ্রহ করে সাইটে রাখতে হবে।
৪. প্রকল্পের বাস্তবায়ন কাজ সমাপ্তির পরে চূড়ান্ত বিলের আবেদনের সাথে সাইট অর্ডার বই সংশ্লষ্ট নিয়ন্ত্রকারী কর্মকর্তার নিকট জমা দিতে হবে।
৫. চলতি বিল প্রদানের ক্ষেত্রে কর্তৃপক্ষের চাহিদা অনুসারে সাইট অর্ডার বইয়ের ফটোকপি বিলের আবেদনের সাথে নিয়ন্ত্রকারী কর্মকর্তার নিকট জমা দিতে হবে।
৬. সাইট অর্ডার বই অন্যান্য দরপত্র দলিলের ন্যায় অফিসিয়াল দলিল হিসাবে বিবেচিত হবে এবং ভবিষ্যতের জন্য সংরক্ষিত হবে।

A copy of Site Order Book is attached in **Annex-IX** of this manual for discussion with the participants through participatory method.

SESSION-20

Topic: Laboratory Testing &Quality Control

Contents

1.0 Introduction

2.0 Quality Control

3.0 Laboratory Facilities of LGED

4.0 Laboratory Tests

5.0 Tests Report

Session Objective:

At the end of the session the participants will be able tounderstand the importance of laboratory tests in regards to quality control and alsoable to know the laboratory facilities in LGED, type and frequency of laboratory tests required for different works in LGED.

Time: 1hour

Methodology

- Lecture /Discussion
- Demonstration
- Open forum discussion

Training Materials: White board, Board marker, Poster paper, Permanent tape, Masking tape, Doc clip, Power Point, Audio-Video CD, Hand out& LGED Quality Control Manual.

Session Plan

Step	Guidelines for the facilitator	Time
01.	The facilitator will thank the participants and brief them about the objectives of the session	5 min
02	Through a participatory approach, the facilitator will present in details the importance of quality control and importance of laboratory tests.	10min.
03.	Through a participatory approach, the facilitator will explain the Laboratory Facilities of LGED, Types of Laboratory tests carried out in LGED.	20 min
04.	Through a participatory approach, the facilitator will explain the test reports.	20 min
06	The facilitator will conclude the session by getting feedback from the participants.	5 min

Overview
Laboratory Testing & Quality Control

1.0 Introduction

Construction is an art, and as with arts the goal is quality. Quality is usually defined as the ability of a product or service to satisfy a given need and hence “fitness for use”. Adequate quality control during construction constitutes a very essential activity for ensuring technically sound civil engineering structures. It also results in economical use of materials through the efficiency of organization. It does not only ensure safe and sound structures, but also significantly reduces the maintenance cost and increases the durability of the structures.

Failures and inadequacies in many structures are due to inadequate attention to quality control during design and construction. Lack of proper knowledge in respect of material testing and quality control is one of the main factors that have been responsible for failure of structures. Therefore, it is of paramount importance to master and practice techniques of testing and quality control in all construction projects.

To achieve the optimum level of quality for a project, there are a few guidelines:

- develop a plan for the project
- conduct pre-construction meetings to ensure that everyone understands his contract responsibilities and all necessary activities
- establish who does what within the organisation
- select people who are qualified for the particular tasks
- train the personnel in their responsibilities

2.0 Quality Control

- The term Quality has been defined as the totality of features and characteristics of a product or services that bear on its ability to satisfy stated or implied needs
- It specifies the acceptable materials of construction outlining the various tests of acceptance
- It defines various design criteria, practical rules and sound engineering practices for guiding the designers in arriving at appropriate structural solutions;
- It deals with the workmanship and other aspects of construction which ensure that design intents are realized in actual construction

১.১ Objective of Quality Control

The aims of institutionalizing of the quality control activities are:

- To establish accountability as well as to justify the feasibility of investment
- To have technically sound and durable structure

- To reduce maintenance cost
- To have economic and safe structural design

১.২ Pre-requisite for Quality Control:

The prerequisite for effective quality control of Infrastructure development projects are as follows:

- Standard construction specification for all items of works should be provided for effective quality control. The specification should be clearly stated and methods of construction should also be written as the contractors may have little qualified technical and skilled personnel.
- Well-equipped laboratory for quality control activities should be set up with adequately trained staff.
- Periodic appraisal of the quality control data should be prepared, reviewed not only for implementation during construction but also for effective possible improvements in quality control and construction techniques in future.
- To impart training to the site supervision staff and contractors staff continuously before the start of each individual section of the project.
- Provision for the cost of QC should be duly incorporated in the estimate and specifications.

