Government of the People's Republic of Bangladesh

Local Government Engineering Department

CONSTRUCTION SUPERVISION MANUAL

December, 2025

Message

Bridge Construction supervision stands as one of the most critical pillars in the successful delivery of any project. It is the bridge between design and execution, ensuring that the vision conceived on paper is translated into a tangible structure that meets quality, safety, and performance standards. The role of supervision extends beyond mere oversight; it encompasses coordination, communication, and control across diverse stakeholders, owners, contractors, consultants, and workers each with their own responsibilities and expectations.

In today's construction industry, where projects are increasingly complex and time-sensitive, effective supervision has become indispensable. It safeguards against risks, minimizes delays, and ensures compliance with regulatory frameworks. More importantly, it fosters a culture of accountability and continuous improvement on site. Supervisors are tasked not only with monitoring progress but also with anticipating challenges, resolving conflicts, and guiding teams toward shared objectives.

This Bridge Construction Supervision Manual is intended to highlight its multifaceted nature and underscore its importance in modern project management. By exploring principles, practices, and case experiences, it seeks to provide readers with a comprehensive understanding of how supervision contributes to project success. Whether one is a student entering the field, a professional seeking to refine skills, or a stakeholder aiming to appreciate the supervisory process, the insights herein will serve as a valuable resource.

Ultimately, construction supervision is not just about managing tasks—it is about shaping outcomes. It ensures that projects are delivered safely, efficiently, and sustainably, while upholding the integrity of the built environment.

I would like to express my sincere thanks to all members of the team who have given their diligence and intelligence in developing the document.

(Kazi Golam Mustafa)
Chief Engineer
Local Government Engineering Department

Message

The Local Government Engineering Department (LGED) is the leading public sector agency responsible for the planning, design, construction, and maintenance of bridge infrastructure in rural areas. Bridges play a vital role in connecting communities, facilitating trade, and supporting socio-economic development. Their structural integrity and longevity directly impact public safety and well-being.

Bridge construction is a complex process, encompassing site investigation, detailed design, foundation work (piers and abutments), superstructure erection (beams, arches, or cables), deck installation, and finishing. Throughout all phases, the focus remains on safety, durability, and the optimal use of materials such as concrete and steel, adapted to various bridge designs including beam, arch, and suspension structures. Key stages include soil analysis, foundation construction, superstructure erection, deck placement, and final inspection to ensure quality and longevity.

In line with its commitment to high-quality infrastructure, LGED has developed the **Bridge Construction Supervision Manual**, providing comprehensive guidance on technical standards, construction procedures, quality control, and safety requirements. This manual serves as a practical reference for engineers, supervisors, and field staff involved in bridge construction, enabling them to ensure that every project meets rigorous standards.

I would like to express my sincere appreciation and gratitude to all members who diligently and meticulously contributed to the development of this manual. Their efforts represent a significant step toward strengthening LGED's capacity to deliver safe, durable, and sustainable bridges for the benefit of communities across the country

(Md. Belal Hossain)
Additional Chief Engineer &
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Program for Supporting Rural Bridges (SupRB)

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ABBREVIATION:

The following list shows the meaning of the abbreviations for the common terms used in Program for Supporting Rural Bridges (SupRB) of Local Government Engineering Department (LGED)

Abbreviation	Term
GoB	The Government of Bangladesh
LGED	Local Government Engineering Department
LGD	Local Government Division
WB	World Bank
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
BOQ	Bill of Quantities
CPTU	Central Procurement Technical Unit
DLP	Defect Liability Period
DoFP	Delegation of Financial Power
EWO	Extra Work Order
GCC	General Conditions of Contract
HOPE	Head of Procuring Entity
IT	Information Technology
ITT	Instructions to Tenderers
JV	Joint Venture
NOA	Notification of Award
PCC	Particular Conditions of Contract
PE	Procuring Entity
PPR	Public Procurement Rules
PM	Project Manager
PW	Procurement of Works
QS	Quantity Survey
RVQ	Request for Variation Quotation
RIMS	Risk Identification and Management System
STD	Standard Template Document
TEC	Tender Evaluation Committee
VO	Variation Order
ASTM	American Society for Testing and Materials
BS	British Standards
ES	European Standards
ISO	International Organization for Standardization
ITP	Inspection and Test Plan
EWS	Engineering Works Schedule
QMP	Quantity Management Plan
HSP	Health and Safety Plan
EIA	Environmental Impact Assessment (report)
RAFR	Reportable Accident Frequency Rate (safety)
IR	Incident Rate (safety)
BOD	Biochemical Oxygen Demand
SS	Suspended Solids
SM	Shield Machines

CCTV	Closed Circuit Television
PP	Polypropylene
PE	Polyethylene
MDPE	Medium-density polyethylene
HDPE	High density polyethylene
PVC-U	Plasticized polyvinyl chloride
GRP	Glass-reinforced thermosetting plastics / Glass Reinforced Plastic

A. CONSTRUCTION MANAGEMENT ASPECTS

1. INTRODUCTION

1.1 SCOPE OF CONSTRUCTION SUPERVISION MANUAL

This Manual describes procedures to be followed for Supervision of Bridge Replacement and Bridge Rehabilitation project undertaken by LGED. Projects are usually carried out by contract but much of the content of this Manual is also applicable to works carried out by force account.

1.2 OBJECTIVE OF MANUAL

The objective of the Construction Supervision Manual is to strengthen the management of the bridge construction process and improve the quality of bridge construction. The Manual contains standard procedures and guidelines for the supervision of bridge projects. Application of uniform and adequate supervision procedures will assist to ensure bridges are completed within time and budget constraints, and will be constructed in accordance with the specifications.

Improvement in the quality of construction will lessen the need for repair and rehabilitation of bridges early in their service life.

1.3 OVERVIEW ON CONTRACT MANAGEMENT

Contract management is one of the most important phases in construction projects and involves numerous tasks occurring before and after contract execution and issuance of Notification of Award (NOA). Furthermore, contract management involves making timely decisions, smooth and efficient flow of information and decisions to enable completion of the project as required by the contract documents, including review, supervision and monitoring of the construction project.

Effective contract administration includes

- Developing proper and accurate contract documents;
- Complying with contract documents and specifications;
- Enforcing national rules and regulations;
- Ensuring quality assurance by overseeing, inspecting, reviewing, sampling and testing of all materials and work;
- Ensuring the works are done within the agreed timeframe and with contracted price;
- Keeping and maintaining accurate construction project records;
- Recording, verifying and preparing monthly pay estimates;
- Negotiating and processing of change orders, supplemental agreements and other contract modifications in a timely manner;
- Promoting good public relations;
- Setting and maintaining a high professional standard etc.

The construction works must be managed in accordance with the contract specifications, terms and Rules.

1.4 TYPE OF BRIDGE AND CULVERT

1.4.1 Type of Culvert

a) Pipe Culvert

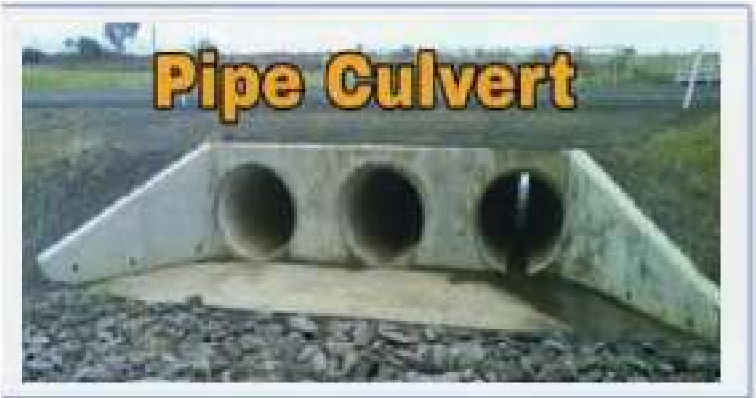


Fig: 1-4-1 Pipe culvert

When a pipe is placed in an excavated trench to move water away, it is known as pipe culvert. It is the most commonly used drainage feature. Economy and ease of installation have made this **type of culvert** very popular. Pipe culverts are found in different shapes such as circular, elliptical, pipe arch etc. Generally, the shape depends on site conditions and constraints. It is usually constructed in lowland paths.

It any desired strength is achievable by proper mix design, thickness, and reinforcement. It is Economical, Easy to Install. It can withhold high tensile stresses and compressive stresses, as pipe culverts don't create barriers in the path; they provide a continuous surface over the pipe.

b) Box culvert

Fig: 1-4-2 Typical Box culvert

A Box Culvert is a Π-shaped reinforced concrete structure used in civil engineering works, including; drainage and road works. Box culverts are most commonly used as an alternative to drainage pipes where design constraints limit the amount of cover available, but are also used in the construction of a range of other assets including; pedestrian underpasses. rectangular structures, the lower side pressed into the ground below, the top serving as the roadway and the lateral sides supported by the soil on either side of the obstruction. It may be constructed with a single box, or multiple box cells placed side by side. The typical size of the boxes is 3'x2' or 12'x12' in 1' span and rise.

Increments. (Usually comes in lengths of 6' and 8') Standard design: Velocity of flowing water might change because of the bottom slab. The sharp corners of the box-shaped slabs make it unsuitable for vehicles running at high velocity. Box culvert is required for purposes which

require artificial flooring. It can be used for rainwater disposal and drainage, hence it might not have used in dry seasons.

C) Slab Culvert

Fig: 1-4-3 Slab culvert

Slab culvert, also known as bridge culverts, can be three-sided, or simply a deck slab embedded in the soil on either side, providing a bridge over the distance. Usually, a series of slabs are laid to form a bridge-like structure, and a pavement surface is placed on top to

serve as the road. The standard span length ranges from 8' to 48'.

Standard design: Slab Culverts do not have bottom slabs, so natural flow of water is maintained and natural bottom substrate remains intact. Slab culverts possess no sharp corners to affect the safety of high-velocity vehicles. Slab culverts can replace box culverts if no artificial flooring is necessary. It provides a crossing over small streams and physical obstructions

1.4.2 Type of Bridge

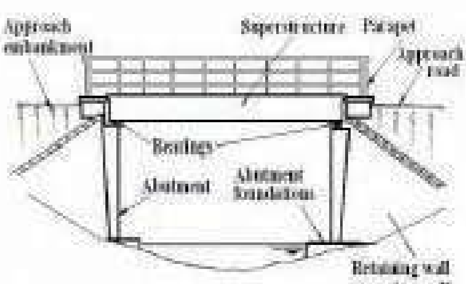


Photo 1.3.1 Girder Components

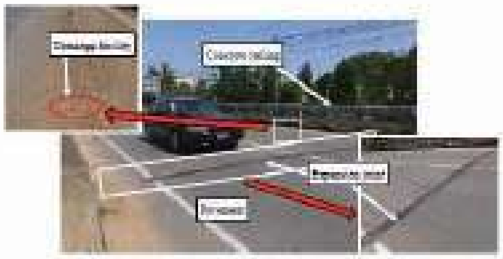


Photo 1.3.1 Superstructure Component on Road Surface

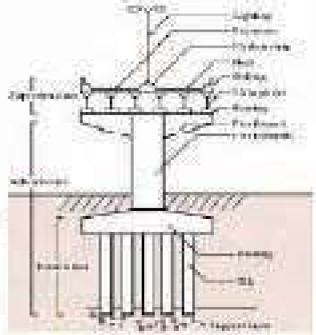


Fig. 1.3.3 Configuration of bridge

Photo 1.3.9 Bearing

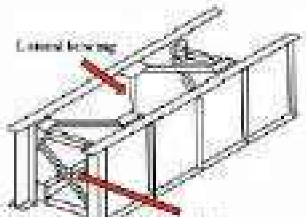
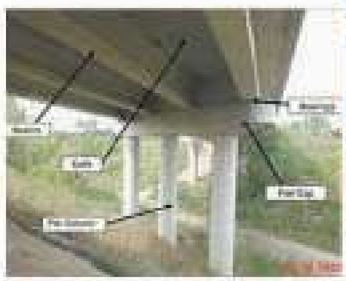


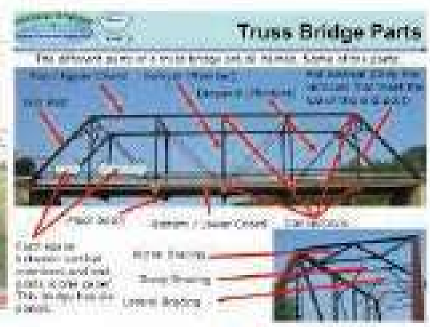
Fig 1.3.4 Bracing

Photo 1.3.10 Drainage facility

Photo 1.3.11 Expansion joint

Curb





a) RCC Girder Bridge

RCC Girder bridges are versatile, cost-effective structures commonly used for 10–25m spans. These bridges typically feature longitudinal T-beams or box sections designed to withstand heavy loads, requiring careful consideration of structural stability and serviceability. They are popular due to simple construction,, easy casting, and, often, use precast components for faster erection

Key Characteristics and Components

- **Structure:** Primarily T-beam or box girder designs.
- **Components:** Longitudinal girders (often with solid ends and I-sections in the middle), pier caps, deck slabs, and bearings.
- **Span:** Most suitable for short to medium spans, typically 10 to 25 meters.
- Construction: Involves piling, pier construction, setting of girders (cast-in-situ or precast), and slab casting.

Design Considerations

- **Loads:** Analysis includes dead loads, live loads (e.g., IRC Class AA/70R), and lateral forces.
- **Methods:** Common methods include Courbon's method for determining reaction factors for the girders.
- **Optimization:** Ensuring proper reinforcement and structural stability is critical, especially for spans at the upper limit of their capacity.

Advantages

- **Cost-Effective:** Often lower cost than other bridge types.
- **Ease of Construction:** Simple geometry, particularly with precast elements.
- **Versatility:** Highly adaptable for various road and environmental conditions.

Typical Construction Steps

1. **Foundation & Substructure:** Piling, boring, and casting piers.
2. **Superstructure:** Placing girders and casting the deck slab.
3. **Finishing:** Applying safety measures and surfacing

Fig: 1-4-4 RCC Girder Bridge

b) PC Girder Bridge

Prestressed Concrete (PC) girder bridges are a widely used, cost-effective structural system for short to medium spans (25m–50m), favored for their durability, ease of fabrication, and high load-bearing capacity. They utilize high-strength concrete subjected to compressive forces from steel tendons, making them dominant in highway and urban infrastructure projects worldwide.

Key Aspects of PC Girder Bridges

- **Design & Components:** Commonly designed as post-tensioned I-girders using AASHTO standards, optimizing materials for cost. They feature concrete girders, a deck slab, and often cross-girders for stability.

- **Advantages:** They are preferred over steel due to lower maintenance, moderate self-weight, and structural efficiency.
- **Applications:** Extensive use in highway bridges, urban viaducts, and river crossings, such as projects in Bangladesh (e.g., Madhumati River bridge).
- **Maintenance & Deterioration:** Key issues include prestress loss, corrosion of tendons, and structural cracking, especially in older structures, demanding robust inspection.

Common Configurations

- **I-Girders:** Standardized shapes (Type III to VII) used for different span lengths.
- **Tendon Configuration:** Post-tensioning is frequently employed for its practicality in construction.
- **Construction:** Often prefabricated or cast in place with detailed reinforcement, ensuring a 28-day concrete strength of roughly 35 MPa – 40 MPa

Common Issues and Considerations

- **Corrosion:** Tendon corrosion is a major issue, induced by water and chloride ion infiltration.
- **Prestress Loss:** Over time, the tension in the cables can decrease, affecting the bridge's strength.
- **Design Standards:** Designs strictly follow AASHTO LRFD specifications to ensure longevity and safety

Fig: 1-4-5 PC Girder Bridge

c) Box Girder Bridge

A box girder bridge features main beams shaped like hollow, closed boxes (rectangular or trapezoidal) made from prestressed concrete, steel, or a composite of both. Highly resistant to torsional forces and efficient in bending, they are ideal for long-span highway, railway, and curved bridges, typically constructed using in-situ casting or segmental prefabrication

Fig: 1-4-6 Box Girder Bridge

Key Characteristics and Components

- **Structure:** Comprises a top slab (deck), bottom flange, and vertical/inclined webs forming a hollow cell.
- **Strength:** Excellent torsional rigidity allows for longer, more slender spans (roughly 30m to 300m) compared to I-beams.
- **Components:**

Includes internal stiffening diaphragms to prevent distortion under load

-

- **Construction Methods:** Often built using the balanced cantilever method, segmental launching, or cast-in-place methods.

Advantages

- **High Torsional Resistance:** Superior performance against twisting forces, crucial for curved bridges.
- **Aesthetics and Maintenance:** The closed structure offers a clean, aesthetic look and protects internal components.
- **Versatility:** Suitable for steel, pre-stressed concrete, or composite construction.
- **Efficiency:** High strength-to-weight ratio allows for longer spans and reduced construction depth.

Applications

- **Highway Flyovers:** Extensively used for elevated roads and complex interchanges.

- **Railway Bridges:** Ideal for carrying heavy dynamic loads with reduced depth.
- **Long-Span Bridges:** Frequently used in cable-stayed designs.

d) Slab Bridge

A slab bridge is a simple, cost-effective, and common short-span bridge (typically 10-20 meters) consisting of a solid, reinforced concrete slab directly supporting traffic while resting on abutments. Ideal for, underpasses and small crossings, these bridges are favored for their simplicity, rapid construction, and ability to handle high compression, though they are usually restricted to shorter spans compared to girder bridges

Key Aspects of Slab Bridges:

- **Structure:** Primarily designed as reinforced concrete slabs, they can be cast in-situ or prefabricated. They function as both the deck and the main load-bearing member.
- **Span & Capacity:** Solid slab bridges typically span up to 10-15 meters, while voided or prestressed concrete slabs can extend to 25 meters.
- **Types:** Solid slab, voided slab (to reduce dead weight), and prestressed concrete slabs.
- **Advantages:** Simple design, low construction cost, quick installation, and suitability for curved, tight-radius, or skewed alignments.
- **Disadvantages:** Heavy self-weight (specifically solid slabs) and limited span length.
- **Components:** Consists of the deck slab, abutments, and reinforced steel bars, which are concentrated in the lower portion to handle tensile forces.

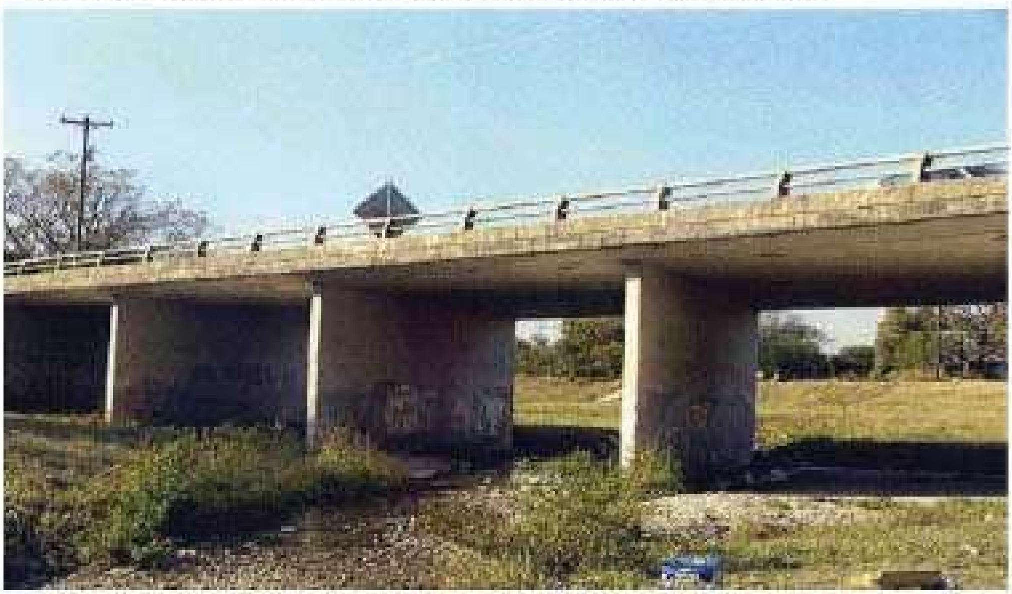


Fig: 1-4-7 Slab Bridge

e) Arch Bridge

An arch bridge is a structure featuring abutments at each end, designed to carry loads primarily through compression along a curved shape. These bridges transfer weight outwards to the supports, allowing for, traditionally, stone construction and, modernly, steel or concrete. They are highly durable, aesthetically pleasing, and efficient for spanning gaps.

Key Principles and Components

- **Structural Mechanics:** Arch bridges work by translating the downward force of weight into horizontal thrust, which is restrained by abutments at each end.
- **Components:**
  - **Keystone:** The central, wedge-shaped stone at the highest point (crown) that locks the arch in place.
  - **Abutments:** The end supports that bear the entire weight and horizontal forces.
  - **Voussoirs:** Individual wedge-shaped units forming the arch.
  - **Spandrel:** The area between the arch curve and the deck.

Types of Arch Bridges

1. **Deck Arch Bridge:** The deck is located above the arch.
2. **Through Arch Bridge (Tied-Arch):** The deck passes through the arch, with the arch rising above it.
3. **Half-Through Arch Bridge:** The deck is located at an intermediate level of the arch.

Advantages and Disadvantages

- **Advantages:** Exceptional strength due to compression, ability to span long distances using, historically, smaller building materials.
- **Disadvantages:** Requires substantial abutments to prevent horizontal shifting, can be complex to construct, and often requires more materials than modern beam bridges.

Fig: 1-4-8 Arch Bridge

F) Belly Bridge

A Bailey bridge has the advantages of requiring no special tools or heavy equipment to assemble. The wood and steel bridge elements were small and light enough to be carried in trucks and lifted into place by hand, without the use of a crane. The bridges were strong enough to carry tanks. Bailey bridges continue to be used extensively in civil engineering construction projects and to provide temporary crossings for Pedestrian and vehicle traffic.