3.0 Laboratory Facilities of LGED

Local Government Engineering Department has established 64 material testing laboratories at all the district headquarters of Bangladesh to achieve a good network of laboratories and quality control activities. These laboratories have been classified into three categories depending on the capabilities and facilities are made available in each laboratory. These are:

a. central laboratory
b. regional laboratories
c. district laboratories

The central laboratory which is located at LGED Bhaban has got the maximum facilities of all necessary tests including sub-soil investigation.

The regional laboratories located at the old district headquarters (20 nos.) have got less testing facilities than the central laboratory. The permeability test of soil, direct shear test and consolidation test of soil, core drilling equipment for in-situ test of concrete etc. have not been made available with the regional laboratories.

All the remaining 43 district laboratories have been provided with essential testing facilities and those are the minimum requirement for quality control.

4.0 Laboratory Tests

In order to ensure that works are carried out to specifications, it is essential that strict procedures are followed whereby written requests for inspection are submitted by the contractor before execution of each part of the works and written approvals are obtained before works proceed. The Inspection would not only cover the particular part of the works requested for approval (for example pier shutters, reinforcement etc.) but also that the arrangements made for execution of the works in accordance with the approved method, statements for plant, labour, materials and

temporary works. It is also essential to carry out test on construction materials to ensure that the specified materials are used.

Types and Frequency of Tests: The frequency and extent of testing are shown in the Table below. LGED 'Quality Control Manual' contains detailing of all these tests here. The frequency of testing indicated in that manual is the minimum that has been considered necessary for the given conditions of testing capabilities and man power available in the laboratories of LGED.

Sl No.	Item of Works	Type / Name of test	Test Frequency		
			No	Per or Part	
1	Embankment	i) Plasticity Index (PI)	One	2000	m^3
		ii) 4 day soaked CBR	One	2000	m^3
		iii) MDD (Standard)	One	2000	m^3
		iv) FDD	One	600	m^3
		v) DCP	One	200	m^3
2	Sub grade	i) Plasticity Index (PI)	One	7500	m^2
		ii) 4 day soaked CBR	One	7500	m^2
		iii) MDD	One	7500	m^2
		iv) FDD	One	2500	m^2
		v) DCP	One	900	m^2
3	Improved Sub grade	i) FM / Gradation	One	500	m^3
		ii) 4 day soaked CBR	One	1500	m^3
		iii) MDD	One	1500	m^3
		iv) FDD	One	500	m^3
		v) DCP	One	150	m^3
4	Sub-base	i) Gradation	One	500	m^3
		ii) 4 day soaked CBR	One	1500	m^3
		iii) LAA	One	1000	m^3
		iv) MDD	One	1500	m^3
		v) FDD	One	500	m^3
		vi) W/A (Stone/Brick)	One	500	m^3
		vii) DCP	One	150	m^3
5	Base Course	i) Gradation	One	500	m^3
		ii) 4 day soaked CBR	One	1500	m^3
		iii) MDD	One	1500	m^3
		iv) FDD	One	500	m^3
		v) LAA	One	1000	m^3
		vi) W/A (Stone/Brick)	One	500	m^3
		vii) DCP	One	150	m^3
6	Brick on End Edging	i) Compressive Strength	Set	4000	m
		ii) Water Absorption	Set	4000	m
7	HBB	i) Compressive Strength	Set	2500	m^2
		ii) Water Absorption	Set	2500	m^2
8	Bituminous Materials	i) Softening Point	One	15000	m^2
		ii) Flash Point	One	15000	m^2
		iii) Penetration	One	7500	m^2
		iv) Gradation of FA	One	7500	m^2
		v) Gradation of CA	One	7500	m^2

		vi) WA of CA	One	7500	m^2
		vii) LAA	One	7500	m^2
		viii) Flakiness Index	One	7500	m^2
9	Concrete	i) FM	One	50	m^3
		ii) W/A (Coarse Aggregate)	One	50	m^3
		iii) LAA /ACV	One	50	m^3
		iv) Gradation of CA	One	50	m^3
		v) Setting Time of Cement	Set	75	m^3
		vi) CS of Cement (3,7,28 days)	Set	75	m^3
		vii) CS of Concrete	Set	50	m^3
10	Brick Works	i) Compressive Strength of Bricks	Set	300	m^3
		ii) Water Absorption of Bricks	Set	300	m^3
		iii) Efflorescence of Bricks	Set	300	m^3
		iv) Setting Time of Cement	Set	300	m^3
		v) CS of Cement	Set	300	m^3
		vi) FM of Sand	One	300	m^3
11	Reinforcement	Unit wt. , Elongation & Tensile Strength	1set / Dia / 10000 Kg		

****** If the number of test(s) to be performed as per specified test-frequency for any item becomes a whole number with a fraction equal to 0.20 or less, in that case the actual number of test (s) shall be the whole number only. On the other hand if the fraction is more than 0.20 then the actual number of test(s) for that item shall be rounded to next whole number .Engineer in-charge has the right to increase the no. of tests for any item beyond the set frequency as he deems required to ensure the quality and contractor is to perform the additional tests on his own.

****** Implementation of various items of work should be carried out according to the set frequency and costs of all tests even additional to the frequency requirement should be covered by the quoted rate.

Quality control is no more a choice but is a reality to safe guard the national assets. The Engineers responsible for infrastructure development should have sufficient skill, knowledge and training in order to maintain proper quality of the infrastructure. This quality control aspect needs to be considered during design and also during implementation process.

LGED has also given much emphasis on quality control of the projects to have technically sound and durable structure and reduce maintenance cost. All the project area has laboratory facilities in this regard where all the necessary tests are done. Guidelines and manuals have been prepared for the Engineers to have clear understanding on the testing procedures, frequency of testing and sampling of the materials. Regular training is also conducted for the Engineers and technicians on quality control aspect.

5.0 Test Reports

(Some Laboratory Test reports are presented here for discussion with the participants)

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

LOCAL GOVERNMENT ENGINEERING DEPARTMENT

CENTRAL QUALITY CONTROL UNIT

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

COMPRESSIVE STRENGTH TEST OF CEMENT (ASTM C-109)

(Using 50 / 50.8 mm Cube of Cement Mortar)

Client :	SINAMM Engineering Limited.	Ref. No. & Date :	Nil, Date: 04.09.12
Scheme : Construction of School-cum-Cyclone Shelter of package-3 **(concrete mix design)**			
Sample No. :	01	Type of Specimen :	Cement
Sampled By :	Abdullah Al Mamun, PE.	Sampled Date :	09.09.12
Quantity Collected from Field :	10 bags	Quantity Represented :	N/M
Brand of Cement (Origin) : KING BRAND (PCC)	Mix Proportion = 1 : 2.75	Water Cement Ratio = 1 : 0.485	
Casting Date (Time) : 10.09.12 (12:30 PM)	Lab. Reg. No. :		
Date of Test (Time) : 3 days : 13.09.12 (12:45 P.M) 7 days : 17.09.12 (12:35 P.M) 28 days : 08.10.12 (12:35 P.M)			
Type of Sand Used : Standard Sand (Imported sand & Grading as per ASTM C-778)			

Specimen no.	Age	Specimen Area	Max. Load	Compressive Strength = Load / Area	Average Com. Strength	Remarks / Allowable limit
	days	m^2	KN	MN / m^2	MN / m^3	
01	3	0.0025	55.7	22.3	= 22.3	Which is greater than 12.4 Mpa
02	3	0.0025	56.9	22.8		
03	3	0.0025	54.6	21.8		
01	7	0.0025	67.7	27.1	= 27.4	Which is greater than 19.3 Mpa
02	7	0.0025	69.1	27.6		
03	7	0.0025	68.4	27.4		
01	28	0.0025	90.7	36.3	= 38.0	Which is greater than 27.6 Mpa
02	28	0.0025	99.7	39.9		
03	28	0.0025	94.5	37.8		

NOTE :- 1 MN/m^2 = 145.038 psi and 1KN = 224.809 lb.

NOTE :- Specified strength of Ordinary Portland Cement as per ASTM C-150 are:- 3-days = 12.4 MN / m^2 (1800 psi)

7-days = 19.3 MN / m^2 (2800 psi)

Optional requirement :- 28-days = 27.6 MN / m^2 (4000 psi)

Tested by : Mr. Md. Yusuf Ali, LT.

Supervised By : Md. Enamul Hoque Khan, Sr. AE (QC), LGED, H/Q.

(Md. Yusuf Ali)	(Md. Enamul Hoque Khan)	(Md. Abul Bashar)
Laboratory Technician	Sr. Assistant Engineer (QC)	Executive Engineer (QC)
Central Quality Control Unit, LGED.	Central Quality Control Unit, LGED.	Central Quality Control Unit, LGED.