The *Iron Bridge* is a cast iron bridge that crosses the River or khal or canal. It is easy to installed and very low cost

Fig: 1-4-9 Bailey with Steel Deck Bridge

g) Iron Bridge

Fig: 1-4-10 Fragile Iron Bridge

2. PRE-CONSTRUCTION ACTIVITIES

2.1. Notification of Award (NOA)

An effective contract management includes the command and control of activities spanning pre-award phase and post-award - construction phase. Proper handling of the activities before awarding a contract is a pre-requisite for successful execution of the construction works and achievement of overall project outcome. A failure in pre-contract management will result in post-contract management time and effort being wasted on trying to resolve and correct omissions and failures of the earlier phase.

Procedure:

1) After the approval of the contract award, the Project Engineer (PE) shall issue the Notification of Award (NOA) to the successful Tenderer. The notification will be issued prior of expiration of the Tender Validity period and within **1 week;** after contract award. The NOA shall state:
   a) the acceptance of the Tender by the LGED;
   b) the price at which the contract is awarded;
   c) the amount of the Performance Security and its format;
   d) the date and time within which the Performance Security shall be furnished; and
   e) the date and time within which the Contract shall be signed.
2) The PE shall notify the Central Procurement Technical Unit for NOA for contract (Contract Value 1 Crore BDT and above) within seven 7 days of its issuance for publication in CPTU website.
3) The PE will send the draft Contract Agreement and all documents forming the Contract to the successful Tenderer at the same time of issuing the NOA.
4) The NOA shall be accepted by the successful Tenderer within seven **(7) working days** from the date of its issuance.
5) Until a formal contract is signed, the NOA will constitute a Contract, which shall become binding upon the furnishing of a Performance Security and the signing of the Contract by both parties.

2.2 PERFORMANCE SECURITY

A Performance Security should be requested by LGED from the selected Contractor in order to mitigate the risks of non-performance and breach of contractual obligations. The performance security should reflect the value of the assessed risk and subsequent loss to LGED if the Contractor fail to fully perform under the respective contract and will be in the amount as stated in the PCC.

Procedure:

1) The Contractor shall furnish the LGED with Performance Security within seven **(7) working days** (PW2); fourteen **(14) days** (PW3); twenty eight **(28)** days (PW5) from the date of acceptance of the NOA. The amount and the date and time within which the Performance Security shall be furnished is stated in NOA. The Performance Security should be provided in a currency and amount specified in TDS.

2) After receiving the Performance Security, Project Manager will send a written request to the Issuing Bank furnished the Performance Security to verify the authenticity of the Performance Security.

3) During the execution of the contract, Project Manager can make any claim against the Bank issuing the Performance Security by notifying the Contractor. Such claims should be made by the Project Manager if the Contractor is in the breach of the Contract and Project Manager has duly notified him.

4) Performance Security shall be valid until a date twenty **(28) days** beyond the Intended Completion Date.

5) After the issuance of Certificate for Completion of Works Project Manager shall initiate the procedure to substitute the Performance Security furnished at the date of signing the contract by a new Security covering fifty **(50) percent** amount of Performance Security to cover Defect Liability Period.

6) If Project Manager finds no reason to call for the retention money, the security shall be discharged by the LGED and returned to the Contractor after the Defects Liability Period has passed and the Project Manager has certified in the form of Defects Corrections Certificates (FORM 11/4).

2.3 AGREEMENT

1) The PE and successful Tenderer shall sign a contract within **twenty eight (28) days** (PW3 and PW5); **fourteen (14) working days** (PW2) of issuance of the NOA. If the successful tender is of JV, all partners of the JV shall sign the contract agreement.

2) The PE proposes the person named in the TDS to be appointed as Adjudicator under the Contract, at an hourly fee and for those reimbursable expenses as specified in the TDS.

3) PE will return Tender Security to Tenderers at different stages of Tendering Process according to the status of the Tender as follows:

   - Just after the Tender Opening Process, PE will return Tender Security to those Tenderers who have withdrawn their Tender before Tender Submission Deadline.
   - Immediately after the Tender Evaluation Report Approval by the Approving Authority, PE will return Tender Security to those Tenderers who's Tender has declared as non-responsive.
   - Immediately after the Tender Evaluation Report Approval by the Approving Authority, PE will return Tender Security to the responsive Tenderer according to their application who's Tenders are not the ranking 1st, 2nd or 3rd position.
   - After the contract signing with lowest evaluated responsive Tenderer, PE will return Tender Security to the rest of the Tenderer (who's Tenders were in ranking 1st, 2nd or 3rd position).
   - In all cases, PE will return Tender Security to the Tenderer before expiry the Tender Validity Period.

4) The Competent Authority responsible for a particular project, shall appoint a Project Manager who will be responsible for administering a construction contract to be awarded to Contractor.

5) Once appointed, Project Manager shall establish promptly the communication with the representatives of the Contractor.

6) Project Manager organizes a pre-construction meeting with clarify with Contractor all contractual related matters such as: the accuracy of contract's documentation, the BOQ, Drawings and Specification, the timeframe for commencing the Works, the issuance of Program of Works and other related documents, the safety measures, provisions in the contract, recourses need to commence and execute the Works etc.

NOTE: The following documents forming the Contract shall be interpreted in the following order of priority:

a) The signed Contract Agreement;
b) The Notification of Award;
c) The completed Tender (i.e. Tender Submission Letter and Tenderer Information Form)
d) The Particular Conditions of Contract;
e) The General Conditions of Contract;
f) The Technical Specifications;
g) The General Specifications;
h) The Drawings;
i) The priced BOQ and the Schedules; and
j) Any other document listed in the PCC forming part of the Contract.

FORM 1: NOTIFICATION OF AWARD FORM 2/1

Contract No: Date:

To:

[Name of Contractor]

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

You are thus requested to take following actions:

i. accept in writing the Notification of Award within seven (7) working days of its issuance in accordance with ITT Clause 64

ii. Furnish a Performance Security in the form as specified and in the amount of Tk *[state amount in figures and words]*, within fourteen (14) days of acceptance of this Notification of Award but not later than *(specify date)*, in accordance with ITT Clause 65 & 66.

iii. Sign the Contract within twenty-eight (28) days of issuance of this Notification of Award but not later than *(specify date)*, in accordance with ITT Clause 70.

You may proceed with the execution of the Works only upon completion of the above tasks.

You may also please note that this Notification of Award shall constitute the formation of this Contract which shall become binding upon you.

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

Signed

Duly authorized to sign for and on behalf of
[Name of Procuring Entity]

Date:

FORM 2: CONTRACT AGREEMENT FORM 2/2

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

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

NOW THIS AGREEMENT WITNESSETH AS FOLLOWS:

1. In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the General Conditions of Contract hereafter referred to.

2. The documents forming the Contract shall be interpreted in the following order of priority:

   (a) the signed Contract Agreement
   (b) the Notification of Award
   (c) the completed Tender and the Appendix to the Tender
   (d) the Particular Conditions of Contract
   (e) the General Conditions of Contract
   (f) the Technical Specifications
   (g) the General Specifications
   (h) the Drawings
   (i) the priced BOQ and the Schedules
   (j) Any other document listed in the PCC forming part of the Contract.

3. In consideration of the payments to be made by the Procuring Entity to the Contractor as hereinafter mentioned, the Contractor hereby covenants with the Procuring Entity to execute and complete the works and to remedy any defects therein in conformity in all respects with the provisions of the Contract.

4. The Procuring Entity hereby covenants to pay the Contractor in consideration of the execution and completion of the works and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract.

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

	For the Procuring Entity	for the Contractor
Signature		
Name		
National ID No.		
Title		
In the presence of Name		
Address.		

2.4. PROCURING ENTITY'S KEY RESPONSIBILITIES

a) Assure the Quality, Time and Price control throughout the execution of the Works by the Contractor.
b) Payment to the Contractor, in consideration of the satisfactory progress of execution and completion of the Works and physical services, and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract Agreement.
c) Payment to the Contractor for any compensation events (refer to GCC Clause 67.1 for the compensation events) occurred during the contract execution. *Example: if LGED has delayed in given the possession of the Site or part of the Site to Contractor, the Project Manager may authorize increase of the contract price and/or extension of completion time.*
d) Approval of the contractor's key personnel named in the Schedule of Key Personnel as referred to in the PCC and replacement of key personnel, to carry out the functions stated in the Schedule.
e) Approval of contractor's Work Plan, proposed by the Contractor as well as any, update in the Work Plan during the contract execution.
f) Give right of access to, and non-exclusive possession of, those parts of the Site set out in the site plan within the time (or times) stated in the PCC.
g) Guide and assist the Contractor in obtaining, if required, any permit, license, and approvals from local public authorities for the purpose of execution of the Works and physical services under the Contract.
h) Recommends the existence of a Force Majeure that will be the basis of the issuance of order for suspension of Works and submit the recommendation to HOPE for final decision on the existence of Force Majeure.
i) Provide directives to Project Manager with regards to contract implementation.

2.5 PROJECT MANAGER'S KEY RESPONSIBILITIES

The Project Manager is LGED staff appointed by Procuring Entity who is responsible for supervising the execution and completion of the Works and physical services and administering the Contract, particularly, but not limited to:

a) Except where otherwise specifically stated in the PCC, decide contractual matters between the Procuring Entity and the Contractor in its role as representative of the Procuring Entity and clarify queries in conditions of the contract on behalf of PE.
b) Assure the Quality, Time and Price control throughout the execution of the Works by the Contractor.
c) Approve a Program of Works showing the general methods, arrangements, order, and timing for all the activities in the Works.
d) Approve the Specifications and Drawings showing the proposed Temporary Works submitted by the Contractor.

e) Give instruction to Contractor for commencement of the Works.
f) Approve the Contractor's key personnel and any changes in the composition key personnel proposed by the Contractor;
g) Check the works executed by the Contractor and notify the Contractor of any defect found, instruct the Contractor to suspend the Works when assessed necessary.
h) Determine the value of the Works executed, check the Contractor's monthly statement and certify the amount to be paid to the Contractor and issue Completion Certificate as evidence that the Contractor has executed the Works and physical services in all respects as per design, drawing, specifications and Conditions of Contract.
i) Manage the contract filing system and ensure proper documentation of all activities pertaining to contract administration.

2.6 RELATION WITH CONTRACTOR

The Project Supervision shall use a courteous, businesslike and ethical procedure when dealing with the Contractor. A good relationship is essential to gain the co-operation of the Contractor.

Notwithstanding the above, the Project Supervision shall ensure that the work is done in strict conformance with the accepted engineering principles and in accordance with the drawings and contract documents.

The Project Supervision shall maintain an impersonal, agreeable and helpful attitude towards the Contractor and the employees of the Contractor. It is an important asset to secure the friendly co-operation and respect of the employees of the Contractor by dealing fairly and by recognizing and commending on good work. The Project Supervisor shall take the attitude that any suggested changes are for the benefit of the work, and the vested authority as all NEVER be abused.

A good start is important and firmness at the beginning of the job will tend to avoid the "bickering" throughout the duration of the contract.

Instructions shall be given only to the authorized representative of the Contractor. However, on minor and routine matters, and to an extent agreeable to the Contractor's organization, instruction may be given directly to the work persons. However, the Project Supervision shall not act as superintendent or perform duties for the Contractor, nor interfere with the management of the work by the Contractor. Any significant orders or instruction which are likely to prove controversial shall be confirmed in writing with a copy to the Project Manager.

The Project Supervisor may deal directly with the subcontractors to an extent agreeable to the Contractor's organization. The Contractor is legally responsible for the performance of the subcontractors. Any correspondence between the LGED and the subcontractor must be submitted through the General Contractor.

Whenever possible, circumstances which may lead to unsatisfactory work shall be pointed out at the earliest opportunity to the Contractor to avoid the waste of materials and labour.

2.7 CONTRACTOR'S KEY RESPONSIBILITIES

The Contractor, throughout the execution and completion of the Works will be responsible to:

a) Carry out all instructions of the PE/Project Managers that are in compliance with applicable Laws.
b) Execute and complete the works and remedy any defects therein according to the provisions stipulated in the contract agreement and in line with BOQ, approved Specification, Drawings and Work Plan.
c) Prepare the Program of Work in the form of an Implementation Schedule showing general methods, arrangements, order and timing for all activities in the Works and submit to Project Manager for approval.
d) Design of Temporary Works and obtain the approval of third parties to the design of the Temporary Works, where required.
e) Execute and complete any works authorized by PE under any Variation or Extra Work Order as well as any remedial work, when approved by Approving Authority (the authority in accordance with Delegation of Financial Powers).
f) Provide access to the site for authorized persons (LGED officials/personnel from ministries/development partners) for examination, inspection, measurements, testing and supervision.
g) Supply "As Built" Drawings and/or operating and maintenance manuals by the date specified in PCC, if required.
h) Submit to Project Manager monthly statements of the estimated value of the works executed less the cumulative amount certified previously.
i) Take all reasonable steps to safeguard the health and safety of all workers working on the Site and other persons entitled to be on it, and to keep the Site in an orderly state.
j) Provide and maintain at the Contractor's own cost all lights, guards, fencing, warning signs and watching for the protection of the Works or for the safety on-site.
k) Take all reasonable steps to protect the environment on and off the Site and to avoid damage or nuisance to persons or to property of the public or others resulting from pollution, noise or other causes arising as a consequence of the Contractors methods of operation.
l) Comply with all the relevant labour Laws applicable to the Contractor's personnel relating to their ***employment, health, safety, welfare, immigration*** and in order to allow them all their legal rights.
m) Adhere to all applicable labour Laws and other relevant treaties ratified by the government which prohibits the ***employment of any child*** to perform any work that is economically exploitative, or is likely to be hazardous to, or to interfere with, the child's education, or to be harmful to the child's health.
n) Provide the proper accommodation to his or her labourers and arrange proper water supply, conservancy and sanitation arrangements at the site for all necessary hygienic requirements and for the prevention of epidemics in accordance with relevant regulations, rules and orders of the government.
o) Pay on time the reasonable wages to his or her labourers.
p) Before starting the Works, provide, in the joint names of the LGED and the Contractor, ***insurance*** cover from the Start Date to the end of the Defects Liability Period, in the

amounts specified in the PCC for the following events which are due to the Contractor's risks:

- Loss of or damage to the Works, Plant, and Materials;
- Loss of or damage to Equipment;
- Loss of or damage to property (except the Works, Plant, Materials, and Equipment) in connection with the Contract; and
- personal injury or death

q) Pay all applicable ***taxes, custom duties, VAT***, and other levies imposed or incurred inside and outside Bangladesh.

r) Take accountability for any act or default of any Subcontractor, his or her agents or employees, as if they were the acts or defaults of the Contractor

3. TIME CONTROL

The aim of the effective time control is to ensure that the construction projects are completed within the contracted timeframe and timely measures are undertaken to avoid potential delays which may impact the overall project objectives. It is a complex task undertaken by the Project Managers in practice, which involves constantly measuring progress, evaluating plans, and taking corrective actions when required throughout the execution of the Works.

3.1 COMMENCEMENT OF WORKS

Except otherwise specified in the PCC, the Project Manager should issue the Instruction to the Contractor for commencing the work (FORM 4/7 INSTRUCTION FOR COMMENCEMENT OF WORK) if the following conditions have all been fulfilled:

a) Contract Agreement has been signed by both parties;

b) Except if otherwise specified in the PCC, possession of the Site given to the Contractor as required for the commencement of the Works; and

c) Receipt by the Contractor of the Advance Payment under GCC Clause 73 (PW3); GCC Clause 78 (PW5) provided that the corresponding Bank Guarantee has been delivered by the Contractor.

Once the Instruction for commencing the works has been issued to Contractor, Project Manager should follow up proactively with Contractor to make sure that the Contractor follows the instruction. In the instruction for commencement of Works, the Contractor should be requested to submit to LGED insurance policy documents and Program of Works to PE/PM for approval within **15 days** of signing of Contract.

In case the Project Manager notices the delays from the Contractor in commencing the works, a warning letter should be drafted and submitted to the Contractor.

Project Manager shall convene the commencement meeting with Contractor to clarify all relevant contractual arrangements. FORM 4/3 (COMMENCEMENT MEETING FORM) should be used to facilitate the commencement meetings.

3.1.1 ACTION PRIOR TO COMMENCEMENT OF WORK

The Engineer and/or the Supervising Engineer should:

(a) Obtain a copy of the letter of Acceptance and note any special provisions contained therein.

(b) Discuss the job with the design engineer to familiarize himself with reasons for various design features.

(c) Satisfy himself that access is available to the site of the bridge and any conditions which may restrict access {such as heavy rainfall).

(d) Check that the Contract has been signed and Security Deposit lodged.

(e) Request the Contractor to supply evidence that the insurance policies. Required by the General Conditions of Contract have been effected. A copy of the Policies should be obtained to ensure that they comply with the requirements o1 the General Conditions.

i. Check on the existence of utilities which may be affected by the work. Obtain copies of correspondence with utilities authorities. Where the Employer is responsible for moving utilities, ensure that the work is done in time to avoid delay to the contract works.

ii. Check that survey pegs are in position and, if necessary, arrange for their re-establishment.

iii. Check materials which are to be supplied by the Employer, to ensure supply will be on time.

(i) Arrange to send a letter delegating authority to the Supervising Engineer (the Engineer's Representative).

(J) Check with other engineers who have had dealings with the Contractor. This may disclose particular aspects which will need close attention.

(k) Request tile Contractor to supply samples of concrete aggregates and his proposed concrete mix design at an early date. Otherwise, he may be delayed awaiting approval for his mix design.

(l) Arrange for an initial site meeting with the Contractor

3.1.2 INITIAL SITE MEETING

The initial site meeting should be held wen in advance of the commencement of work on the site. This meeting should be attended by the Engineer, his assistants, the Supervising Engineer(s) and the Constructor's Representatives.

The purpose of this meeting is to discuss the Construction Schedule, equipment to be used, and general organization of the job.

The Contractor should be asked to supply the Construction Schedule and details of major formwork and false work for approval.

3.1.3 SITE MEETINGS

Site meetings should be arranged at monthly intervals to review progress and discuss problems which arise. Special site meetings should also be called if necessary to deal with specific problems.

Minutes of site meetings should be an accurate record of the proceedings of the meeting, and should be written immediately following the meeting. A copy must always be sent to the Contractor with a covering letter requesting his comments as to their correctness. Minutes of site meetings have considerable importance on matters in dispute, and it is essential that the Contractor be given the opportunity to comment on their correctness. Lack of comment can be taken as agreement to the correctness of the record.

3.2. ISSUE OF DRAWINGS AND OTHER DOCUMENTS

The drawings are contractual documents that represent the scope of the works as listed in the schedule of works or any additional or modified drawings issued by PE. The Contractor is obliged to perform the construction works in full accordance with the drawings, as an integral part of the contract.

The issue of other documents to the Contractor must be in line with contractual requirements and should be recorded accurately.

Procedure:

1) As required by the contract, the Project Manager will issue to the Contractor the sets of construction drawings, with prior approval of PE
2) The drawings issued by LGED to the contractor should be previously approved as an integral part of the Contract and clearly marked "APPROVED FOR CONSTRUCTION". The "Approved for Construction" drawings will accurately reflect the work upon which the tender was accepted..
3) In case of revision of drawing, the copy of the revised drawings should be shared with contractor with clearly marked revisions.
4) The Drawings shall be dated and numbered and show the revision number, signed by Competent Authority. To avoid unnecessary disputes and claims, the transmittal of drawings should be handled carefully and properly recorded on a regular basis at all stages during the construction works.
5) Before issuing the drawings, the PE/Project Manager should check for potential variation of revised and/or new drawings from the scope of work or specification.
6) Any changes in the drawings should result in issuance of a Variation Order accordingly.
7) For revised drawing preparation, the following aspects should be taken into consideration:
   a) Contractor's construction program and construction sequence;
   b) Delivery time for construction materials;
   c) Fabrication time for manufactured items (if any);
   d) Any design work or drawings required from the contractor.

8) If deemed necessary, the PE/Project Manager should liaise with the project specific designer to ensure that the designer is aware of any drawing that is inconsistent with the contract and which might result in a variation.
9) Once the "Approved for Construction" drawings are issued, the Project Manager is responsible to file to the contract file.

3.3 SITE MANAGEMENT COMMENCEMENT MEETING

The site management commencement meeting will be held to establish clear lines of authority, determine the duties and responsibilities, communications, subcontractor's requirements and usage, Project Manager, clarify potential misunderstandings and agree on the detailed implementation arrangements for successful completion of the contract. A successful contract commencement meeting should result in both the Contractor and the Project Manager having a clear understanding of the construction plan, expectations and responsibilities of all parties. The PE/PM should reach the mutual understanding with the contractor and sub-contractor/s on all terms and conditions of the contract document.

Procedure:

1) After the contract has been awarded, the PE/Project Manager should confer and arrange a site management commencement meeting with the Contractor, sub-contractor/s and all other stakeholders to review and agree on contract obligations, work schedule, construction arrangements and any other relevant issues of the construction project. It is fundamental that all LGED staff involved in managing the respective contract is familiarized with the implementation plan and project site as well as about all contract requirements and conditions.
2) The Meeting is to be attended by following representatives:
a) Procuring Entity
b) Project Manager and any other LGED staff assigned by Project Manager
c) Contractor's site engineer
d) Sub contractor's nominated representative (if any)
e) Representatives from utility companies (if required)
f) The representatives from emergency entities - hospitals, fire departments etc. (if required)
g) Any other representative, as assessed as important based on specific project requirements.
3) The PE/Project Manager should schedule the contract commencement meeting sufficiently in advance to allow the attendance of all parties invited. All attendees will be given a **ten (10) days** advance notice of the date, time and location of the meeting venue. Subcontractor/s should be advised by the Contractor to attend.
4) A PE/Project Manager representative is responsible for taking minutes from the meeting and maintains the minutes of the meeting in the contract file along with any other required documentation. A copy of the minutes report should be submitted to all attendees.

3.4. PROGRAM OF WORKS

The Program of Works will be used for monitoring the progress of the execution of the Works.

Procedure:

1) The Project Manager is responsible for approval of the Program of Works (as stated in GCC Clause 12.1(PW2); Clause 41.1(PW3); Clause 41.1(PW5) submitted by the Contractor within the time stated in the PCC. The Program of Works should represent the general methods, arrangements, order and timing for all activities in the Works.
2) The Project Manager should also review and approve any updated Program of Works, within contract period, submitted by the Contractor at intervals no longer than the period stated in the PCC. The updated Program will show the actual progress achieved on each activity and the effect of the progress achieved on the timing of the remaining work, including any changes to the sequence of the activities.
3) If the Contractor does not submit an updated Program of Work at the stipulated interval in the PCC, the Project Manager is authorized to withhold an amount from the next payment certificate and continue to withhold this amount until the next due payment after the date on which the overdue Program of Works has been submitted as per PCC.

NOTE: The submission to, and review by, the Project Manager of any amended or revised Program of Work or any other document or revision thereof under shall not in any way relieve the Contractor of any of its warranties, obligations or liabilities under or in connection with the Contract.

3.5. EARLY WARNING

Early warning is a partnering-based approach to resolve the issues arising during contract implementation. The Contractor should give early warning of any issues, events, circumstances or conditions that may affect the quality of the work, increase the original Contract Price or delay the execution of the Works. The contractor should give early warnings as soon as he become aware of it in order to minimize the detrimental impact on the work flow and to help reduce the risk of penalties being applied.

Procedure:

1) The Project Manager should make sure that Contractor understands the requirements for giving early warnings to LGED in cases he encounters any issue in complying with the contracted terms and conditions.
2) If the LGED receive an early warning from the Contractor, the Project Manager should review the warning note, evaluate the situation and work collaboratively with the Contractor to find the proper solution.
3) The Project Manager will organize an early warning meeting to discuss with the Contractor and sub-contractor/s (if any) how to avoid or mitigate the impacts of

the warned issue and decide what actions should be taken next by each party to resolve the matter in the most efficient manner.

4) The Project Manager may require the Contractor to provide an estimate of the expected effect of the future event or circumstance on the original Contract Price and Completion Date.

5) The Project Manager, Assistant Upazila Engineer (Upazila level) or Senior Assistant Engineer (District level) should share with Contractor the FORM 4/5 (EARLY WARNING NOTE) for maintaining administration of early warnings.

3.6. EXTENSION OF INTENDED COMPLETION DATE

The extension of completion date is required due to the circumstances which might arise during the execution of contract that make it impossible to complete the Works within the contracted completion period. The Contractor may be granted the approval for extension of Intended Completion Date based on following provisions: a) Occurrence of Compensation Events b) Variations and c) Extra Work Order.

Whenever LGED determine the need for extension of intended completion date, a formal amendment of Contract will be required.

Procedure:

1) The Project Manager should become familiarized with the contract's grounds for extension of intended completion date of the works.

2) In case the Contractor consider himself eligible for extension of Intended Completion Date, he should submit the early warning note to Procuring Entity informing on the circumstances occurred that require the need for extension of time for completion of Works. The Contractor should submit the notice no later than **twenty-eight (28) days** after the Contractor became aware of such circumstances.

3) The PE should carefully review the claim note, in conjunction with site staff and determine the entitlement of the Contractor and decide within **twenty-one (21) days** of the submission of notice by Contractor. A form 4/6 CHECK LIST FOR EXTENSION OF INTENDED COMPLETION DATE will be used to ensure that all aspects are considered in the review.

4) If the Contractor has not submitted the written notice on time, the delay by the particular failure shall not be considered in assessing the extension of Intended Completion Date. In this case PE/PM submits the explanation letter to the Contractor.

5) Procuring Entity may extend by up to **twenty (20) percent** of the original contract time, as stated in PPR 39.

6) The Head of Procuring Entity can approve, or authorize a person to approve the extension of time for completion by more **than twenty (20) percent** of the original contract time.

7) If it is determined that the Contractor is entitled to an extension of the time for completion, the Project Manager should request from Contractor to submit the

revised program that shows the effect of the approved extension of time for completion.

8) If PE agrees with the Contractor's proposal to extend the Intended Completion Date, Contractor will submit the Claim requesting the amendment of the contract. The Contractor should submit the claim for Extension of Completion Date within **forty-two (42) days** as per GCC Sub Clause 91.3 (PW3); Sub Clause 99.3. (PW5) after Contractor became aware of the circumstances arisen that required the need for extension.

9) After receipt of a claim, PE will allocate a claim number and record the claim in the Extension of Time Claim Register.

3.7. DELAYS AND ACCELERATIONS

When managing construction contracts, LGED staff should be aware of the ***delays caused by LGED*** such as: delays in issuing Drawings, Specifications, or instructions required for execution of the Works and giving the Contractor possession of the site, delays in approving Program of Works, processing payment on time and in accordance to the schedule, delays in responding to Contractor's claims, approving process, delays due to the suspension of the Works ordered by Project Manager, delays conducting inspections and tests, delays in issuing Completion Certificate, delays in timely giving warning notes to Contractor etc.

The delays ***caused by the Contractor*** are commonly related to: submission of Program of Works, delays in submission of Performance Guarantee, delays in commencing the works, delays in submitting to Project Manager early warning notifications, delays in completing the Works and physical services within the Intended Completion Date, not giving LGED staff access to the site on time for the purpose of inspection and test, delays in paying the wages to its labourers etc.

There are also delays caused by ***Public Authorities*** which may disrupt contractor's Works. These public authorities delays might be considered as compensation event if nor LGED neither Contractor have not foreseen such delays and Contractor has diligently followed the procedure laid down by legally constituted public authorities.

The occurrence of the exceptional events or circumstances caused by ***Force Majeure*** may also cause delays in timely completion of construction works.

Procedure for Delays:

1) Project Manager should be aware of contractual provisions stipulating the rights and obligations of both LGED and Contractor with regards to all kind of delays which may occur during the execution of the Works.

2) After contract is signed and Instruction for commencement has submitted to Contractor, Project Manager should ensure that the Contractor will commence the Work within the date specified in the instruction.

3) Project Manager will make sure that all payments are processed to Contractor on time;

4) Project Manager will work closely with Contractor in monitoring whether the progress of the works is in line the agreed schedule and assess if there is any delay.

5) Project Manager will give notice to Contractor in case he/she observe any potential delays which may occur.
6) The Project Manager may instruct the Contractor to delay the start or progress of any activity within the Works.

Acceleration occurs when LGED requests from Contractor completion of particular work activity earlier than the planned or contracted timeframe.

Procedure for Acceleration:

1) If LGED wants to request from the Contractor completion of the Works before the Intended Completion Date, the Project Manager will obtain priced proposals for achieving the necessary acceleration from the Contractor.
2) If the priced proposal is accepted by Project Manager, the Intended Completion Date will be advanced accordingly and confirmed by both the LGED and the Contractor.
3) The priced proposals for acceleration accepted by both parties will be incorporated in the Contract Price and treated as a Variation.

3.8. SUSPENSION OF WORK AND CONSEQUENCES

The LGED can decide to suspend the progress of part or all the Works. Such suspension of the Works may cause the delays in completion of the works and may increase the cost.

Procedure:

1) Project Manager is responsible to instruct the Contractor for any suspension of the Works.
2) When instructing for suspension, the Project Manager should make sure that the Contractor is protecting, storing and securing such part of the Works against any deterioration, loss or damage.
3) When the work is suspended, the Project Manager should provide the Contractor with a notice that includes the effective date of the suspension and states the specific reason for the suspension referring to the specifications and GCC Sub Clause 49.1 (PW3); Sub Clause 49.1 (PW5) under which the action is taken, what actions the Contractor must take before resuming work and the conditions under which the suspension will be revoked.
4) Project Manager will issue a written suspension order except when work must be stopped at once and time does not permit issuance of a written order. A written order confirming the verbal order must be issued at the earliest possible time. Project Manager before issuing the suspension order should make an assessment of the consequences of the suspension pertaining to the need for extension of the Intended Completion date and/or increase of the cost
5) If the suspension order cause any delays and financial implications and when the suspension is due to no fault of the Contractor, and once the Contractor has submitted the claim, the Project Manager shall proceed to agree or determine the length of extension of Intended Completion Date and/or changes in the contract price.
6) Suspension and reasons should be recorded in the diary accordingly.

FORM 3: AGENDA FOR INITIAL SITE MEETING FORM 3/1

Contractor:		Date:	

1.	Opening	• Introduction • General description of the contract scope
2.	Organization	• LGED organization and its personnel involved • Contractor's organization and personnel
3.	Communication	• Verbal communications • Site memos/instructions • Correspondence and drawings transmittals
4.	Program	• Work plan and program • Manpower • Coordination with sub-contractors
5.	Construction material	• Supply plan • Transport arrangements and storage procedures
6.	Survey and utilities/facilities	• Survey marks • Construction power (if applicable) and contractor's extensions • Accommodation or camp facilities • Water and sewerage (if applicable) • Sewage and waste disposal • Telecommunications (if applicable) • Operation in borrow areas, quarries, disposal and stockpile areas • Other services
7.	Contractor's plant and equipment	• Proposed plant • Supply plan • Proposed maintenance facilities
8.	Contractor's storage areas	• Location and layout Buildings • Conditions or restrictions on use • Requirements of other contractors (if applicable)
9.	Work rules	• Regular work hours and work outside agreed hours • Security and Camp regulations
10.	Safety	• Safety provisions and procedures • First aid and medical provisions • Accident reporting
11.	Quality control program	• Inspection of the work and Testing
12.	Measurement of the work	• Agreed Method of Measurement • Agreed measurement schedule • Who has authority to agree measure on site (for Contractor and for LGED)
13.	Monthly progress statement procedure	• Agreement of monthly progress measurements • Form of submittal • Payment for variations • Deductions for retention, etc
14.	Issue of variation orders	• Confirm who has authority to issue variations
15.	Claims or other dispute handling	
16.	Reporting requirements	• Monthly reports • Weekly reports?
17.	Drawing and data submittal and review procedure	
18.	Contractor's appointment of subcontractors	
19.	Insurance	
20.	Other matters	

FORM 4: PROJECT EMERGENCY CONTACT NUMBERS FORM 3/2

Project Title			
Project Location			
Contractor			
Date of issue		Revision	

Service	Telephone Number	Name/Details/Address
LGED representative		
Contractor Contact		
Site First Aid givers		
Nearest Doctor		
Nearest Medical Clinic /Hospital		
Ambulance Service		
Nearest Fire Service		
Nearest Police Station		
Services Providers Electricity Water Service Gas Service		
Other		

Form 5: COMMENCEMENT MEETING FORM 3/3

Project Title		**Meeting Number**	
Meeting Purpose			
Meeting Location		**Meeting Date & Time**	
Present			
Distribution	(additional to those present)		
Notes prepared by		**Distribution Date**	

1. Project Staff and Key Personnel

	No.	Name and surname	Title	Phone no.
LGED	2			
	2			
	3			
	4			
CONTRACTOR	1			
	2			
	3			
	4			
	5			
	6			

2. Timing and Dates (Confirmation)

Proposed start date on site	
Overall contract duration	
Defects Liability Period	
Note any milestone/stage completions	
Confirmation of site working hours	

3. Contract Commencement Deliverables

Prior to any works being carried out on site, including site establishment, temporary works, delivery of materials, etc., the Project Manager should make sure the Contractor has submitted for review and approval the following documentation

- Bank Guarantee for Performance
  Submitted by: ______________________ Date: ______________________
- Documented confirmation that all required Insurances are in place
  Submitted by: ______________________ Date: ______________________
- Any Local Authority permits, consents, licenses or fees required?
  Submitted by: ______________________ Date: ______________________
- Other Requirements? ____
  Submitted by: ______________________ Date: ______________________

4. Project Quality Procedures Planning

The Contractor is to actively engage with, execute and comply with the LGED quality, health & safety and environmental procedures and processes as outlined within the Contract documentation.

The appropriate LGED and Contractor staffs are to meet as soon as possible prior to works commencement on site to establish and activate the procedures and controls required.

Initial Quality Procedures Planning Program	LGED representative	Contractors representative	Meeting date and time	Initial once completed
Health & Safety				
Key issues to address: Project Site Emergency and Evacuation plan, Site Induction procedures and Site Safety Rules, Hazard Identification and Risk control assessment procedures, project safety meetings, work permit system, accident and incident reporting, safety inspections etc.				
Environmental Management				
Key issues to address: Environmental Risk assessment procedures, site waste management plan, emergency details, incident and spill reporting and investigation, site environmental inspections etc.				
Implementation Procedures				
Key issues to address: Program and planning, inspection and test planning, task analysis, site inspections, trade control sheets etc.				

5. Site Inspection

Is an initial site inspection prior to full site possession and works starting required? Full dilapidation report/photographic record/joint stakeholder walk round and sign off.

If required, confirm date/time and attendees involved.

Date: ______________________ Time: ______________________

Attendees: ____

6. Construction Contract Time Frames

The Construction Contract for this project outlines the timeframes and durations for the various processes administered within it. Both LGED and the Contractor have a contractual obligation to adhere to the timeframes detailed.

Important contractual activities such as processing interim payments, variations, extension of time claims and certificates are governed by set time periods for each step in the process. Confirmation and clarification of exactly what LGED and the Contractors obligations are timing wise will help eliminate misunderstandings in the future.

Discuss and confirm under this Construction Contract:

- process and timeframe for making an Interim Payment claim:
- process and timeframe for submitting a **Variation** claim (LGED or Contractor requested)
- process and timeframe for submitting an **Extension of Time** claim
- process and timeframe for submitting a Claim (either from Contractor or LGED)

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7. Program

In accordance with the relevant contract conditions, submission of the Program of Work is due: ______________________ (Date)

Short term / target roll out programs will be required based on a _______________ week work period cycle.

Program monitoring and review meetings will be held regularly throughout the project duration.

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8. Communication

Confirm that for the purpose of giving written correspondence and communication including notices, requests and consents under the terms of the Contract Conditions; that the representatives and contact details noted on Emergency contact numbers are correct and will be used throughout the contract implementation.

On completion of the initial quality procedure planning meetings, a schedule of all the proposed regular project site meetings will be collated, drafted and transferred onto an overall Project Meeting Schedule and issued to all relevant parties.

The initial release of the meeting schedule will be produced by: __________________ and will be

available from _________________________(Date)

9. **General** (Other items for discussion)

FORM 6: DRAWING ISSUE REGISTER FORM 3/4

INSERT THE NAME OF THE PROJECT

No.	Draw. No.	Description	Purpose of issue	ISSUED BY			RECEIVED BY		
				Name and Surname	Signature	Date	Name and Surname	Signature	Date

Note: Insert under the ***Purpose of issue*** the following codes: Information – I , For approval – A , For Construction – C , Preliminary-P, Other – O

FORM 7: EARLY WARNING NOTE FORM 3/5

Project Title		**Project No.**	
Location			
Name of Project Manager			
Name of Contractor		**Contract No.**	
EARLY WARNING NOTIFICATION		EW No.	
Issued: Contractor to Project Manager			
Description of early warning:			

Is the matter referred to above likely to: **Yes** **No**

Increase the total contract price ☐ ☐

Delay Completion ☐ ☐

Impair the performance of the works in use ☐ ☐

Is an early warning meeting required ☐ ☐

(Tick box as appropriate)

Signed by:________________________ (Contractor) Date:________________

FORM 8: CHECK LIST FOR EXTENSION OF INTENDED COMPLETION DATE FORM 3/6

Project name:	
Name of the Contractor	
Contract number:	
Name of Project Manager	

Claim No.:	
Contractor's claim reference:	
Time claimed:	
Time in calendar or working days	
Cause of delay:	
Applicable Contract clause:	
Any associated notice provisions	
Notice provisions complied with?	
Program of Works checked?	
Extension of time justified?	**Yes** ☐ **No** ☐
Period recommended:	

Signed by: ________________________ **Date:** ___________________________

(Project Manager)

FORM 9: INSTRUCTION FOR COMMENCEMENT OF WORK FORM 3/7

Local Government Engineering Department (LGED)

Office Memo No: Date:

To:

[Name of Contractor]

[Address)

Contract Reference:

Pursuant to GCC Sub Clause 39.1 (PW3); Sub Clause 40.1 (PW5) of the above mentioned Contract Agreement, this is to notify you that the following precedent conditions have been duly fulfilled:

(i) the Contract Agreement has been signed;

(ii) the possession of the Site has been given; and

(iii) the advance payment has been made *(delete if not appropriate).*

You are therefore requested to:

1. Commence execution of the Works, in accordance with GCC Sub Clause 1.1(w)(PW2); Sub Clause 1.1(nn)(PW3);Sub Clause 1.1(oo)(PW3) within *(specify date);*
2. Submit Insurance Policy Documents, in accordance with GCC Sub Clause 38.2(PW3); Sub Clause 37.2(PW5) within *(specify date) – applicable only for Pw3 and Pw5*
3. Submit Program of Works, in accordance with GCC Sub Clause 12.1(PW2); Sub Clause 41.1(PW3); Sub Clause 42.1 (PW5), within *(specify date)*

Signed by:

(name of authorized Project Manager)

Date:

FORM 10: REVISED WORK PROGRAM FORM 3/8

Name of the Work: ___________________ **Name of Upazila:**___________________ **Name o Zilla:** __________________

Start Day: ____________________ **End Day:** ____________________**Total working Days:**_______________

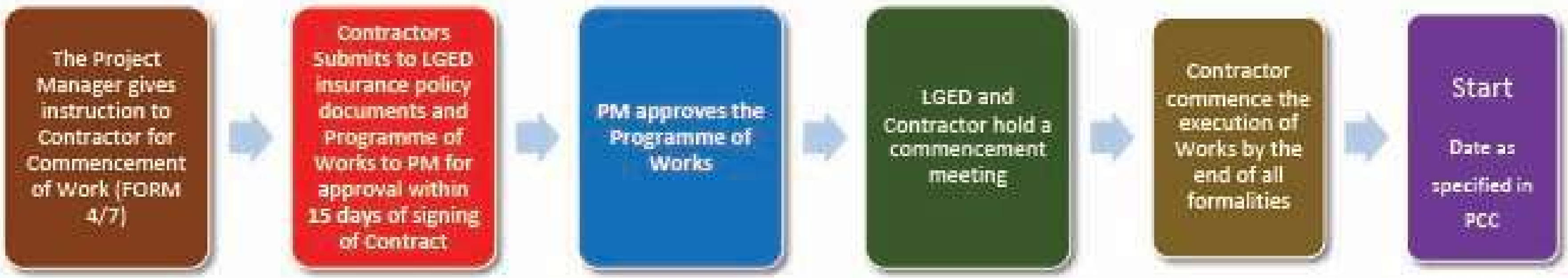
Sl No.	Description		Days	January 2020				February 2020				March2020				April 2020				May 2020				June 2020			
	Work component	Activities		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1	Site Possession																										
2	Protection Work	M. Testing																									
		M. Mobilization																									
		Work Execution																									
3	Earth Work																										
4	Surfacing Damage Repair	M. Testing																									
		M. Mobilization																									
		Work Execution																									
5	Surfacing Work	M. Testing																									
		M. Mobilization																									
		Work Execution																									
6	Work Completion & Site Hand Over																										

Material Testing

Material Mobilization ______________________ **Checked by:** ________________________**Approved by:** ___________________

Work Execution **Signature of the Contractor**

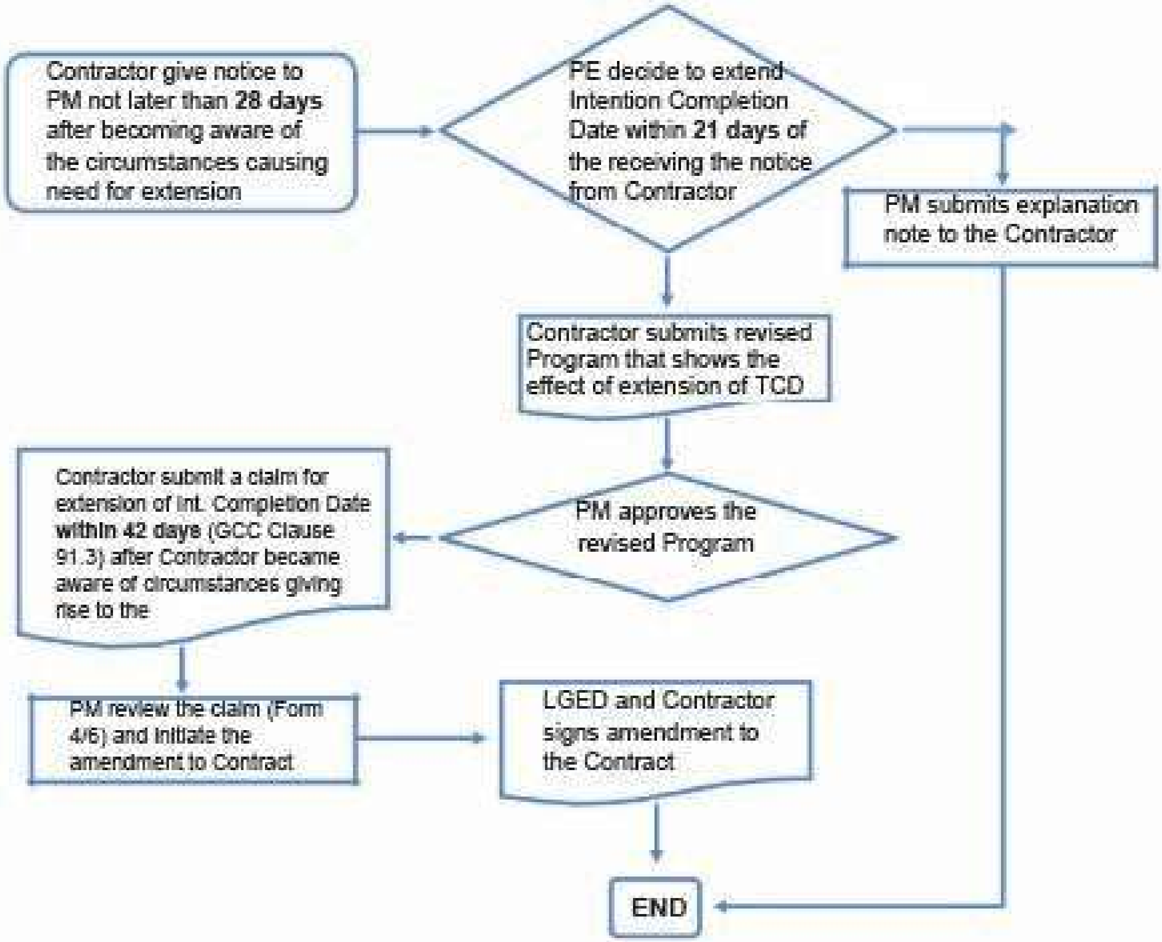
FLOW CHART 1: COMMENCEMENT OF WORK FLOW CHART 3/1



Notes:

1. *The Project Manager will give instruction to Contractor for Commencement of work after the following conditions have been duly fulfilled:*
   - *Contract Agreement has been signed;*
   - *Contractor received advance payment (when applicable) and*
   - *Possession of Site is given to the Contractor*
2. *Project Manager should be proactive and liaise with Contractor after giving instruction to prevent potential delays*
3. *If Contractor does not commence the Works as per instruction, the Project Manager should submit a warning letter to Contracto*

FLOW CHART 2: EXTENSION OF INTENDED COMPLETION DATE FLOW CHART 3/2



Note:

1. PE *may extend the Intention Completion Date by 20% of the contract time.*
2. *The approval of HOPE is required for extension of more 20% of contracted time*
3. *According to GCC Clause 21 (PW2), Clause 67 (PW3) and Clause 71 (PW5) the following are considered as compensation events, based on which Contractor can claim the extension of Intended Completion Date.*

a) LGED does not give Contractor access to the site b) LGED modified the schedule of other Contractors c) PE/PM orders delay or does not issue instructions required for executions of Works d) The PE/PM unreasonably does not approve subcontract to be let e) It is assessed that ground conditions are more adverse and they can cause delays or extra costs to the Contractor f) The advance payment is delayed.	g) The effect on Contractor of any LGED risks h) E/PM unreasonably delay in issuing a Completion Certificate i) The occurrence of Force Majeure as defined in GCC j) Other Contractors, public authorities, utilities or PE/PM cause delays k) PE/PM instruct Contractor to carry out additional tests resulting in finding no defects l) Any other compensation event stipulated in contract

4. SUPERVISION OF BRIDGE CONSTRUCTION

4.1 Site General Issues

4.1.1 Submital:

A submittal is the act of presenting something for review or approval, or the thing that is submitted. In construction, a submittal is the process of submitting documents, samples, or materials to the project owner or design professional.