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

LOCAL GOVERNMENT ENGINEERING DEPARTMENT

CENTRAL QUALITY CONTROL UNIT

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

NORMAL CONSISTENCY (ASTM C-187) & SETTING TIME (ASTM C-191)

DETERMINATION OF CEMENT BY VICAT APPARATUS

Client : SINAMM Engineering Limited.		Ref. No. & Date : Nil, Date: 04.09.12	
Scheme : Construction of School-cum-Cyclone Shelter of package-3 **(concrete mix design)**			
Sample No. :	01	Type of Specimen :	
Sampled By :	Abdullah Al Mamun, PE.	Sampled Date :	09.09.12
Quantity Collected from Field :	10 Bagas	Quantity Represented	N/A
Brand of Cement :	KING BRAND (PCC)	Date of Test :	10.09.12
Lab. Reg. No. :			

NORMAL CONSISTENCY DETERMINATION

Trial No.	1	2	3	4	5
Wt. of Cement (gm)	500	500	500	-	-
Volume of Water (cc)	130	132.5	135	-	-
Penetration (mm)	6	7	9	-	-
Normal Consistency (%)	27.0	(Rounded to the nearest 0.5% of the weight of the dry cement as per ASTM)			

SETTING TIME DETERMINATION

Sl. No.	Elapsed Time	Time	Penetration (mm	Sl. No.	Elapsed Time	Time	Penetration (mm
1	Start	1 : 50 : 00 pm	-	13	195	05 : 05 : 00 pm	<1
2	30	2 : 20 : 00 pm	Full	14	210	05 : 15 : 00 pm	Just Impression
3	45	2 : 35 : 00 pm	Full	15	225		
4	60	2 : 50 : 00 pm	Full	16	240		
5	75	3 : 05 : 00 pm	Full	17	255		
6	90	3 : 20 : 00 pm	Full	18	270		
7	105	3 : 35 : 00 pm	37	19	285		
8	120	3 : 50 : 00 pm	36	20	300		
9	135	4 : 05 : 00 pm	38	21	315		
10	150	4 : 20 : 00 pm	32	22	330		
11	165	4 : 35 : 00 pm	2	23	345		
12	180	4 : 50 : 00 pm	1	24	360		

Initial Setting Time = $T_1 + \frac{(T_2-T_1)}{(P_1-P_2)} \times (P_1-25) = 154$ **Min.**

(by linear interpolation for 25mm penetration)

Final Setting Time = 210 Min.

NOTE : As per ASTM C-150 (Specification for Ordinary Portland Cement) the Initial Setting Time should no be less than 45 min. and Final Setting Time should not be more than 375 min.

Tested by : **Md. Abdul Bateni, Sub-Assistant Engineer (QC).**

Supervised by : **Md. Khorshed Alam, Assistant Engineer (QC), LGED, H/Q.**

(Md. Abdul Baten)	(Md. Khorshaed Alam)	(Md. Abul Bashar)
Sub-Assistant Engineer (QC)	Assistant Engineer (QC)	Executive Engineer (QC)
Central Quality Control Unit, LGED.	Central Quality Control Unit, LGED.	Central Quality Control Unit, LGED.

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

LOCAL GOVERNMENT ENGINEERING DEPARTMENT

CENTRAL QUALITY CONTROL UNIT

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

COMPRESSIVE STRENGTH TEST OF CONCRETE

Client : SINAMM Engineering Limited.		Ref. No. & Date : Nil, Date: 04.09.12	
Scheme : Construction of School-cum-Cyclone Shelter of package-3 **(concrete mix design)**			
Sampled By : Abdullah Al Mamun, PE.		Sampled Date :	09.09.12
Quantity Represented	Not applicable	Brand of Cement :	KING BRAND (PCC)
Type of Aggregates :	Stone chips	Max. Agg. Size :	19mm down graded
F.M of Aggregates :	2.62	Average Slump :	140 mm
Mix Proportion :	By Volume / **By Weight**	Min. Cement Content :	450 kg/m^3
Type of Specimen :	Cylinder (4" X 8")	Lab. Reg. No. :	

Specimen no.	Type of Specimen	Location	Date of Casting	Date of Testing	Age	Area	Max. Load	Compressive Strength =Load/ Area	Average Com. Strength	Remarks / Allowable limit
					days	m^2	KN	MN / m^2	MN / m^2	
1	Cylinder	Pile casting	10.09.12	08.10.12	28	0.0081	379.9	46.9	45.3	
2	Cylinder	Pile casting	10.09.12	08.10.12	28	0.0081	375.1	46.3		
3	Cylinder	Pile casting	10.09.12	08.10.12	28	0.0081	346.5	42.8		

NOTE :-1 MN/m^2 = 145.038 psi and 1KN = 224.809 lb.