Purpose of submittals

- To ensure that the proposed materials meet the project's requirements, codes, standards, and design specifications
- To ensure that the proposed items meet the project's quality control standards.

What is included in a submittal

- Shop drawings
- Material samples
- Test reports
- Certificates
- Product data sheets
- Any other supporting information requested

Who submits submittals

- contractors, suppliers, and vendors

When are submittals required.

- Submittal requirements are usually specified in the contract documents
- Regulatory or certification requirements may determine when to start the submittals process

Example of a bridge construction submittal:

- A contractor submitting detailed shop drawings for the bridge deck design, including reinforcement details, concrete mix specifications, and anticipated construction procedures, to the engineer for approval before pouring the deck concrete.

4.1.2 Work Plan:

The Work plan is a graphical presentation of a project/scheme showing proposed starting and completion times of each activities of the project/scheme. The contractor responsibilities 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 to also provide in the work plan. The main purpose 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

4.1.3 As-built Drawing:

During the construction phase of a project, it's important to note what changes contractors have made to the initial project drawing and specifications. Contractors can reference as-built drawings when adding updates and renovations to the project in the future. Learning about as-built drawings can help you properly record any changes that construction workers have applied and the dates they made these changes.

What is an as-built drawing

An as-built drawing is a drawing that the designer, engineer or contractor of a construction project creates after successfully completing a project. Construction workers typically compare the as-built drawing to the original drawings and the specifications they made at the start of the project. Project managers typically review as-built drawings to examine all the changes made to the specifications during the construction phase of the project. As-built drawings also display the geometry of the work completed and allow you to track and record changes to the project throughout each stage. As a contractor, you can also save your as-built drawings and present them during interviews. As-built drawings may make you look more professional and allow you to demonstrate how successful and well-made your previous work is. This can be a great way to impress project managers and showcase your skills among other contractors

What to include in as-built drawings

The main elements included in an as-built drawing are:

- Shop drawing changes
- Extra works
- Field changes
- Design changes
- Modifications
- Labels and dates
- Locations and dimensions

Why are as-built drawings important?

An as-built drawing provides a complete history of every change and update made to a project, allowing teams to reference this document when they need to apply changes, repairs or renovations. Contractors can see what previous employees built, which materials they used and how long ago they constructed it. This helps the contractor save time because they don't need to test the structure to determine its existing conditions. Instead, the as-built drawing informs them of the conditions so that they can immediately begin adding their renovations or enhancements. If they must later fix a finished structure, the facilities team can also reference the as-built drawing to review the specifications and materials that make up the project. This helps them identify any broken parts of the structure and repair them efficiently, which may save time and costs.

Who uses as-built drawings

Usually, the contractors, architects and designers create and use as-built drawings. The person who creates the original drawing and design for the project typically creates the as-built drawing as well, since they're the most familiar with the specifications. They're also a part of the construction process, so they usually direct and record the changes as they occur. When the construction workers finish the project and the contractor, architect or designer makes the as-built drawing, they submit it to the project manager for review. The project manager ensures the final drawing meets all the client's requirements and notes any differences from the original specifications. After reviewing the as-built drawing, the project manager submits it to the client for their final approval.

How to use an as-built drawing

As-built drawings can benefit many employees involved in the **construction phase** of a project. You can follow these steps to use an at-built drawing properly for your next construction project:

1. Reference the original specifications

To effectively document your changes, first review the specifications listed in the original project's drawing. This can make it easier to compare the original drawing with the final as-built drawing. It's helpful to take the physical copy of the specifications and use them to document changes made throughout the construction process. You can also take a picture of the specifications on your phone and use the photo as a reference when crafting the as-built drawing.

2. Document any changes made

As the construction process occurs, regularly document any changes you instruct construction workers and subcontractors to make. Write these changes down as soon as employees make them, and include the date next to each change. You use these documented changes later as a guide when creating your as-built drawing, so make sure you're taking clear notes.

3. Create a clean and labeled drawing

Once you complete the project, you can begin creating your as-built drawing. A wide variety of employees involved in the project are likely to view your drawing, so it's important to craft a clean and labeled drawing that's easy for you and other readers to understand. You can do this by using elements like a format of changes logged, a color scale and a drawing scale. This provides a clean, consistent and professional look you can show the project manager and display in your portfolio for future construction jobs.

4. Use software tools to build it

Contractors, designers or architects can use pen and paper to create as-built drawings, but there are also software systems available to help you craft them. Using these tools can help you save time and make it easier to email and submit your drawing to project managers.

When project managers receive the as-built drawing digitally, they can forward it to clients for their review and approval, which improves efficiencies for all project members. You can also include the digital version of your as-built drawing in a digital portfolio for hiring managers to view more easily.

5. Save and review the drawing

Once you've completed the as-built drawing, you can save it in a file for future reference. Contractors can locate it if they want to better understand what materials you used for the structure and review additional details about the construction process. They can also review the drawing years later if they need to add updates, enhancements or renovations to the project. This makes it easier for them to determine what tools, equipment and materials they need to construct the structure successfully.

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4.1.4 Shop drawing:

Shop drawings, also known as 'technical drawings' or 'fabrication drawings', are detailed plans created by contractors, manufacturers, or fabricators to illustrate how specific components will be manufactured, assembled, and installed as part of a construction project. They serve as a guide for producing key project elements such as structural steel, pre-cast concrete, windows, elevators, and millwork.

What's in a shop drawing?

Shop drawings include detailed specifications, dimensions, materials, fabrication methods, and installation instructions to ensure each component fits the overall design. They also show how parts connect, comply with building codes, and may feature different views such as section, detail, and elevation perspectives. Additionally, shop drawings often include schedules, diagrams, illustrations, brochures, and sample submittals to provide further clarity.

Here is a more detailed breakdown of what's included in a a shop drawing:

- **Dimensions** – Precise measurements for fabrication and installation.
- **Materials** – Specifications for materials, finishes, and coatings.
- **Fabrication details** – Instructions on how components are manufactured or assembled.
- **Installation instructions** – Guidance on how elements should be placed or secured.
- **Connections and joints** – Details on how parts fit and interact with other elements.
- **Compliance information** – Notes on building codes, regulations, and standards.
- **Schedules, diagrams, and illustrations** – Visual representations of the design and construction process.
- **Brochures and sample submittals** – Supporting documents that provide additional product details.

They may also feature different views to clarify design intent, such as:

- **Section view** – Shows phases of construction and how elements connect.
- **Detail view** – Highlights small but crucial design details.
- **Elevation view** – Provides a straight-on perspective of the component.

Importance of Shop Drawings

Shop drawings are crucial in the construction and manufacturing industries for several reasons. Here are some key aspects highlighting their importance:

- **Detailed Representation:** Shop drawings provide a detailed representation of the design and specifications of a construction project or a manufactured product. They offer a more granular view compared to the general plans and drawings, showing specific dimensions, materials, and construction details.

- **Communication and Coordination:** Shop drawings serve as a means of communication between different parties involved in a project, such as architects, engineers, contractors, and fabricators. They help in coordinating various aspects of the project and ensure that everyone is on the same page regarding the design intent and requirements.
- **Verification of Design Intent:** Shop drawings allow for a thorough review and verification of the design intent. They help identify any discrepancies or issues that may arise during the construction or manufacturing process, allowing for corrections before work begins.
- **Fabrication Guidance:** For manufacturing projects, shop drawings are essential as they provide detailed guidance for fabricators. These drawings include information about materials, dimensions, tolerances, and assembly instructions, ensuring that the final product matches the design specifications.
- **Quality Control:** Shop drawings play a vital role in quality control by serving as a reference for the expected quality and standards of the final product. They help identify any deviations from the original design and ensure that the finished work meets the required standards and specifications.
- **Regulatory Compliance:** Shop drawings are often required to comply with local building codes, regulations, and industry standards. They demonstrate that the proposed construction or manufacturing methods meet the necessary safety and quality requirements.
- **Clash Detection:** In construction projects, shop drawings are used for clash detection. This involves identifying and resolving any conflicts or clashes between different building components, systems, or installations before they become issues during construction.

4.1.5 Taking over Possession of Site:

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

4.1.6 Mobilization:

The work of mobilization shall consist of carrying out of the following listed action together with all other requirement of the contract with regard to commencing the execution of the work by the contractor at his own cost.

i) Procurement, assembly, repair and make to running condition of all the contractor-owned constructional plant and equipment by the contractor convenient to him at any site other than the actual place of construction.

ii) Transportation of contractor-owned constructional plant, equipment and material from the storage site as mentioned above in a to be place of construction.

iii) Assembling and installation of all items of constructional plants, equipment, etc. required for the execution of the work.

iv) Receiving all constructional plants, equipment and materials to be furnished by the Employer, if any, and collect and transport those to the work site. All materials shall be properly stored, inventoried and protected until used in to the work and all plans and equipment shall be tested and made ready for use.

v) Construction of a suitable site office building or shed for storage of materials and equipment, workshop, other operational building and First-Aid center attended by the competent Medical Assistants.

vi) Maintenance of all temporary roads, fences and sanitary facilities, keep all areas used by the contractor clean, neat, well-kept and in good repair and provide proper drainage to protect the area from surface run-off and flooding.

vii) Provide all the required electric power, water supply and other utility connections to temporary installation at the site as may be necessary for the expectation of the work,

4.1.7 Site Facilities:

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

i. Temporary stores (including warehouse for cement and other perishable materials) warehouse and workshop.

ii. Temporary building for office accommodation for the Contractor's staff

iii. Living accommodation for staff.

iv. Adequate number of toilets necessary for all persons engaged for the work with separate arrangement for women. All sewage from toilet shall be disposed of by means of septic tank and soak pit or by some other acceptable disposal system.

v. To keep all sanitary facilities clean and their frequent disinfecting.

vi. Fencing, lighting and security

4.1.8 Traffic Management:

From the date of commencement of the contract to the date of issue of certificate of completion for the work whole of the work as provided in the contract, the contractor shall at all-time bear the full technical and statutory responsibility in maintaining the public and vehicular access along the existing roads, rivers and canals.

The contractor shall so conduct his operations as to offer the least possible obstruction and inconvenience to the public.

Areas of roadway designed in the contractor's Working plans for the use of traffic shall not be obstructed or used in any way by the contractor or his suppliers or sub-contractors. Materials dumped or contractor's equipment parked in any public roadway area shall be promptly removed by the contractor at the direction of the Engineer.

At least 30 days before commencing work, the contractor shall submit to the Engineer his proposals for the maintenance of traffic including working Drawings to traffic arrangements, showing all detours, temporary roads, temporary bridges, necessary barricades, and warning. The contractor shall provide and maintain all detours, temporary roads, temporary bridges, necessary barricades, warning lights and guide signs as well as other equipment at all hours during the day and night throughout the period of construction.

The passage of traffic in one-way operation shall be controlled by the contractor either manually by posting flagmen or using signals.

Within the limits of the site all sections of existing carriageway, shoulder and sidetracks which are being used by traffic shall be maintained in a safe and trafficable condition by the contractor during the period of the contract. Potholes, cracks washouts and pavement defects shall be promptly repaired to a safe condition.

The contractor shall take care that the construction equipment and vehicles do not damage weak bridges on adjacent sections of road. Weak bridges required to carry loads in excess of their apparent capacity shall be propped or otherwise strengthened. The contractor shall be responsible for the replacement, at his own cost, of weak bridges damaged by his overloaded vehicles, flood damage or other causes imitated by his activities and will have no claim on the Engineer for time lost or disruption of his work due to collapse of weak bridges. Which provides access to his work.

In the event of a bridge failure, which servers public access through his contract area the contractor will provide temporary bridging or a serviceable by-pass without delay and in no case more than 48 (forty eight) hours following the severance of access.

Barriers shall be used for closing of lanes or roads, the protection of workmen and guidance of vehicular traffic. The barriers shall be distinctly visible and be mounted with red lamp during all hours of darkness. These shall be strong and inviolable.

Immediately upon completion of the contract all temporary roads, temporary brides, barricades, signs and other equipment shall be completely removed

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:

- Contractor's Site Lay-out & Site Preparation
- Selection of Labor/Workers
- Facilities of Labor/Workers
- Health and Safety of Labor/Workers and staffs.
- Water and electricity
- Store and Stack yard for materials
- Availability of necessary equipment's 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 reports of materials
- Work plan/Bar chart and updating of progress in the bar chart
- Site meeting
- Construction progress meeting etc.

4.1.9 Sign Board:

The Contractor shall supply, erect and maintain in good condition at least two identification Signboards of sizes to be specified by the Engineer to be fixed one at each end of the Work at a place clearly visible to the public. The Signboards shall be mounted on steel pipe frames with the required sizes at a height 2m above the ground and shall be sufficiently strong to withstand the wind forces. The boars shall be fabricated from steel angle and plated and painted with suitable colours and written in English and / or Bengali as per direction of the Engineer

Each board shall display:

- ➢ The name of the Project
- ➢ The name of the Work
- ➢ The name of the Employer
- ➢ Other particulars, which will be asked by the Engineer

4.1.10: Tools and Equipment:

Heavy Machinery

1. **Excavators**: For digging foundations and trenches.
2. **Cranes**: Essential for lifting heavy materials, such as beams and girders.
3. **Bulldozers**: Used for grading and clearing the construction site.
4. **Dump Trucks**: For transporting materials like soil, gravel, and concrete.
5. **Concrete Mixers**: For mixing and pouring concrete.

Construction Tools

1. **Formwork**: Temporary structures to shape and support concrete until it hardens.
2. **Scaffolding**: Provides a platform for workers and materials at various heights.
3. **Rebar Benders and Cutters**: Tools for shaping and cutting reinforcing bars.
4. **Leveling Tools**: Such as laser levels and spirit levels to ensure proper alignment.
5. **Measuring Tools**: Tape measures, plumb bobs, and surveying equipment.

Safety Equipment

1. **Personal Protective Equipment (PPE)**: Hard hats, gloves, safety glasses, and reflective vests.
2. **Fall Protection Systems**: Harnesses and guardrails for workers at heights.

Specialized Equipment

1. **Piling Rigs**: For driving piles into the ground to provide foundation support.
2. **Bridge Launching Equipment**: For moving large bridge sections into place.
3. **Post Tensioning Equipment**: Used in prestressed concrete bridges to apply tension to cables.

Surveying Equipment

1. **Total Stations**: For precise measurements and layout of the bridge.
2. **GPS Surveying Equipment**: For accurate positioning and alignment.

Miscellaneous Tools

1. **Welding Equipment**: For joining metal components.
2. **Concrete Vibrators**: To eliminate air bubbles in poured concrete.
3. **Hydraulic Jacks**: For lifting and positioning heavy components.

4.1.11 Demolition & Removal of Existing Structure etc.

Danger sign shall be posted round the property. All entrances shall be barricaded or manned. Warning lights shall be placed above all barricades during night and dark hours. Watchmen shall be provided to prevent unauthorized entry of the public in the danger zone. All utility lines shall be disconnected upon the approval of the relevant Authorities. Temporary service connection for the demolition work shall be taken separately.

Worker men shall be provided with all necessary safety appliances prior to the start of work. Safety precautions for fire shall be provided and site shall be thoroughly cleaned of combustible materials.

4.2 Site Supervision Issue

- **Site Supervision**

Supervision is a team, 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 mistakes 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 supervisions 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 advice from the sub-ordinate
- Create congenial environment to develop good working relation among all staffs
- Provide instant decision on complex situation and work.

- **Tools for Site Supervision**

A contract is made between Implementing agency and Contractor for the implementation of the scheme. Under this contract, the contractor implement the scheme and technical staff of implementing agency (LGED/Pourashava) 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

- **Guidelines for Construction Supervisors**

Following are guidelines that apply to duties and responsibilities of the construction supervisors/ Field Inspectors:

i. Know the drawing, design and specifications, and enforce them
ii. Know the specific instructions given by the superiors
iii. When relieving another Inspector, check on the status of work and any special instructions
iv. Report promptly to the superior any conditions that differ from those in project plans, designs, drawings and specifications.
v. Report all unsafe practices to the superiors and advise immediately of any accidents
vi. If work is not being performed in accordance with plans/ specifications, advise the Contractor's superintendent and note this in the Site Order Book. If the work is not immediately corrected, or if there is a disagreement, consult with the superior.
vii. Make an accurate, comprehensive record of all work inspected
viii. Maintain a courteous and tactful attitude, but never become complacent in inspection duties
ix. Consult with the superior if a question arises that you cannot answer

- **Preparation for Site Supervision**

Supervisor must be thoroughly familiar with Projects plans, specifications, Drawing-design and Construction methods to be used.

To perform effectively, the Supervisor must also be familiar with other contract documents, especially the contract General Provisions, Supplemental Provision and Contract General Requirements (sometimes titled "Special Condition"). O not assume that any documents remain unchanged and are applicable from one job to next. Any questions concerning contract documents should be referred to the Project Manager.

- **Understanding of Specifications/Items of Work:** To perform effectively, the Supervisor must have clear understanding about each item of work described in the LGED Rate Schedule. Any scheme may have 30 to 40 items of works. It is the responsibility of field supervisory staff to complete work as pas drawing-design and specifications.
- **Understanding of Drawing-Design:** Drawing are a part of the information prepared by the design team in order to provide important instructions regarding the proposed bridge and how it is to be constructed. These drawing usually consist of a set that includes plan., Section, Elevations and Structural details etc. They are included in the construction contract and tender documents, which makes them a vitally important part if the agreement between the construction company/contractor and the client.

For ease of understanding, we can divide these drawing into the following categories:

Architectural Drawing: Site plan, Bridge Top plans, Sections and Elevations.

Structural Drawing: Structural plans, Detail drawing of specific parts (Bridge Deck details, Girder details, Bridge Railing details, foundation details etc.)

Mechanical Drawing: Include information on mechanical work i.e. Expansion joint, Bearing, Seismic Device, electrical installations etc.

Site Plan: "Plan" refers to the top view if an object, and so a Site Plan is essentially a map that shows the extent of the proposed site. The is created after a careful and thorough analysis of the proposed area for construction and the new construction is marked on it, this provides the contractor with the exact dimensions, access point, greenery, existing physical feature, and other details of the site. The neighboring context is also included in the site plan as it might the impact the functionality of the neighboring structure.

Table: List of Drawing for Construction of Bridge/Culvert:

The standard bridge drawing shall contain followings:

1. General Notes for RCC components 2. Guide line for Cast-in-site bored piles 3. Sub-soil Bore log 4. Topographical Survey and Bridge Lay-out Plan 5. General Plan and Elevation 6. Bridge Deck Profile 7. Pile Lay-out Plan 8. Details of Bridge Deck 9. Details of RC Girders (Long & Cross sections) 10. Details of Pre-stressed Concrete Girders 11. Details of Abutments 12. Details of Abutment Piles 13. Details of Pier	14. Details of Pier Pile 15. Details of Railing 16. Details of Bearing on abutment and Pier 17. Expansion Joint 18. Protective Works around Abutment & Approach road 19. Details of Guard Post 20. Approach road cross-section & Alignment plan 21. Electrical installation & circuit diagram 22. Long & cross drain of Approach road 23. Details of underpass (if needed) 24. Drawing for assumed construction sequence 25. Camber drawing

- **Understanding of General Specification of drawings:** Details drawings of bridges, culverts, 0or buildings have a page at t6he beginning where the "general specifications" are presented at a glance. Field supervisory personnel must follow this specification very strictly

4.3 Sequence of Bridge Construction

1. Bridge site selection
2. Bridge Lay-out Setting
3. Bridge Foundation Lay-out setting
4. Foundation Excavation up-to top of pile cap.
5. Bridge Pile lay-out setting
6. Installation of Pile
7. Foundation excavation and breaking of pile head
8. Preparation and casting of pile cap.
9. Preparation and casting of Abutment/Pier stem
10. Preparation and casting of pier head
11. Preparation and casting of Bridge Girder
12. Preparation and casting of Bridge deck slab

4.4 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 streams/ 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. Others a square crossing as far as practicable

Before giving lay-out in the practical situation, it is convenient to plot a map of the proposed bridge location and superimposed 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 center 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.

4.5 Job Layout including Diversion

Following issues will be considered for a bridge layout:

- Fix the TBM which will be marked in a permanent structure like building, Mosque, permanent Electrical post or a brick pillar.
- Centre line of flow of river & alignment of access road & approach road will be perpendicular.
- Follow the setting procedure & check point as per design.
- As per approved design plot the pile location of abutment & pier.
- With respect to TBM & approved design the RL of pile top & pile cap top will be fix.
- The horizontal and vertical alignments of bridge will be fix as per design of BIWTA guideline.
- Plot the abutment base, pier base as per approved design.
- Easy access and safety during construction
- Determine the profile grade at the outside face of the exterior soffit or girder at each side of the bridge and super elevation as per approved design.

It is a temporary earth made road with pipe/belly constructed across a narrow canal/river/khal/water. There are Two type of Diversion in LGED practice:

a) Pedestrian diversion
b) All traffic diversion

- The work shall be consist of arranged earth by furnishing, placing body to divert the traffic/public movement in an alternative way.
- The temporary diversion road of minimum 4.8m width

• Compacting and shaping with suitable fill in accordance with the specification. The work of this temporary road shall be carried out with adequate height so that it will not be submerged during monsoon.

• In constructing the diversion palisading wall shall be erected on both sides with bullah/bamboo post/pins walling with double Tarja mat or bitumen drum sheets forming an enclosed area for filling earth.

• The contractor filled the earth with layer by layer compaction when necessary. To facilate the flowing water through the diversion different size of RCC pipe/Belly of required size, nos and length shall be provided as per site requirement.

The earthen diversion shall be maintained in proper condition by the contractor until the completion of bridge. The temporary diversion shall be removed on completion of the bridge. The removal of this diversion shall be effected in such a manner as not to disturb the bridge work.

Figure: Road Diversion

4.6 Bridge Layout Setting using Total Station

Before giving layout 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 beeches. These should also be located in the map. Such map also helpful to locate areas over which excavation materials will be dumped and construction materials are to be stored. For all structure a main reference line should be chosen. All other distance and offsets are to be measures from this main reference line. Similarly a permanent bench mark should be installed. All other levels to be established from the permanent bench mark,

The layout of the construction site shall be carefully planned keeping in view the various requirements to construction activities and the specific constraint in terms of its size, shape, topography, traffic and other restrictions in public interest. The site layout shall take into considerations the following factors:

a) Easy access and exit, with proper parking of vehicle and equipment during construction
b) Properly located material stores for easy handling and storage
c) Adequate stack areas for bulk construction materials
d) Optimum location of plants and equipment (batching plants etc.)

e) Layout of temporary services (water, power, power suppression unit hoists, cranes, elevators etc.)
f) Adequate yard lighting and lighting for night shifts
g) Temporary building, site office and shelter for workers with use of non-combustible materials as per as possible including emergency medical aids
h) Roads for vehicular movement with effective drainage plan
i) Construction safety with emergency access and evacuations and security measures.
j) Fabrication yard for reinforcement assembly, concrete casting and shuttering materials and
k) Fencing barricades and signage

4.7 Bridge Approach Layout

A bridge's approach layout includes the design of the part of the bridge that connects the roadway to the bridge itself. This includes the approach slab, which smooths the transition between the road and the bridge.

There are many factors that influence the layout of the horizontal and vertical alignment. In general, the alignment needs to accommodate environmental, safety and right-of-way concerns while keeping a constant eye out for constructability issues.

Before You Start You will need: 1) Survey 2) Approx. Length of Project 3) Horizontal and Vertical Limitations

Environment it is necessary to gage the environmental impact of the new roadway. The most common impact to gage is where toes of slope may fall in wetlands. Additionally, toes of slope need to be evaluated against historic preservation concerns.

Safety The location and radii of curves on an alignment have an impact on the overall safety of the project. These affect sight distance and design speed. N Refer to the Urban and Arterial Highway Design Guide, Bridge Design Guide and AASHTO Policy on Geometric Design of Highways and Streets for more information.

Right-Of-Way Alignments are often affected by ROW concerns. These may include impacts on private landowner's lawns, structures, trees, and drainage ways. Utilities can also impact ROW concerns.

Constructability Many factors affect the constructability of an alignment. Alignments need to be designed to facilitate maintenance of traffic during the project. Consideration should be given to Staged Construction, temporary structures, on-site detours, etc.

Approach slab

- The approach slab spans the embankment behind the abutment.
- It's designed to provide a smooth transition between the road and the bridge.
- The approach slab should be at least 3.5 meters long and 300 millimeters thick.
- For moderate conditions, the approach slab should be made of M25 concrete, and for severe conditions, it should be made of M30 concrete.

Bridge approach layout

- The bridge layout includes the geometric and substructure placement relative to the construction baseline.

- The bridge layout forms the basis for developing the substructure layout.
- The bridge and substructure layouts should have common features and parameters.

Bridge approach design

- The approach layout includes determining the location of bridge supports, abutment location, and points of minimum vertical clearance.

4.8 Bridge Pile Layout Setting using Total Station

4.8.1 Prepare the Equipment

Before you start using a total station, you need to make sure that it is properly set up and calibrated. You will need a tripod, a prism pole, a prism, and a data collector. You should also have a site plan that shows the coordinates and dimensions of the layout. First, mount the total station on the tripod and level it using the circular and plate bubbles. Then, connect the data collector to the total station using a cable or Bluetooth. Finally, check the battery level, the settings, and the calibration of the instrument.

4.8.2 Establish a reference point:

A reference point is a fixed and known location on the site that can use to orient the total station and measure other points. You can use an existing point, such as a corner of a building or a survey marker, or create a new one by driving a stake or a nail into the ground. You should record the coordinates and elevation of the reference point on the data collector or a note book, then, place the prism pole on the reference point and align the prim with the total station.

4.8.3 Set up the back sight

A back sight is another point on the site that you can use to verify the accuracy and direction of the total station. It should be at least 30 meters away from the reference point and have a clear line of sight. You can also use an existing or a new point as a back sight. Place the prism pole on the back sight and align the prism with the total station. Then, use the data collector to enter the coordinates and elevation of the back sight and calculated the azimuth and distance between the reference point and the back sight,

4.8.4 Perform the layout

Now that you have established the reference point and the back sight, you can start laying out the points of the design on the site. You can use the data collector to enter the coordinates and elevation of each point, or select them from a preloaded file. The total station will then guide you to the location of each point by displaying the horizontal and vertical angles and the distance on the screen. You can also use the laser pointer or the audible tone to help you locate the point. Once you reach the point, you can mark it on the ground with a stake, a nail or a spray paint.

4.8.5 Check the accuracy

After you have laid out all the points, you should check the accuracy of your work by measuring some of them again with the total station. You can compare the measured coordinates and elevation with the entered or preloaded ones and see if there are any discrepancies. If there are, you should adjusted the total station setting or the layout marks accordingly. You should also check the accuracy of the reference point and the Bach sight periodically by measuring them again and making sure they match the initial values.

4.8.6 Record the data

The last step is to record the data of your layout on the data collector or a notebook you should include the coordinates, elevation, azimuth and distance of each point, as well as the reference point and the back sight. You should also note any changes or corrections that you made during the layout process. You can then transfer the data to a computer or a cloud storage for further analysis or documentation. You should also store the total station and the accessories in a safe and dry place when you are done.

4.9 Excavation & Shoring

4.9.1 Excavation:

The contractor shall notify the Engineer before commencing excavation of the foundation trenches. So that the cross-section, elevation and measurement of the undisturbed ground mat be taken. The natural ground adjacent to the structure shall not be disturbed without taking any permission from the Engineer.

Trenches and foundation pits for structure shall be excavated to the lines. Grades and elevation as shown on the drawing or as described by the Engineer. The elevations of the bottom of the foundation shown on the Drawing are approximate only and the Engineer may order such changes as deemed necessary to provide a secured foundation.

Where unstable soil is encountered at the bed level, it should be brought to the notice of Engineer and all such unstable soil shall be removed as directed and replaced with suitable materials to provide adequate support for the structure.

On acceptance of the martials forming the bottom of any excavation by the Engineer subsequently becoming unacceptance to him/her due to exposure to weather condition or due to flooding of have become puddled. Soft or loose during the work process, the contractor shall remove such damaged softened, or loose materials and excavate additional. Such further excavation shall be held as excess excavation and the cost of the excess excavation and subsequent replacement with a suitable back-fill shall be at the expenses of the contractor.

Excavation shall be sufficiently large to provide necessary working space, shuttering and any other temporary works required during construction.

Boulders, roots and any other objectionable materials encountered in excavation, shall be removed. The excavated foundation shall be cleared of all loose materials and cut to a firm surface.

When the footing is to rest on the ground and not on piles, special care shall be taken not to disturb the bottom of the excavation and excavation to final grade shall be deferred until immediately before the footing is placed. If foundation fill material if required, it shall be placed and compacted in layers not more than 150mm thick or as directed by the Engineer. The dry density on compaction within 300mm below the top level shall not be less than 100% maximum dry density as determined in accordance with STP T4.5 (Standard Compaction)

In excavation foundation trenches, the last 150mm layer shall not be excavated until immediately before commencing the construction work except that the Engineer shall permit otherwise. Any damage to the work due to the contractor's shall be repaired at the expenses of the contractor.

The contractor shall be solely responsible for the safety and stability of the excavation and shall all protection supports, bracing, sheet piles shoring etc. as required. Shoring should be adequate to provide enough safety to all the adjacent structure and land.

Excavation materials, classified as suitable for fill, shall be stockpiled. Waste materials and suitable fill materials in excess of requirement shall be disposed of by the contractor outside the limit of the site.

No footing, bedding material or structure shall be placed on any foundation until the Engineer has inspected and approved the depth of excavation and the foundation materials.

4.9.2 Slope of Excavation

The depth band slope of excavation and ground water condition control the overall stability and movement of open excavations. The phenomenon is affected by soil type, depth of cut, side slope and or berm geometry, Ground water conditions and construction procedure. Where seepage is in control, the following slopes may provide stable cut:

Soil Type	Slope (V:H)
Wet clays and Silts	1:2
Dry Sand and gravel	1:1.75
Dry Clay	1:1
Moist Sand	1:1.25
Hard and Compacted Soil	1: 1.05

The above values are to be used as an approximate guide. These may vary depending on local conditions, seasons and duration of the construction as well as experience and judgement of the engineer in charge.

4.9.3 Excavation Shoring

Excavation below the foundation level of an adjacent structure usually to the necessary for supporting the structure temporary. The provision of temporary support is known as shoring. On many instances it is not possible to provide sloped excavation. This would require vertical supporting system to ensure stability of cuts this is also known as shoring. Timber is usually used as the shoring material. Figure below illustrates various methods of shoring.

4.9.4 Pumping and Bailing

The foundation shall be kept free from water at all times during the construction period. The ground water level shall be maintained at a minimum of 0.9m below the lowest designed excavation level.

Pumping and bailing from any foundation shall be done so as to preclude the possibility of the movement of water through any concrete being placed. No pumping or bailing will be permitted during the placing of concrete and for at least 24 hours thereafter, unless it is done from a suitable separated from the concrete work by a watertight wall or from well point.

The contractor shall be solely responsible and include in his rates all costs in designing the de-watering system, providing all equipment and accessories required for de-watering. The rates shall also include cost for transportation, famishing, installation, safe operation and maintaining of the system including operation, mechanics, the supply of power, fuel lubricant, spares repairing etc. throughout and the removal of the equipment at the end of the construction period under this contract. Excavation shall be as dry as possible prior to and during placing concrete. Concrete placing under water will only be permitted if indicated on the Drawings or approved by the Engineer.

4.10 Environmental & Social Safeguard Monitoring

Environmental and social Monitoring is an integral part of overall site supervision Environmental Management System (EMS) as it established how the project is performing against objectives and targets set in the Environmental Management plan (EMS) . A schedule and standards for monitoring and reporting Environmental and Social safeguards for a world Bank project has been shown in the Environmental and Social Monitoring/Inspection format in the following page,. The main purpose of Environmental and Social Monitoring is to

- Identify any negative impacts from construction activities
- Assess the effectiveness of control measure
- Demonstrate compliance with regulatory conditions and objectives and targets set in the EMP
- Identify if further control/corrective action is required

LGED	Field Inspection Checklist (Form-5) Check list for monitoring Environmental, Social & OHS safeguard	Date of Inspection	Page 1 of 2

Name of Visitor with designation:		Date of Visit
Upazila:	District:	Contract Package No.:
Name & Type of structure		Intervention:
Road Name:		Road ID: Structure ID:
Date of Commencement (Start) as per Contract:		Actual Date of Commencement:
Date of Completion as per Contract / Revised :		Up to date progress of work (Physical):_______________%
Name of the Contractor:		
A. Are the following documents available at site?		

	Y		N		N/A
1. Site Order Book.					

2. Environmental Screening List in standard Format.					
3. Social Screening List in Standard Format.					
4. EA (Environmental Assessment) Report for specific work.					
5. EMP (Environmental Management Plan) for specified work.					
6. CEMAP (Contractor's Environmental Management Action Plan					
7. Surface water Quality Test Report at start/Interim/Completion).					
8. Air Quality Test Report (at start/Interim/Completion).					
B. Environmental & Social Safe Guard Issues:					
1. Has earth cutting and filing of bridge approach road embankment been within the right of way?					
2. Has earth cutting and filing of bridge approach road embankment been disturbed of debris?					
3. Has waterway been obstructed within 150m up and down stream due to accumulation of debris?					
4. Has hazardous materials (Bitumen, Fuels Lubricants etc.) been stored over raised platform (not directly on the ground)?					
5. Has playground of the educational institutes been used as a stack yard or labor camp?					
6. Are dust Suppression Measures by spraying water being carried out at satisfactory?					
7. Are transportation of construction materials being carried in scheduled time (mainly at day time)?					
8. Is sound of Mechanical equipment/machinery being disturbed?					
9. Are construction and demolition (C&D) waste being disposed in specified places (not in water bodies, forest area etc.)?					
10. Has agricultural land been disturbed due to construction of labor camp?					
11. Has labor camp been constructed away from water bodies?					
12. Has tree cutting been carried out for any purpose (for construction of labor camp/material store yard etc.)?					
13. Has tree plantation been carried out to compensate tree cutting?					
14. Has Hot mix plants/Tar boiler been located at a safe distance from the nearest habitation/dense forest?					

15. Is construction material covered during transportation from source to site?					
C. Health & Safety Issues:					
1. Has Sanitation Facility been provided adequately to male and female workers separately?					
2. Has temporary campsite waste disposal facility been provided?					
3. Has source provided for supply of safe drinking water at labor campsite?					
4. Has source provided for supply of safe drinking water at work site?					
5. Has drainage Facility been provided at camp / work site?					
6. Is First Aid Box available at site?					
7. Is personal protective equipment (safety shoes, helmet, safety jacket etc.) properly provided to laborers considering Operational Health & Safety (OHS)?					
8. Has Sign Board been erected at site as per sample incorporating Environmental Issues (see sample of sign board in the reverse side)?					

Remarks and Recommendations:

Name & Signature with designation

Date:

5. SAFETY DURING BRIDGE CONSTRUCTION

5.1 Personnel Safety/Personal Protective Equipment (PPE) Plan

5.1.1 PPE Plan provide by Contractor

The Contractor shall provide the proper PPE Plan to protect all persons legitimately on site, and Safety Equipment and Materials to react special hazards.

Mandatory PPE

Mandatory PPE identified in below is specific to all persons in all Project managed areas.

- Hard Hat;
- Safety Footwear / Steel toed Boots.

Optional PPE

The following optional PPE is specific to all persons entering in the specific operation area.

- Eye Protection;
- Reflective Jacket;
- Gloves;
- Coveralls;
- Hearing Protection;
- Safety Harnesses;
- Respirators;
- Breathing Apparatus;
- Face Visors / Shields;
- High Visibility Vests.

Special Equipment

The Contractor shall provide other necessary special Safety equipment or materials to identify the core hazards as instructed by the Engineer.

- Test Equipment;
- Cable Location Detection Tools;
- Self-Contained Breathing Apparatus;
- Rescue Equipment.

The above specified equipment is minimum requirements. The Contractor shall provide all kinds of Safety Equipment to ensure Health and Safety in working areas.

5.1.2 Housekeeping, Sanitation and Hygiene Plan

The clean and tidy conditions of the construction site and all associated areas shall be ensured to minimize the potential accidents and incidents in workplace (e.g. trips, slips, fires and spills), and to avoid blockage of important emergency access.

Construction waste both hazardous and non-hazardous shall be properly collected and disposed daily to appropriate waste collection bins at the end of each day/shift. Flammable and combustible materials shall be properly stored in appropriate containers located in designated storage area. Spillages of oil, chemical, solvent or any other hazardous waste shall be clean up immediately and reported to the competent personnel.

th ineffective housekeeping, sanitation and hygiene measures during construction. This Plan applies to all construction activities and areas, including the construction site, workshops, warehouses, offices, camps, tank farm, roads and common areas.

This Housekeeping, Sanitation and Hygiene Plan shall be thoroughly communicated to all relevant personnel during all construction phases of the Project, and this Plan is strictly observed and complied with by the Contractor and its employees to ensure compliance with applicable laws, legislation, regulations and requirements of the GOB.

This Plan includes, but is not limited to, the following issues:

General Housekeeping and Site Cleanliness;

Accommodation;

Dust Control;

Waste Management;

Toilet and Washing Facilities;

Drainage facilities

Water Supply for drinking and other purposes.

5.1.3 Excavation Safety Plan

Excavation is an essential operation of the construction process. In the process of carrying out an excavation operation, it is often necessary to assess the ground condition when determining the type of shoring necessary as well as the detection of buried services to prevent injury to person and damage to services.

This excavation safe operating plan outlines the required safety and prevention measures necessary in the performance of an excavation operation. Safety and prevention measures discuss are:

5.1.4 Excavation Safety Measures

5.1.4.1 Access, Ingress and Egress

Access to, from and over excavation area and pit shall be adequately considered and provided for the many types of vehicles:

Sufficient number of Ingress to and Egress from an excavation pit shall be strategically provided.

5.1.4.2 Storage and Placement

Spoils shall be immediately transported to the stockpile or dumping ground;

Materials such as spoils, shoring materials, tools and equipment shall be stored at a distance of least 1 meter away from the edge of an excavation;

Excavation plant or machinery shall not be operated close to an excavation pit unless effective shoring system has been provided;

Other construction plants including mobile crane shall position at least 2 meters away from the edge of an excavation. In addition to the above, steel plate of sufficient thickness shall be used to spread the load of the plant imposed on the shoring.

5.1.4.3 Barrier and Stop Block

Effective guarding shall be erected and installed on excavations with depth of more than 2 meters;

Warning lights, sturdy guarding (water barriers) and warning signage shall be erected on excavation (regardless of depth of excavation) located adjacent to public access and vehicular access ways;

Watchman shall be provided for deep excavation when operators are not able to see the base of excavation. Watchman plays an important role when both top and bottom excavation is being carried out concurrently.

5.1.4.4 Lighting

Excavation pit adjacent to public access shall be adequately illuminated;
Adequate lighting shall be provided for deep excavation.

5.1.5 Support System

When determining the support system for an excavation, following factors shall be considered:
Type of excavation (Mechanical or Manual).
Ground condition (Soft, Hard, Clay, Rock etc.)
Ground water condition.
Depends upon the above mentioned factors, the Contractor shall decide the supporting system in both of shoring or slope system. This support system shall be designed by a qualified engineer.

5.1.6 Buried Service

Buried services, existing or newly installed, are a major concern for excavation operation in a construction site. Potential hazards include injury to person and damage to equipment, unanticipated public impact or loss and delay to work schedule. Common buried services found in a construction site are:
Water mains (Fire, Industrial and Common Services);
Electrical cables (High Voltage and Low Voltage, Permanent and Temporary);
Drainages and Sewers;
Fuel pipes (Oil, Gas and Chemical);
Communication and Optic Fiber cables (Telephone and Instrumentation).

5.1.6.1 Control Method

The Contractor shall be responsible for detecting, identifying and marking of all buried services on work area affected by the excavation operation.
The Contractor shall indicate and submit to the Engineer a copy of the updated utilities and services drawing;
Before the commencement of excavation work where buried services have been detected, trial pits shall be manually open to determine the exact location of the buried services, the depth where it is rested, types of protection provided and more importantly, the direction on the where the buried services lead;
During excavation, buried services shall be prominently marked or peg for easy identification;
Regard all underground services as "live";
Manual excavation shall be employed until services are exposed and instruction given by Competent Person before work commences.

5.1.6.2 Inspection and Examination

The inspection items shall include the following:
Location of buried services prominently marked and protected;
Prevention measures such manual digging made to expose and determine exact location and depth of buried services;
Barrier erection of at least 2m away from known buried services;

Attendance of a full time supervisor during mechanical excavation;

Cable markers and concrete tiles are re-instated after excavation. Inspection shall be called before a trench is backfilled;

A trained and qualified person shall perform examination of the atmospheric condition continuously before and throughout the duration where work is being carried out inside deep and narrow excavation.

5.2 Preparation of Site Specific Traffic Management Plan

Thoroughly assess the construction site, identify potential traffic hazards, understand existing traffic patterns, and then design a plan that minimizes disruption to road users while ensuring safety for workers, using appropriate traffic control devices and signage, and clearly defining traffic flow management strategies based on the unique site conditions.

1. Site Assessment:

a) Traffic Volume and Pattern Analysis:

Study existing traffic volumes, peak hours, traffic flow directions, and key intersections around the construction site.

b) Roadway Conditions:

Evaluate road width, lane configuration, visibility, and any existing road hazards.

c) Pedestrian Access:

Identify pedestrian crossing points and potential conflicts with construction activities.

d) Site Access Points:

Determine the location of construction site access points and egress routes.

e) Potential Hazards:

Identify potential hazards like heavy vehicle movements, excavations, uneven surfaces, and areas with limited visibility.

2. Plan Objectives and Strategies:

a) Safety First: Prioritize worker and road user safety as the primary objective.

b) Minimize Disruption: Aim to minimize traffic congestion and delays for existing road users.

c) Traffic Flow Management: Design traffic flow strategies based on the site layout, including lane closures, diversions, one-way traffic, or temporary traffic signals if necessary.

d) Pedestrian Management: Plan pedestrian access routes and safety measures like designated crossing points and signage.