For Diameter / Area determination : refer to ASTM-C-39

Tested by : Mr. Md. Yusuf Ali, LT.

Supervised By : Md. Enamul Hoque Khan, Sr. AE (QC), LGED, H/Q.

(Md. Yusuf Ali) Laboratory Technician Central Quality Control Unit, LGED.	(Md. Enamul Hoque Khan) Sr. Assistant Engineer (QC) Central Quality Control Unit, LGED.	(Md. Abul Bashar) Executive Engineer (QC) Central Quality Control Unit, LGED.

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

LOCAL GOVERNMENT ENGINEERING DEPARTMENT

CENTRAL QUALITY CONTROL UNIT

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

PENETRATION TEST OF BITUMINOUS MATERIAL

Client :	XEN, LGED, Comilla.	Ref. No. & Date :	LGED/Xen/Com/RTIP/M-18/2004/707, 10.02.12
Scheme :	Suagonj-Pipulia-S.Bijoypur Upazila Road, Sadar Upazila, Comilla.		
Quantity Received :	5 kg	Quantity Represented :	Not Informed
Probable Type of Material :	Bitumen of 80/100 gra	Standard--Temp./Load/Time:	25^0C / 100 gm / 5 sec
Sampled By :	LT, Comilla.	Sampled Date :	08.02.12
Lab. Registration No. :		Date of test :	15.02.12

TEST DATA

Test No.	Container Size (Dia x Height) mm	Actual Temperature	Penetration div	Average Penetration div	Result div
01	55 X 35	25^0C	69 72 75		Difference of highest & Lowest reading exceeds 4 div. (for 50-149 div. Range)
01	55 X 35	25^0C	80 81 82	81	Result = 81

NOTE :- 1 If the difference of the highest & lowest reading exceed 4 Div. (for 50-149 div. Range.) than it should be re-tested.

NOTE :- 2 --For Penetration below 200, 55 mm dia x 35 mm. depth container (3 oz.) and for penetration between 200 and 350, 70 mm. Dia x 45 mm depth container (6 oz.) to be used.

-- For penetration 350 to 500, a special container of at least 60 mm depth is required for direct penetration determination. Alternatively (using 6oz. Container & 50 gm loading) it can be measured as:- Penetration under 100gm load = Penetration under 50gm load X 1.41

Tested by : Md. Mockshadur Rahman, SAE (QC).

Supervised By : Md. Khorshad Alam, Assistant Engineer (QC).

(Md. Mockshadur Rahamn)	(Md. Khorshad Alam)	(Md. Abul Bashar)
Sub-Assistant Engineer (QC)	Assistant Engineer (QC)	Executive Engineer (QC)
Central Quality Control Unit, LGED.	Central Quality Control Unit, LGED.	Central Quality Control Unit, LGED.

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

LOCAL GOVERNMENT ENGINEERING DEPARTMENT

CENTRAL QUALITY CONTROL UNIT

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

SOFTENING POINT TEST OF BITUMEN BY RING & BALL METHOD

Ref. No. & Date	MaPauSa/Prasa/2005/1087, Date: 31.05.2012		
Client :	Executive Engineer, Manikgonj Paurashava.		
Name of scheme	Baitha main Road.		
Quantity Received	2 kg (Approximate)	Quantity represented :	Not Mentioned
Location :	Not Mentioned	Date of Test :	03.06.12
Probable Type of Materic	80-100 Penetration Graded Bitumen		
Sample by & Date :	Not Mentioned		
Lab. Registration No.	LGED/C-Lab./R-07/'04-'05/		

TEST DATA

Description (Trial Test / Test / Retest)	Expected Soft. Point ^{0}C	Fluid Used	Reading ^{0}C	Mean ^{0}C	Result ^{0}C
Test	Below 50^{0}C	Water	46.8 47.2	47	Result are within 1^{0}C. Hence the average is calculated

NOTE :- SP above 80^{0}C shall be determined in glycerin and up to 80^{0}C in water

Tested by : Mrs. Hosneara Begum, SAE, (QC)

Supervised By : Md. Tariquzzaman, Sr. Assistant Engineer (QC).

(Mrs. Hosneara Begum) Sub-assistant Engineer(QC) Central Quality Control Unit, LGED	(Md. Tariquzzaman) Sr. Assistant Engineer (QC) Central Quality Control Unit, LGED	(Md. Abul Bashar) Executive Engineer (QC) Central Quality Control Unit, LGED,