3. Traffic Control Device Selection:

a) Signage: Utilize appropriate warning signs, directional signs, and regulatory signs to inform drivers about construction activities and traffic changes.

b) Traffic Cones: Use cones to delineate traffic lanes, lane closures, and pedestrian areas.

c) Barricades: Employ barricades to block off hazardous areas and create clear boundaries.

d) Traffic Signals: Consider temporary traffic signals for complex intersections or lane closures.

e) Channelizing Devices: Use channelizing devices to guide traffic flow through designated areas.

4. Implementation and Monitoring:

a) Detailed Plan Documentation:

Create a comprehensive traffic management plan document outlining all traffic control measures, signage, and implementation procedures.

b) Stakeholder Consultation:

Consult with local authorities, residents, and businesses to address concerns and incorporate feedback.

c) Training and Supervision:

Ensure construction personnel are adequately trained in traffic management procedures and proper signage placement.

d) Regular Inspections:

Conduct regular site inspections to identify any issues with traffic control measures and make necessary adjustments.

Important Considerations:

e) Weather Conditions: Plan for potential impacts of weather on traffic management strategies.

e) Emergency Procedures: Develop procedures for handling unexpected incidents and traffic disruptions.

f) Accessibility Needs: Ensure that the traffic management plan considers the needs of pedestrians and people with disabilities.

5.3 Traffic Control and Management of Traffic

- The contractor shall at all-time maintain the traffic flow along the existing roads, rivers and canals. The Contractor shall provide and maintain all detours, temporary roads, temporary bridges, necessary barricades, warning lights and guide signs as well as other equipment at all hours during the day and-night throughout the period of construction. If there is drawing for "Traffic Control Plan" which may be provided by the project, the contractor shall follow that "Traffic Control Plan" drawing for all-time (Day & Night) maintain the traffic flow with safety.
- Upon completion of the work all temporary roads, temporary bridges, barricades, signs and other equipment shall be completely removed.

5.4 Environmental, Social, OHS and Traffic Safety Inspection Checklist:

A. Possible Environmental & Social Safe Guard Issues					
A1. Has earth cutting and filling of bridge approach road embankment been within the right of way?					
A2. Has earth cutting and filling of bridge approach road embankment been disturbed the crops?					

A3 Has water way been obstructed within 150m up and down stream due to accumulation of debris?					
A4. Has hazardous materials (Bitumen, Fuels, Lubricants etc.) been stored over raised platform (not directly on the ground?					
A5. Has playground of the educational institutes been used as a stack yard or labor camp?					
A6. Are dust Suppression Measures by spraying water being carried out at satisfactory level (at least 3 times daily)?					
A7. Are transportation of construction materials being carried in scheduled time (mainly at day time)?					
A8.Is sound of Mechanical equipment/machinery being disturbed?					
A9. Are construction and demolition (C&D) waste being disposed in specified places (not in water bodies, forest area etc.)?					
A10. Has agricultural land been disturbed due to construction of labor camp?					
A11. Has labor camp been constructed away from water bodies?					
A12.Has tree cutting been carried out for any purpose (for construction of labor camp/material store yard etc.)?					
A13. Has tree plantation been carried out to compensate tree cutting?					
A14. Has Hot mix plants/ Tar boiler located at a distance from the nearest habitation/dense forest?					
A15. Is construction material covered during transportation from source to site?					
A. Health & Safety Issues					
B1. Has Sanitation Facility been provided adequately to male and female workers separately>					
B2. Has temporary camp site waste disposal facility been provided?					
B3. Has source provided for supply of safe drinking water at labor camp site?					
B4. Has source provided for supply of safe drinking water at work site?					
B5. Has Drainage Facility been provided at camp/ work site?					
B6. Is First Aid Box Available at site?					
B7. Is personal protective equipment (safety shoes, helmet, safety jacket etc.)?					
B8. Has sign Board been erected at site as per sample incorporating Environmental Issues?					
B. Traffic safety Issues					
C1. Has safe diversion road been constructed?					
C2. Has safety Road Sign plate Been provided at correct location?					

C3. Has Directional Road Sign been provided correctly for use of diversion road?					
C4. Has traffic been maintain at all time for traffic management?					
C5. Is safety road sign plate visible at night also?					
C6. Have all suggestion, instructions incorporated in Site Order Book?					
C7. Has rectification been carried out as per suggestion in last inspection Report/Site Order book?					

5.5 Bridge Site Work Place Safety Issues

The contractor shall maintain control of the work site, all personal on the work sits and all equipment on the work site. The table below shows work palaces and tasks where accident/incidents occur frequently. Site specific safety measures are recommended to prevent such accident / incident in accordance with those recommendations the following checklist has been prepared which can be used by field Supervisors/Monitoring officers during their site visits.

Table: Workplace Safety Inspection Check List

SL No.	Workplace and Works Safety Safeguards Check point
1.	**Excavation and Shoring**
	a. Is Excavation and Shoring plan is available at site?
	b. Is Excavation and Shoring plan approved?
	c. Is Excavation area barricaded?
	d. Are excavated soil and other construction equipment kept at safe distance (at least 10'-0") from the edges of excavated area?
	e. Is Excavation and shoring plan/procedure/ risk shared with all the workers?
	f. Is excavation work going on under close supervision of Site Supervisor?
	g. Are appropriate PPE's used by all workers?
	h. Are the workers aware of excavation and shoring plan/procedure?
	i. Has rectification been carried out as per instruction of last visit?
	General safety Measures at Bridge sites
	a. Is the slogan "SAFETY FIRST" displayed at construction site?
	b. Is the Site clean and orderly condition?
	c. Is there a First Aid Box with necessary medicine?
	d. Is there enough oral saline for emergencies if the temperature is high?
	e. Is the Construction site clearly divided between workers and third party?
	f. Is there a system for preventing entry that prevents others such as children from entering easily?
	g. Are there safety signs as "Work in Progress", "Road Closed", "Alternative Road ahead" etc.?
	h. Is the work lay-out plan followed?
3.	Demolition/dismantling of Bridge
	a. Is there a demolition plan with demolition procedures?

	b. Has the demolition plan been approved?
	c. Are there safety signs such as "Risky Work in progress", "Road Closed", Movement is prohibited etc. ?
	d. Is the demolition area barricaded?
	e. Is the method and sequence of demolition process followed?
	f. Are there metal nets for protection against dumping of waste in rivers/canals?
	g. Are appropriate PPE's used by all workers?
	h. Has the local people been informed about demolition work before the work start?
4.	**Precautions against fall from height**
	a. Are fall arrest systems properly provided to workers?
	b. Using prefabricated frames for work ay height?
	c. Are trained/experienced workers employed to work at height?
	d. Are there any training arrangement for new workers to work at height?
5.	**Flying and Falling Object Prevention**
	a. Has protection against flying and falling objects been provided at an entrance location at the crossing point of external scaffolding?
	b. Are proper mesh nets fitted that are suitable for use?
	c. Using the damaged net?
	d. Are there any arrangement such as rolling up of net in consideration of an impact of strong wind?
	e. Are objects being dropped from a height of more than 3 meters?
6.	**Key measures For Works with heavy Construction Equipment**
	a. Are the following safety apparatus being checked regularly like headlight, Warning device, Top guard, Roll-over protective structure etc.?
	b. Has inspection of Machinery been done based on check list of machinery before commencing the work?
	c. Is Machinery not being used until maintenance is completed, when an abnormality is found?
	d. Is operational work being initialed after ensuring that no safety is mind for the site of use, work in/out and fall down?
	e. Are Construction equipment being selected with safety in mind for the site of use, work in/out and fall down?
	f. Are construction machine being operated by qualified personnel and person?
7.	**Scaffolding Installation/Construction**
	a. Is the construction/installation of scaffolding being planned taking into account loads that do not always act, such as wing loads, and loading objects etc.?
	b. Is timing of assembling and dismantling scaffolding being clarified?
	c. Are fall and fall resistance being adequately tested for single row scaffolding, narrow board single row scaffolding and special scaffolding?
	d. Are all scaffolding inspected upon erected and prior to use for any visible defects, missing platform or guard rails, loose parts etc.?
8.	**Welding**
	a. Is Frame of welding machine being earthed when implementing electric welding work?
	b. Is the earth connecting being confirmed certainly before using welding machine?

	c.	Is damaged of cover of wire being checked and repaired if damaged before welding work?
	d.	Are workers using proper PPE such as face shield, protective glove, apron etc.?
	e.	Are other workers instructed not to see arc with the unaided eye?
	f.	Is electrode holder being checked before working and stet to prescribed sack whenever work is stopped?
	g.	Is Automatic electric shock prevention device for AC arc welding machine being used?
	h.	Are wet groves and shoes worn in welding work?
	i.	Are acetylene welding being implemented by qualified workers?
9.	**Bridge Foundation**	
	a.	Key Points for Pre-cast Pile
	b.	Is regular pile cap being used and attached to hammer when driving pile?
	c.	When climbing up, is the main loop being set and is safety belt with fall arrest device being used?
	d.	When constructing by hollow trench pressing fit technique, is preventive measure of scattering being taken because there is a risk of scattering of removed soil?
	ii. Key Points for Cast-in-situ Pile installation work.	
	a.	When moving machine by pulling or jack, is work being implemented according to signal or whistle of signal man?
	b.	Are Equipment such as jack and pulley being maintained?
	c.	Wire rope used, meets the specified safety rate?
	d.	Are worker being approached digging machine, after hummer grab enters inside of casting and stop, if necessary?
	e.	Is changing of band comply with designated working procedure?
	f.	When entering inside of casing, is casing being ventilated in advanced or it is being confirmed that there is no risk by measuring toxic gas, etc.?
10.	**Safety in Concrete Work**	
	a.	Long span object shall be brought by more than 2 persons and not transported by force. Is it followed?
	b.	Front and rear shall be taken caution against so as not to touch other object during transportation, Is it followed?
	c.	At the place of assembling reinforced bar, safety passage such as setting board shall be secured for walking on the reinforced bar? Is it followed?
	d.	From support shall be firm structure based on method of casting concrete, and assembled according to drawing for assembling .Is it followed?
	e.	Is form support being taken measure of prevention from falling?
	f.	To pre4vent subsidence and slid of support, use of cover sand and iron boars, concrete basement casting, driving pile, and attaching root colt etc. are being implemented?
	g.	Are the joints of support butted or inserted and are the metals connected by means of bolts and clamps etc.?
	h.	When the form is a curved surface, are measures taken to prevent the form from floating, such as attachment of overhangs?
	i.	Are bracing being installed between steel pile frames?
	j.	When using the concrete pump, is the pipe being firmly attached and the removal of the pipe being carried out carefully?
11.	**Fire Protection and Prevention**	
	a.	Is the fire prevention management system being organized for the fire prevention of office, labor camp and construction site?

	b. Is the fire extinguishing equipment being installed corresponding to the purpose of use in the place where fire is handled?
	c. Are stay connected with local safety security offices/personnel like fire station/police station/hospital/clinics?
	d. Are emergency telephone/mobile numbers displayed and numbers kept visible for emergency calks?
	e. Is there water/sand ready on site for use in case of general fire?
	f. Are "No Smoking" signs posted in designated dangerous Ares?
12.	**Pre-stressed Concrete**
	a. Are rigid safety barriers and safety signs provided at both jacking ends to prevent accidents during cable tensioning?
	b. Are adequate safety precaution such as the use of appropriate PPEs for all workers and supervisor being ensured when using stressing equipment?
	c. Keep the anchor very close to the plate during jacking operations to avoid dangerous accidents if the hydraulic line fails. Is it followed?
	d. Pulling Headers and Hydraulic jack should be examined regularly, Is it followed?
	e. No one shall be allowed in the same line of tensioning element and jacking equipment during tensioning operation. Is it followed?
	f. No one shall be allowed directly above the jacking equipment during deflection carried. Is it followed?
13.	**Bituminous Work**
	a. Is the use of proper PPE (gumboots, hand gloves etc.) and safety measure ensured during bituminous work?
	b. Are signs with "No Entry" information and other safety signs displayed around the working area of the bituminous work?
	c. Are there strong safety barriers around the bituminous work?
	d. Are the trained flagman appointed with proper gears to control traffic?
	e. Do all fires extinguished at the end of daily work?
14.	**Bridge Approach Construction Work**
	a. The safety signs such as Work in Progress, Go Slowly, Workers at Work etc. should be erected during construction of bridge approach. Is it followed?
	b. Are the trained flagman appointed with proper gears to control traffic?
	c. Ate there barricades to protect/safety public movement?
	d. Bridge approach construction materials shall be kept away from area/shoulder for safe movement of the public vehicle. Is it followed?
	e. Park road rollers and other heavy equipment in safe places to avoid traffic jams. Is it followed?
	f. Do experience personnel operate Road roller and others heavy equipment?
	g. Are all workers and supervisions using appropriate PPE?

5.6 Reporting of Site Accident/Incident

- Except as required by Bangladesh Law, contractor will not be liable for or in respect of any damages or compensation payable to any employs, other than death or injury resulting from any act or default of his agents or servants.

- The contractor will ensure details of any accident as soon as possible after its occurrence and responsible to report to appropriate project staff. In the case of any fatality or serious accident. The contractor will notify instantly the appropriate staff of the SupRB project at the quickest time following the accident as well as inform the organization by written.

6. QUALITY CONTROL & QUALITY ASSURANCE

Quality control and assurance are vitally important to a successful construction project and should be adhered to throughout the project from the commencement and design phases and throughout the construction and installation phases. A good quality assurance system during the construction of the works will ensure longevity of the construction itself.

6.1. INSPECTION AND TESTING

Having a good quality assurance process in place means conducting regular inspections to ensure that the works are completed in conformity with the drawings, Bills of Quantities (BOQ) and technical specifications. Regular inspections during construction will prevent costly repairs after the project is completed.

Procedure:

1) Based on the specifications and quality control requirements, the Project Manager will develop and agree with the Contractor on the inspection course of action, to make sure that the works are completed in line with the contracted quality standards.
2) During the course of inspection, the Project Manager and site staff in charge of inspection should check whether the Contractor is constructing, installing and carrying out the Works and physical services in accordance with the Specifications and Drawings as stipulated in the contract.
3) The Project Manager should give advance notice to the Contractor in case the LGED representatives are planning the examination, inspection, measurements, testing or supervision of the works under the Contract. The Project Manager can decide for such quality assurance actions at any time when he/she assess as necessary while Contractor is obliged to allow access to the Site all the time during the execution of the works.
4) The supervision, equipment, location of the material and the type of testing should be described. As e regular practice, the testing will be conducted using the LGED laboratory. However, if tests require special equipment they are to be performed by outside laboratories.
5) The Project Manager is responsible to check the Works executed by the Contractor and to notify the Contractor of any Defects found.
6) The Project Manager may also instruct the Contractor to search for a defect, to uncover and test any work that the Project Manager considers may have a Defect.
7) The Project Manager may instruct the Contractor to carry out a test not specified in the Specification to check whether any work has a Defect. In case that such the test shows any defect, the Contractor shall pay for the test and any samples. If there is no Defect, The Project Manager shall instruct the Contractor on the procedure for reimbursement of the related costs.
8) Project Manager may decide to reject the Work if the result of examination, inspection, measurement of Works shows that the works are not constructed in accordance with a Contract. Further to a decision for rejection of Works, Project Manager should give notice to the Contractor with detailed explanation.
9) FORM 8/1 (INSPECTION & TEST PLAN) will be used for planning purposes to identify the key performance criteria for the works and allow allocation of appropriate implementation control measures to assist achieving the required outcomes. Furthermore, such a plan will provide a framework for the works to be packaged into controllable portions, where specific risk and specification requirements can be identified and controlled.
10) PE/PM and assigned other LGED Engineers, under their duties and responsibilities are in charge of regular supervision of the works and conducting other necessary activities to ensure quality of the construction works. The supervision should be conducted at a frequency to ensure that elements of the work are in compliance with the specified standards.

11) The supervision team should be aware of the works that will become covered and cannot be inspected after the fact. This includes concrete, where the size, number, and location or reinforcing steel cannot be readily determined after the concrete is placed. Likewise, underground utilities cannot be inspected after covering. Work of this nature must be closely controlled and monitored during construction.
12) FORM 8/2 (INSPECTION REPORT) should be completed by the Project Manager or by the Engineer assigned by the Project Manager for inspection. The purpose of reporting is to document the observation, investigation and analysis of inspection work. Summary items that have been corrected with the date completed and items requiring additional time to complete should also be included in the inspection report.

Responsibilities:

The Project Manager is responsible for:

- Preparing and managing the quality assurance plan, including supervision, inspections, measurements, tests and examinations.
- Supervise the staff in charge of quality assurance, to ensure that the inspection is done in conformity to the highest quality standards
- Ensure proper recording and filing of inspection work and test results

Project Manager's delegates are responsible for:

- Assisting the Project Manager in preparation of the inspection and supervision plan;
- Conduct regular supervision and inspection of the work to ensure the works are done in full compliance with the specifications and drawings;
- Recording all quality assurance activities and filing all related documents accordingly;
- All field staff are responsible for quality assurance and identifying of non-conformances;

6.2. MEASUREMENT OF WORKS

Except as otherwise stated in the Contract, measurement shall be made of the net actual quantity of each item of the permanent works and the method of measurement shall be in accordance with the Bill of Quantities or other applicable Schedules. Measurement is practically made for finished items of work and the description of each item shall include materials, transport, labour, fabrication tools and plant and all types of overheads needed to complete the work to the required shape, size and specification.

Procedure:

1) Whenever the LGED requires any part of the Works to be measured, the Project Manager will give a reasonable notice (FORM 9/1MEASUREMENT NOTICE FORM) to the Contractor's Representative, who shall:
    a) Promptly either attend or send another qualified representative to assist the LGED representative in making the measurement; and
    b) Supply any particulars requested by the LGED.
2) The Project Manager and Contractor's representative staff should meet on a regular basis to review measurement records and quantity calculations. These meetings must ensure that all items are measured and measurements, calculations, etc., are correct.
3) Project Manager may exclude any item certified in a previous certificate or reduce the proportion of any items previously certified in any certificate in the light of later information. Pay quantities will be reconciled or provisional payments will be made on Project Manager's calculations and payment will be corrected on following Interim Certificate. The

4) Project Manager will review Interim Statements based on quantity survey (FORM QUANTITY SURVEY FOR COVERED ITEMS), calculations and other data submitted to him/her by site staff and the Contractor. Interim Statements will be reviewed by the Project Manager and certified prior to forwarding to the LGED for payment.
5) The method of measurement for each item will be agreed upon with the Contractor and the agreement should be recorded accordingly.
6) The representative of the Contractor should be present during all kind of measures and should sign the FORM 9/2.
7) All calculations will be made on standard calculation sheets. It is essential that calculations are clear, concise and set out to make for easy verification and cross checking.

6.3. REMEDIAL WORKS

Remedial works refers to corrections of any defects of the works that are not in accordance with the contract.

Procedure:

1) A non-conformance procedure should be initiated when it is noted that the works on the project are not executed in line with contracted standards.
2) If any inspection reveals that the works are not in line with the specifications, the Project Manager shall immediately inform the Contractor and issue a Defect Correction Notice (FORM 8/3).
3) Details of the non-conformance are to be recorded so that notice can be given to the concerned parties that a non-conformance has occurred and that remedial work is required to be undertaken.
4) Project Manager may instruct the Contractor to remove from the Site and replace any Plant or Materials and/or remove and re-execute any other work which is not in accordance with the Contract and in line with GCC;
5) Project Manager may instruct Contractor to execute any work which is considered to be urgent in order to ensure safety of the Workers, whether because of an accident, unforeseeable event or otherwise.
6) If the Contractor fails to comply with the instruction issued for remedial work within the time specified in the instruction, the Project Manager should consider the option to employ and pay other persons to carry out the works, as specified in GCC;
7) Project Manager shall give notice to the Contractor of any Defect before the end of the Defect Liability Period which is specified in the PCC.
8) Project Manager will ensure that the Contractor corrects all non-conformances.
9) When needed, the Project Manager will initiate extension of Defect Liability Period for as long as Defects remain to be corrected.
10) Inspection teams should carry out follow-up inspections to verify that the remedial work has been carried out. Findings of follow up inspections should be recorded.
11) If the Contractor has not corrected a Defect within the time specified in the Project Manager's notice, the PE/PM shall assess the cost of having the Defect corrected by LGED, and the Contractor shall remain liable to pay the expenditures incurred on account of correction of such Defect.
12) Depending on special project requirements, a lesson learned report can be prepared to highlight any significant issue or event that required remedial or corrective action on the project for the purpose of eliminating reoccurrence in the future on other LGED projects. Along with lessons learned, any suggested improvements to the LGED infrastructure project implementation process should also be detailed and recorded as part of the Lessons Learned process. As a good contract management practice, the lessons learned report may be shared widely with LGED.

13) The Assistant Upazila Engineer (Upazila level), Senior Assistant Engineer (District level) or other assigned LGED staff shall keep the summary record and log of all project non-conformances raised.

6.4. CONTROL OF SUB-CONTRACTORS

Procedure:

1) The Contractor will be legally responsible to LGED for the quality of the works performed by sub-contractors.
2) The Project Manager should promote a good cooperation and coordination among LGED, Contractor and all subcontractors.
3) Subcontractors named in the Contract shall be entitled to execute the specific components of the Works stated in the PCC.
4) The prior consent, in writing, of the Project Manager shall however be obtained for other proposed Subcontractor(s).
5) In terms of quality assurance activities (supervision, inspections, measurements, tests) all above mentioned procedures apply for subcontractors, given that the proper communication is established between all parties.
6) The Project Manager should identify and address any issues arising between the Contractor and subcontractor/s which might, in any form, jeopardize the successful execution of the works as per the required standards.
7) The Project Manager should also be aware of the consequences of compliance with the payment obligations of Contractors to subcontractors and suppliers. The Contractor should pay its subcontractors and suppliers in accordance with the provisions of the relevant contract and ensure that labourers employed in the execution of the Works, whether by the Contractor or by its Subcontractors, are paid in accordance with their respective contracts and the Laws.
8) The Project Manager will make sure that all sub-contractors are fully complying to the highest standard of ethics during the execution of the Contract under public funds.

6.5. PHOTOGRAPHS

Photographs are used in infrastructure projects to certify the progress achieved and also to provide a record of various events and issues.

Procedure:

1) The site staff will document the works through photographs. These shall include:

   A. Views of major construction projected during various stages of progress;
   B. Materials or construction related to changed conditions, claims, or potential claims;

   C. Work in place for which removal has been ordered because of noncompliance with plans and specifications;
   D. Photos of technical interest;
   E. Bad and good safety practices by the Contractor;
   F. New methods of construction;
   G. Property or material damages;
   H. Manufacturer's labels and installation instructions;
   I. Emergency conditions and safety violations;
   J. Accident scenes; and,

K. Defective work

2) While site staffs are responsible for taking pictures on a regular basis, the Project Manager should also arrange twice monthly photographs of all major parts of the project. It is strongly recommended that photos are taken from the same vantage point to provide a clear comparison of progress.

3) The Project Manager should instruct the Contractor on the location where photos are to be taken. FORM 5/4 (INFORMATION ON PHOTOGRAPHS) should be used for instruction purposes. The Project Manager will monitor the Contractor to ensure that photos have been taken.

4) Photographs/videos should be taken from the perimeter of the area in toward the center in increasingly close shots. Be sure to capture all objects and markings thoroughly so they can be identified later.

5) Once the photographs are delivered, the Project Manager will check them for compliance- if the each photograph taken is completely described, identified, and dated.

6) When possible, photographers should use tape measures or other readable measured devices with pictures to show actual sizes and distances.

7) The Project Manager should advise the Contractor not to publish any photographs of the Works or allow the Works to be used in any form of advertising whatsoever without the prior approval in writing from the LGED.

The Assistant Upazila Engineer (Upazila level), Senior Assistant Engineer (District level) or other assigned LGED staff will keep a record of photographs taken by site staff.

Form 11: INSPECTION & TEST PLAN Form 6/1

"Insert the name of the project"

Item	Reference	Type of Test	Quality Assurance Acceptance Criteria	Frequency of Testing	Responsible person	Approval by	Comments /Status

Prepared by: ____________________ Date: __________________

FORM 12: INSPECTION REPORT FORM 6/2

Project title:	
Contract number:	
Location:	
Report No.	
Name of the Project Manager:	
Purpose of the inspection:	

We the undersigned agree the outcome detailed below as a true record of the inspection carried out on ________________________ *(insert date of inspection)*

Item No.	Location	Description	Completed works component	Checked by

Signed by: ____________________________ Date: ________________________

Project Manager

FORM 13: DEFECT CORRECTION NOTICE FORM 6/3

FROM:	*"insert the name of Project Manager"*
TO:	*"insert the Contractor's details"*
Project name:	
Contract number:	
DCN No.	

Hereby, we notify you that __ Test/ ☐ Inspection ☐ Other (pls. specify)
....

Indicate that ....

....

Does not conform to requirements of the Specification/Drawing. The Specification/Drawing Violated is Section.................., Clause ...., Drawing Number .... Under the provisions of the Specification/Drawing, the requirements are:

....
....

....
....

Non-conforming work may be required to be removed and replaced at no cost to the LGED.

It is your responsibility to determine the corrective action necessary, and to determine whether you wish to discontinue operations until additional investigation confirms or refutes the initial findings.

Your proposed remedial action should be submitted for review.

Project Manager: .... **Date:** ....

FORM 14: INFORMATION ON PHOTOGRAPHS FORM 6/4

Project title:	
Contract number:	
Name of Contractor	
Date of last photos taken	

In accordance to Clause ____________________ of the contracted specification, you are instructed to take the following photographs:

Location	Description	Number of photos

The photographs are to be taken in the period

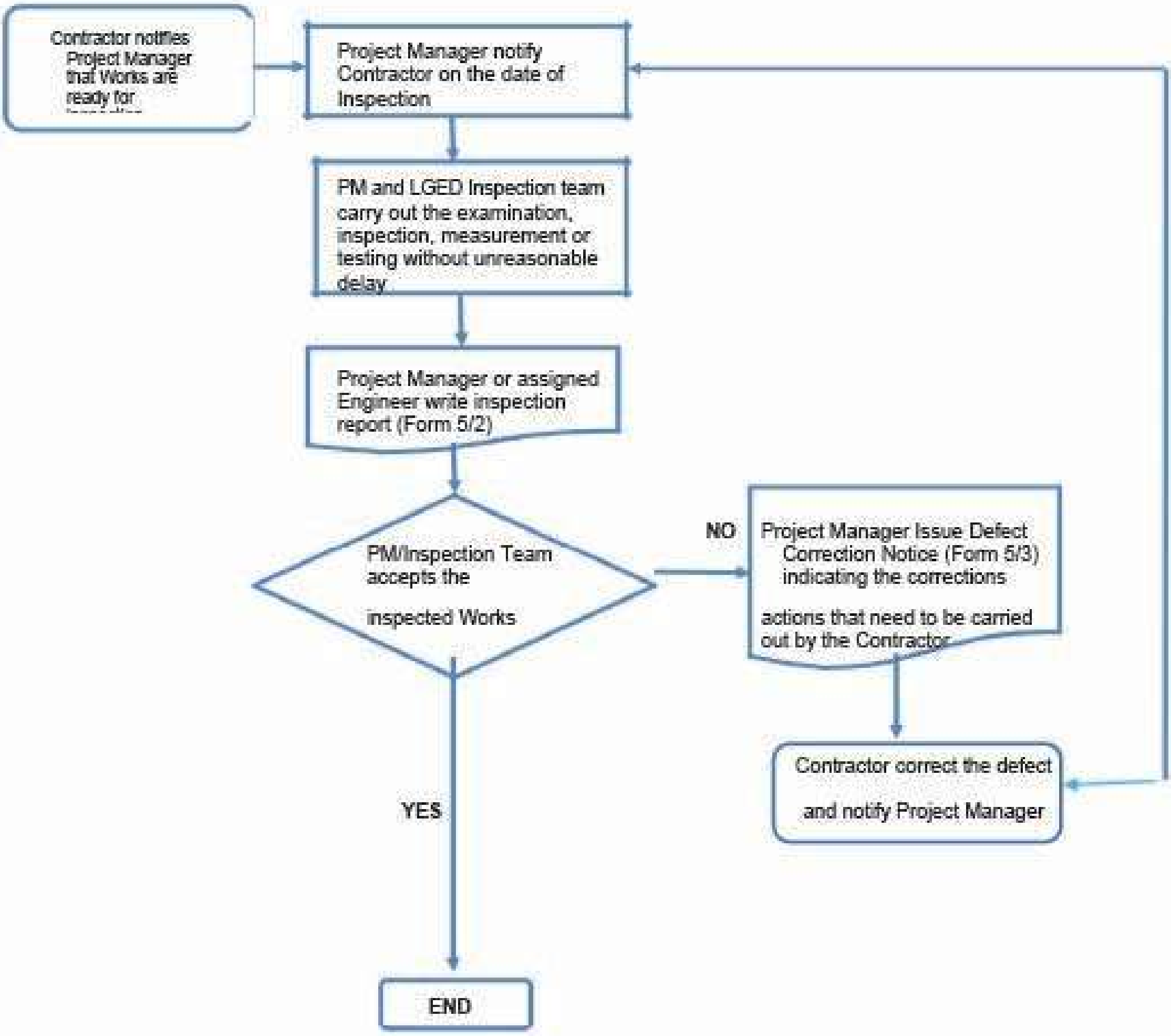
From ________________to___________________ and submitted in the specified format and numbers by

____________________.

____________________ ______________________

Project Manager Date

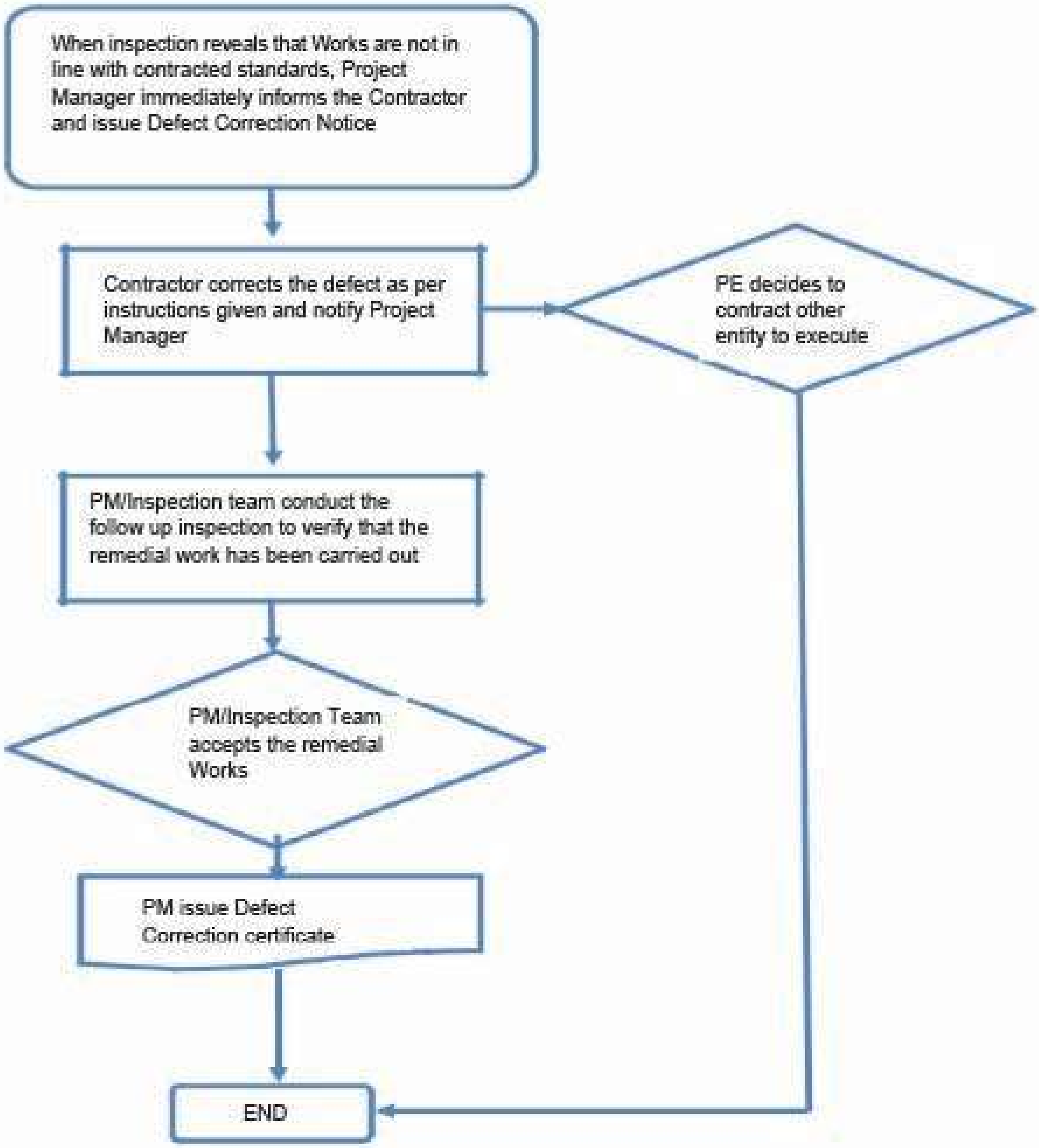
FLOW CHART 3: INSPECTION FLOW CHART 6/1



Note:

Project Manager may instruct the Contractor to carry out a test not specified in the Specification to check whether any work has a Defect. In case that such the test shows any defect, the Contractor shall pay for the test and any samples. If there is no Defect, The Project Manager shall instruct the Contractor on the procedure for reimbursement of the related costs.

FLOW CHART 4: REMEDIAL WORK FLOW CHART 6/2



Note:

1. Project Manager shall give notice to the Contractor of any Defect before the end of the Defect Liability Period which is specified in the PCC.

2. If the inspection is carried out after issuance of Completion Certificate, when needed, the Project Manager will initiate extension of Defect Liability Period for as long as Defects remain to be corrected

3. Contractor shall pay to LGED all costs arisen from the failure of the Contractor to comply with PM instructions in Defect Correction Notice

7.0 QUALITY CONTROL TESTS REQUIREMENT

7.1 Quality Control Tests and Tests frequency

The quality control tests listed in the table below are the tests required by the LGED general specification of works. Where works are to be undertaken that are not covered by the general specification of works, the contractor also be obliged to carry out quality control of those. Quality Control Tests fall into three categories:

- Tests on materials prior to and during construction/maintenance
- Tests on the quality of workmanship
- Tests on the finished works after construction.

The authority will review the Test Schedule included in LGED general specification also in Technical Specifications part of the contract document prior to construction start to confirm understanding of the test program.

⇒ **Quality Control Tests on Materials during construction**

All requisite tests for materials shall be performed by Contractor before using in any works. The field supervisory officials of LGED & Consultants will verify that the contractor has conducted materials meets the requirements of the standard design, drawings and the contract specifications. Copies of all sample test reports will be maintained at the Upazila Engineer's Office and Consultant's office. The approval authority for all material testing is the District Executive Engineer with notification to the management. In the event that materials fail testing, a written notice will be issued by the Upazila Engineer and all materials will be removed from the site immediately by the contractor.

⇒ **Quality Control Tests on Workmanship**

To a large extent these tests are required to ensure that the approved construction materials are correctly mixed, placed and compacted during the work. Where on-site mixing is employed by the contractor, the grading and proportioning of the materials must be strictly controlled so that all times the final mix complies with the design mix that has been approved by the Engineer. Where the results of these tests show that the materials/works do not comply with the specification further intrusive and/ or non-destructive tests must be carried out on the completed works for deciding whether or not to reject the works by the Engineer-in-charge.

⇒ **Quality Control Testing Requirement and Frequency**

Notwithstanding the requirements stated in the detailed specifications for individual items, the following minimum tests shall be carried out in the LGED specific laboratories and in the field. In cases the testing facilities are not available in the LGED laboratory; the tests shall be performed elsewhere as directed by the Engineer-in-charge. All test types and quantities described in the following tables are considered "Normal Testing", whereas anything beyond that in type and quantity is considered as "Special Testing". The Engineer may increase the frequency of testing as required.

Table 7-1: Types and Frequency of Tests for Concrete Works

ITEM & TYPES OF TESTS		TEST FREQUENCY
CEMENT		
i)	Setting Time	1 for each brand for approval and only the approved brand will be used
ii)	Compressive strength test	
FINE AGGREGATE (Sand)		
i)	FM	For each stockyard at site but further tests shall be carried out immediately before casting as per requirement shown in table 7-2.
ii)	Grading	

COARSE AGGREGATE		
i)	Gradation	For each stockyard at site but further tests shall be carried out immediately before casting as per requirement shown in table 7-2.
ii)	Water Absorption	
iii)	AIV or Los Angeles Abrasion	
Fresh Concrete		
i)	Slump	As frequently as required by the Engineer but not less than one per hour during concreting operations
ii)	Cylinder Strength at 3 days, 7 days and 28 days	At least 6 cylinders (1 set) shall be kept from each class of concrete for each days casting or at least 1 set per 15m3 for new construction and at least 1 set per 5m3 for repair works of each class of concrete for testing at 3 days, 7 days and 28 days whichever is greater. Engineer in-charge has the right to increase the no. of tests beyond the set frequency as he deems required and the contractor is to perform additional tests on its own costs. If the casting of concrete less than 1m3 in a day, concrete strength test can be avoided but in that case quantity of cement must be increased by minimum 10% and slump test should be carried out for each batch mixing.
REINFORCEMENT BARS		
i)	Unit Wt.	At least 1 set per dia. Shall be carried out for each brand. Only test Certificates issued by BUET/RUET/KUET/CUET/DUET shall be accepted by the Engineer
ii)	Diameter	
iii)	Elongation	
iv)	Tensile strength	

Table 7-2: Laboratory Test Frequency, LGED

Sl No	Item of Works	Name of Test	
1	Embankment	i) Plasticity Index (PI)	One 2,000 m3
		ii) 4day soaked CBR	One 2,000 m3
		iii) MDD (Standard)	One 2,000 m3
		iv) FDD	One 600 m3
		v) DCP	One 200 m3
2	Sub grade	i) Plasticity Index (PI)	One 5,000 m2
		ii) 4day soaked CBR	One 5,000 m2
		iii) MDD (Standard)	One 5,000 m2
		iv) FDD	One 900 m2
		v) DCP	One 300 m2
3	Improved Sub grade	i) FM/Gradation	One 500 m3
		ii) 4day soaked CBR	One 1,000 m3
		iii) MDD	One 1,000 m3
		iv) FDD	One 300 m3
		v) DCP	One 100 m3
4	Sub-base	i) Gradation	One 500 m3
		ii) 4day soaked CBR	One 1,000 m3
		iii) LAA	One 750 m3
		iv) MDD	One 1,000 m3
		v) FDD	One 1,000 m3
		vi) W/A (Stone/Brick)	One 500 m3
		vii) DCP	One 50 m3
5	Base Course	i) Gradation	One 500 m3
		ii) 4day soaked CBR	One 750 m3
		iii) LAA	One 1,000 m3
		iv) MDD	One 750 m3
		v) FDD	One 150 m3
		vi) W/A (Stone/Brick)	One 500 m3
		vii) DCP	One 50 m3
6	Brick on End Edging	i) Compressive Strength	Set 1,000 m
		ii) Water Absorption	Set 1,000 m
7	HBB	i) Compressive Strength	Set 2,000 m2
		ii) Water Absorption	Set 2,000 m2
8	Bituminous Materials	i) Softening Point	One 10,000 m2
		ii) Flash Point	One 10,000 m2
		iii) Penetration	One 7,500 m2
		iv) Gradation of FA	One 5,000 m2
		v) Gradation of CA	One 5,000 m2

		vi) WA of CA	One 5,000 m2
		vii) LAA	One 5,000 m2
		viii) Flakiness Index	One 5,000 m2
		ix) Job Mix Design (Marshall Method)	One for more than 240 m3 up to 5km.
9	Concrete	i) FM	One 50 m3
		ii) W/A (Coarse Aggregate)	One 50 m3
		iii) LAA/ACV	One 50 m3
		iv) Gradation of CA	One 50 m3
		v) Setting time of Cement	One 50 m3
		vi) CS of Cement ((3, 7, 28 days)	One 50 m3
		vii) CS of Concrete	Set 300 m3
10	Brick Works	i) Compressive Strength of Bricks	Set 300 m3
		ii) Water Absorption of Bricks	Set 300 m3
		iii) Efflorescence of Bricks	Set 300 m3
		iv) Setting Time of Cement	Set 300 m3
		v) CS of Cement	Set 300 m3
		vi) FM of Sand	Set 300 m3
11	Reinforcement	Unit weight, Elongation & Tensile Strength	1 set/Dia./10,000 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.

7.2 Testing Laboratory Requirement

LGED has a well-equipped laboratory in each district with sufficient instruments. One Assistant Engineer is in charge of the laboratory supported by Laboratory Technician (LT) and one Laboratory Assistant (LA). All material and field tests shall be performed by LGED's laboratory in charge. Test reports will be signed by the Lab Technician, Assistant Engineer and District Executive Engineer. In cases where the testing facilities are not available in the LGED laboratory; the tests shall be performed elsewhere as directed by the District Executive Engineer.

7.3 Test Requirement for Sub-Soil Investigation (Guide Line 2018)

⇒ Sub-Soil Investigation shall be carried out to establish soil parameters required for detailed design in accordance with relevant provision of AASHTO LRFD

⇒ Minimum depth of bore hole from lowest riverbed level should be minimum 40m for the Cox's Bazar (Coastal Side), Chittagong (Coastal Side), Feni, Laxmipur, Noakhali, Chandpur, Bhola, Barisal, Patuakhali, Barguna, Jhalokathi, Pirojpur, Bagerhat, Khulna & Satkhira. For other areas, that should be minimum 30m. Hence, the minimum depth should be increased as per design requirement

⇒ At the time of construction, on confirmatory soil test should be done in each abutment and pier location after finally setup the layout to review the design. In such case, bore-hole depth should be finalized according to design requirement

⇒ Minimum 4 bore hole (2 in the river and 2 in bank position) should be done for bridges more than 100m length. Minimum 3 bore hole (1 in the river and 2 in bank position) should be done for bridges less than 100m length for design purpose or as instructed by Design Unit, LGED.

In general, the Sub-Soil Investigation Reports should include the following laboratory Tests from disturbed or undisturbed soil samples:

⇒ Natural Moisture Content
⇒ Liquid Limit and Plastic Limit
⇒ Unconfined Compression
⇒ Specific Gravity
⇒ Direct Shear Test
⇒ Grain Size Analysis
⇒ Consolidation

7.4 Test Requirement for Strand of PC Girder and Bridge Bearing

The Following tests are needed to be performed for Strand prior to use in PC girder,

- Ultimate Tensile Strength
- Yield Strength
- Unit Weight/Cross sectional area
- Modulus of Elasticity and
- % of Elongation at Rupture

Test Requirement for Post Tensioning Anchorage

Anchorage efficiency test must be carried out from approved laboratory to confirm the quality and capacity and capacity of post tensioning anchorage (Bearing plate test, Wedge plea test, Strand-Wedge connection) in accordance with PTI-M60, 1-98.

Test Requirement for Bearings

The following tests are needed to be performed for elastomeric bearing pad

- Hardness (ASTMD-2240)
- Compression set for 22hr at 100°c (ATMD-395)
- Ash Content
- Short Duration Compression
- Long Duration Compression
- Volcanized Bond Test (ASTMD-429) Method-B
- No and thickness of elastomer layer and Steel Plate

7.5 Quality Control Test Report Review and Analysis

7.5.1 Quality Control Test Reports Review and Analysis

Sample Test Reports related to the RCC, PSC and Arch Bridge Construction works are presented here in the following pages for general discussion, Test Reports Review and Test Result analysis. Test result analysis is the process of interpreting and evaluating the outcome of testing. It involves comparing of test results with expected or desired results, identifying deviation/non-compliances, trends and patterns and drawing conclusions from testing. Test result analysis is a critical and most technical that requires expertise and skills.

Test reporting is essential for making sure your product/materials is achieving an acceptable level of quality.

In this session the resource person/trainer shall discuss all the test reports in detail shown in the following pages by displaying each on a multimedia projector so that the participants can questions.

The resource person/trainer can discuss following issues in his discussion:

1. About sampling of the test specimen.
2. About Preparation of the Test Specimen
3. About accuracy of the tools and equipment that to be used in the testing.
4. Standard/Desired specification of tested specimen
5. Deviations/non-compliances found in the test results
6. Conclusion with the test results.

The test reports shown in the following pages are:

Test Report-1: Compressive Strength Test of Cement
Test Report-2: Normal Consistency & Setting Time of Cement
Test Report-3: Sieve Analysis (Grading of Sand)
Test Report-4: Sieve Analysis (F.M of Sand)
Test Report-5: Resistance to Abrasion of Coarse Aggregate by LAA Test
Test Report-6: Sieve Analysis of Coarse Aggregate
Test Report-7: Compressive Strength Test of Brick
Test Report-8: Water Absorption Test of Brick
Test Report-9: Penetration of Bituminous Material
Test Report-10: Softening Point Test of Bitumen
Test Report-11: Sp. Gravity and Density Test of Semisolid Bituminous Material
Test Report-12: Determination of Bituminous Content
Test Report-13: Proctor test for MDD and OMC Determination
Test Report-14: Field Density and % Compaction by Sand Cone
Test Report-15: Atterberg Limit Test of Soil
Test Report-16: Test Report Elastomeric Bearing Test
Test Report-17: Concrete Mix Design
Test Report-18: Calibration of Hydraulic Jack
Test Report-19: Tension Test of 7-Wire Pre-stressing Strand
Test Report-20: -do-
Test Report-21: Test of Deformed M.S bars
Test Report-22: Pile Integrity Test (Static)
Test Report-23: Pile Load Test (Static)
Test Report-24: Compressive Strength Test of Concrete

TEST REPORT 1

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

(Using 50 / 50.8 mm Cube of Cement Mortar)

Client :

Ref. No. :

Scheme :

Location :

Sample No. :

Type of Specimen :

Sampled By :

Sampled Date :

Quantity Collected from Field :

Quantity Represented :

Casting Date (Time) : 09.03.05 (12.30 P.M)

Mix Proportion = 1 : 2.75

Date of Test (Time) : 3 days : 12.03.05 (12.45 P.M) 7 days : 16.03.05 (12.35 P.M) 28 days : 6.04.05 (12.35 P.M)

Brand of Cement (Origin) :

Water Cement Ratio = 1 : 0.485

Type of Sand Used : Stndards Sand (Imported sand & Grading as per ASTM C-78)

Lab. Reg. No. :

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^2	
01	3	0.0025	52.80	21.12		
02	3	0.0025	51.40	20.56	=#VALUE!	Which is greater than 1800 Psi
03	3	0.0025	49.40			
01	7	0.0025	68.10	27.24		
02	7	0.0025	71.20	28.48	= 28.5	Which is greater than 2800 Psi
03	7	0.0025	74.50	29.80		
01	28	0.0025	94.10	37.64		
02	28	0.0025	90.00	36.00	= 36.3	Which is greater than 4000 Psi
03	28	0.0025	87.80	35.12		

NOTE :- 1 MN/m2 = 145.038 psi and 1KN = 224.809 lb.

NOTE :- In calculating the average strength, do not consider specimens for which strength are differing by more than 10% from the average value of all (3) specimens. After discarding specimens or strength values, if less than two strength values are left for calculating the average strength, make a retest as per ASTM C-109.

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. Modnhadur Rahman, SAE, (QC)

Comments :

The results are within the allowable limit.

(Specification for ordinary Portland cement of ASTM C-150)

Laboratory Technician Central Quality Control Unit, LGED	Assistant Engineer (QC) Central Quality Control Unit, LGED	Executive Engineer (QC) Central Quality Control Unit, LGED

TEST REPORT 2

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: Mir Cement Ltd. Ref. No. & Date : Nil, Date: 21.10.18

Scheme : Physical test of Cement

Sample No. : 01 Type of Specimen : PCC Cement

Sampled By: Client Sampled Date : 28.10.18

Quantity Collected from F 1 bags Quantity Represented : N/M

Brand of Cement (Origin) : Mir Cement (PCC) Casting Date (Time) : 29.10.18 (12:30 PM)

Lab. Reg. No. : LGED/C-Lab/

NORMAL CONSISTENCY DETERMINATION:

Trial No.	1	2	3	4	5
Wt. of Cement (gm)	500	500			
Volume of Water (cc)	130	132.5			
Penetration (mm)	8	10			
Normal Consistency (%)	26.5	(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	11:50 : Am	-				
2	30	12:20	Full				
3	45	12:35	Full				
4	60	12:50	Full				
5	75	1:05	Full				
6	90	1:20	Full				
7	105	1:35	Full				
8	120	1:50	Full				
9	135	2:05	Full				
10	150	2:20	36				
11	165	2:35	29				
12	180	2:50	16				
13	195	3:05	6				
14	210	3:20	1				
15	225	3:35	<1				
16	240	3:50	Just Impression				

Initial Setting Time = $T_1 + \frac{(T_2-T_1)}{(P_1-P_2)} \times (P_1-25)$ = 170 Min. Final Setting Time = 240 Min.

(by linear interpolation for 25mm penetration)

NOTE : As per ASTM C-595 (Specification for Portland Composite Cement) the Initial Setting Time should not be les and Final Setting Time should not be more than 420 min.

Tested by : Md. Yusuf Ali, Laboratory Technician

Supervised by : Md. Enamul Hoque Khan

(Md. Yusuf Ali) Lab. Technician(QC)

(Md. Enamul Hoque Khan) Sr. Assistant Engineer (QC)

(Md. Tarikuzzaman) Executive Engineer (QC)

TEST REPORT 3

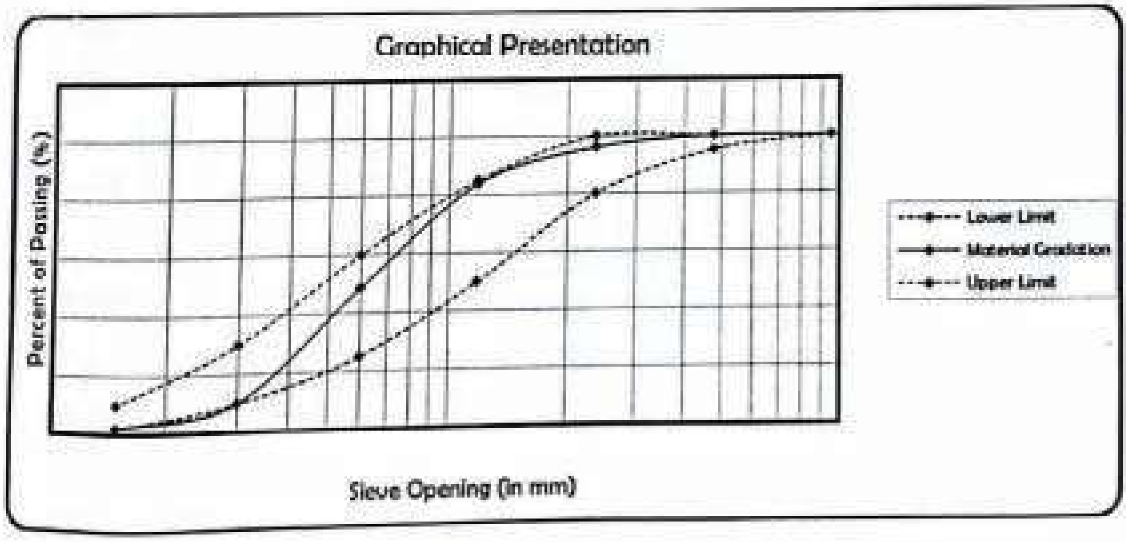
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
CENTRAL MATERIAL TESTING LABORATORY
Agargoon, Sher-e-Bangla Nagar, Dhaka-1207

SIEVE ANALYSIS (Gradation of SAND)

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 : Coarse Sand
Sampled by : Abdullah Al Mamun, PE. Sampled Date : 09.09.12
Quantity Received : 1.5 m^3 Quantity represented : N/M
Lab. Registration No. : Date of Test : 10.09.12

Wt. of dry Sample + Container = 525.0 gm
Wt. of Container = 25.0 gm
Wt. of dry Sample = 500.0 gm

Sieve Size		Weight Retained(gm)	Percent Retained	Cumulative Percent Retained	Percent Passing	Specified % Passing	Remarks
Inch	mm						
5/8	9.5	0.0	0.0	0	100	100	
#4	4.75	0.7	0.1	0.1	100	95-100	
#8	2.36	18.3	3.7	3.8	96	80-100	
#16	1.18	62.1	12.4	16.2	84	50-85	
#30	0.600	175.7	35.1	51.4	49	25-60	
#50	0.300	192.0	38.4	89.8	10	10-30	
# 100	0.150	40.5	8.1	97.9	2.1	2-10	
PAN		10.1					
TOTAL wt.		499.4					



Tested by : Md. Rabiul Haque, SAE (QC).
Supervised By : Md. Enamul Hoque Khan, Sr. AE (QC).

(Md. Rabiul Haque)
Sub-Assistant Engineer (QC)
Central Quality Control Unit, LGED

(Md. Enamul Hoque Khan)
Sr. Assistant Engineer (QC)
Central Quality Control Unit, LGED

(Md. Moniruzzaman)
Executive Engineer (QC)
Central Quality Control Unit, LGED

TEST REPORT 4

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

LOCAL GOVERNMENT ENGINEERING DEPARTMENT

CENTRAL QUALITY CONTROL UNIT

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

SIEVE ANALYSIS (FM of sand)

Client : Toma Construction & Co. — Ref. No. & Date : Nil.

Scheme : Construction of Moghbazar-Mouchak flyover, Wb

Sample No. : 04 — Type of Specimen : Coarse sand

Sampled by : M. Engr. — Sampled Date : 2.7.13

Quantity Received : Not mentioned — Quantity Represented : Not mentioned

Lab. Registration No. : — Date of Test : 3.7.13

Wt. of dry Sample + Container =	400.0	gm
Wt. of Container =	0.0	gm
Wt. of dry Sample =	400.0	gm

SIEVE ANALYSIS DATA

Sieve Size		Weight Retained (gm)	Percent Retained	Cumulative Percent Retained	Percent Passing	Specified Limit
Inch	mm					
3/4	19.0	0.0	0	0	100	
3/8	9.5	0.0	0	0	100	
#4	4.75	3.3	0.8	0.8	99	
#8	2.36	29.7	7.4	8.2	92	
#16	1.18	84.6	21.2	29.4	71	
#30	0.600	155.5	38.9	68.3	32	
#50	0.300	96.5	24.1	92.4	8	
#100	0.150	23.9	6.0	98.4	2	
# 200	0.075	5.1	1.3	99.7	0.3	
Pan		1.0				
Total wt.		399.6				

FM- 2.98 — Amount of silt and clay = 0.3 %

Tested by : Md. YUSUF Ali, Lab. Technician

Supervised By : Md. Enamul Hoque Khan, Sr. Assistant Engineer (QC)

(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

RESISTANCE TO ABRASION OF COARSE AGGREGATE BY THE USE OF LOS ANGELES ABRASION TEST (ASTM C-131)

Client : Ref. No. & Date :

Scheme : Location :

Sample No : Type of Specimen :

Sampled By : Sampled Date :

Quantity Collected from Field : Quantity represented :

Lab. Registration No. : Date of Test :

Test no.	Sieve size in mm		Wt. of material (gm)	Other information's		Abrasion value, (%) $= [(W_1-W_2)/W_1]$ X100	Remarks
	Passing	Retained					
1	19.0 mm	12.5 mm	2500 gm	Grading =	"B"	$\left[\frac{5000-3577}{(5000)}\right]$ X 100	
	12.5 mm	9.5 mm	2500 gm	No. of Spheres =	11		
				Wt. of Charge, gm =	4584	= 28 %	
				wt. retained in #12 sieve after test (W_2) =	3577		
	Total Weight (W_1) =		5000	gm			

- For "A"-grading, use 12 balls of total weight = 5000 ± 25 gm
- For "B"-grading, use 11 balls of total weight = 4584 ± 25 gm
- For "C"-grading, use 8 balls of total weight = 3330 ± 20 gm
- For "D"-grading, use 6 balls of total weight = 2500 ± 15 gm
- Number of Revolution = 500

Tested by :

Comments :

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.

TEST REPORT 6

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

LOCAL GOVERNMENT ENGINEERING DEPARTMENT

CENTRAL QUALITY CONTROL UNIT

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

SIEVE ANALYSIS FOR COARSE AGGREGATE

Client Project Director, DDIRWSP, LGED Ref. 46.02.0000.965..99.013.22.920, date: 09.11.22

Scheme Widenning and strengthening of Nimtala NHW Mdhukhali GC Road. ch.7+990km to 15+220km under Sadar upazila, District: Rajbari. Package No. DDIRWSP/Rajbari/Sadar/20-

Chainage : 8+150 KM

Sampled by : XEN Rajbari, UE Sadar& CSE Consultant, DDI

Maximum Size of Aggregate : 25mm down

Type of Specimen : Bituminous dense carpeting

Sampling Date: 10.11.22

Date of Test : 17.11.22

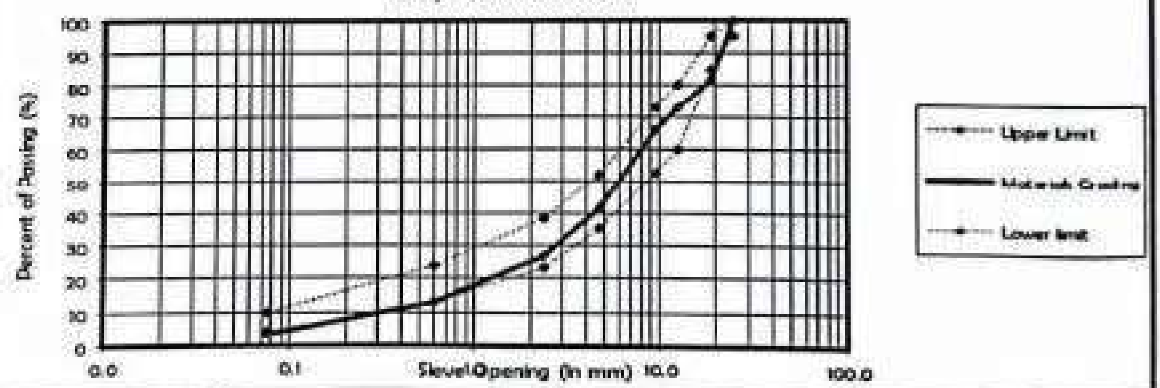
Density of bitumino Not done

Lab Registration No. : LGED/QCU/02/

Wt. of dry Sample + Container	=	807.2	gm
Wt. of Container	=	100.0	gm
Wt. of dry Sample	=	707.2	gm

Sieve Size Inch	Sieve Size mm	Weight Retained (gm)	Percent Retained	Cumulative Percent Retained	Percent Passing	Specified % Passing	Remarks
1"	25.0	0.0	0.0	0	100	95 - 100	
3/4"	19.0	124.5	17.6	18	82	85 - 95	
1/2"	12.5	65.6	9.3	27	73	60 - 80	
3/8"	9.50	48.8	6.9	34	66	53 - 73	
#4	4.75	170.2	24.1	58	42	35 - 52	
#8	2.36	100.2	14.2	72	28	23 - 38	
# 30	0.600	98.8	14.0	86	14	13 - 24	
# 200	0.075	70.9	10.0	96	4	4 10	
PAN		27.4					
TOTAL wt.		706.4					

Graphical Presentation



Tested b Md. Yusuf Ali, LT, (QC)

(Md. Yusuf Ali) Lab. Technician(QC)	(Rabiul Haque) Assistant Engineer (QC)	(Md. Tarikuzzaman) Executive Engineer (QC)

TEST REPORT 7

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 BRICK (ASTM C-67)

Client : Project Director, GCP-3, LGED
Ref. No. & Date : 46.02.0000.906.99.019.20-140, Date: 15.3.21

Project : Const. of Jibanganj bazar R&H- Shahpur GC via Mte Bishara bazar road. Ch. 4920-6730m under Nabinagar upazila, District Brahmanbaria. Road ID: 4126

Type of Specimen : Bricks
Frog Mark : ISLAM

Samled By : Client
Sampled Date : 15.03.2021

Quantity collected from field : 5 Nos. (from Ch. 6300m)
Quantity represented : Not mentioned

Date of Test : 08.04.2021
Lab. Reg. No. : LGED/QCU/02/

Area (for strength calculation): avg./Min.
Testing Standard : ASTM C-67

Specimen no.	Specimen Dimension Top			Specimen Dimension Bottom			Average or Min. area	Max. Load	Compressive Strength =Load/Area	Results / Remarks
	m^2			m^2			m^2	KN	MN/m^2	MN / m2
ISLAM-1	0.118	x	0.127	0.130	x	0.110	0.01460	215.6	14.8	15.6
ISLAM-2	0.128	x	0.126	0.115	x	0.125	0.01527	173.3	11.3	
ISLAM-3	0.126	x	0.124	0.112	x	0.122	0.01470	343.6	23.4	
ISLAM-4	0.128	x	0.133	0.107	x	0.121	0.01498	215.1	14.4	
ISLAM-5	0.124	x	0.125	0.122	x	0.128	0.01550	218.5	14.1	

NOTE :-1 MN/m^2 = 145.038 psi and 1KN = 224.809 lb.
For Diameter / Area determination : refer to ASTM-C-39

Tested by : Md. YUSUF Ali.

Comments of the Laboratory Incharge :

(Md. Yusuf Ali)
Laboratory Technician(QC)

(Md. Shafior Alam)
Sr. Assistant Engineer (QC)

(Md. Tarikuzzaman)
Executive Engineer (QC)

TEST REPORT 8

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
CENTRAL QUALITY CONTROL UNIT
Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

WATER ABSORPTION TEST OF BRICK

Client :
Scheme :
Sampled By :
Quantity collected from field :
Type of Specimen :
Date of Test :

Ref. No. & Date :
Location :
Sampled Date :
Quantity represented :
Prog Mode :
Lab. Reg. No. :

Specimen no.	Oven Dry Wight (Kg)	S. S. D. Weight (Kg)	Water Absorption (%)	Results / Remarks
ABM	1.490	1.730	16.1	
ABM	1.181	1.616	17.0	
ABM	1.404	1.637	16.6	
ABM	1.407	1.551	10.2	
ABM	1.320	1.537	16.4	Average Absorption
ABM	1.457	1.734	19.0	= 17.2 %
ABM	1.390	1.640	18.0	
ABM	1.368	1.652	21.5	
RBM	1.425	1.705	19.6	
RBM	1.520	1.789	17.7	

NOTE: 1 MN/m^2 = 145.038 psi and 1KN = 224.809 lb.

Tested by :

Comments of the Laboratory Incharge :

Sub-Assistant Eng. (QC)
Central Quality Control Unit, LGED.

Assistant Engineer (QC)
Central Quality Control Unit, LGED.

Executive Engineer (QC)
Central Quality Control Unit, LGED.

TEST REPORT 9

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

Ref. No. & Date :

Client :

Name of scheme :

Quantity Received : Quantity represented :

Location :

Probable Type of Material : Standard–Temp./Load/Time: 25°C / 100 gm / 5 sec

Sample by & Date :

Lab. Registration No. :

TEST DATA

Test No.	Container Size (Dia x Height) mm	Actual Temperature	Penetration div	Average Penetration div	Result div
01	55 X 35	250C	69 73 75		Difference of highest & Lowest reading exceeds 4 div. (for 50-149 div. Range)
01	55 X 35	250C	80 81 82	81	Result = 81

NOTE :- 1 If the difference of the highest & lowest reading exceed 4 Div. (for 50-149 div. Range) then 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 1.414

Tested by : Mrs. Hasnaara Begum, SAE, (QC)

Comments of the Laboratory Incharge :

The Bitumen could be Penetration Graded one and of 80-100 grade.

Sub-Assistant Engineer (QC)
Central Quality Control Unit, LGED

Assistant Engineer (QC)
Central Quality Control Unit, LGED

Executive Engineer (QC)
Central Quality Control Unit, LGED

TEST REPORT 10

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 (ASTM D 36)

Client : Executive Engineer, LGED, Kishoı Ref. No. & Date: 46.02.4800.000.14.118.21.828, da

Name of schem : Rehabilitation of Bajitpur-Agorpur(Bajitpur Part) road from ch. 2000 m - 2684 m under Bajitpur upazila, District: Kishoreganj

Project : GOBM Package No. : GOBM/21-22/W-29.

Qtty. Received : 3.0 kg Quantity Represented : Not Mentioned

Sample by : Md. Habibullah, Sr. AE, Kishoregc Sampled Date: 15.03.22

Probable grade : 60-70 Peneration Graded Bitumen

Lab. Register Nc : LGED/QCU/02/ Date of Test: 30.03.22

TEST DATA

Description (Trial Test / Test / ReTest)	Expected Assumed Soft. Point °C	Fluid Used	Reading °C	Mean °C	Result °C
Test	-	Water	45.6 45.8	45.7	46.0

Tested by : Md. Yusuf Ali, LT (QC)

Comments: Sample were received in sealed condition

(Md. Yusuf Ali)
Lab. Technician (QC)

(S M Zakaria Rafe)
Assistant Engineer (QC)

(Md. Enamul Hoque Khan)
Executive Engineer (QC)

TEST REPORT 11

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
CENTRAL QUALITY CONTROL UNIT
Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

SPECIFIC GRAVITY & DENSITY OF SEMISOLID BITUMINOUS MATERIAL BY THE USE OF PYCNOMETER (ASTM D 70)

Client	: Executive Engineer, LGED, Kishoreganj	Ref. No.: 46.02.4800.000.14.118.21.828, date: 15.03
Name of	: Rehabilitation of Bajitpur-Agorpur(Bajitpur Part) road from ch. 2000 m - 2684 m. under Bajitpur upazila, District: Kishoreganj	
Project	: GOBM	Package No.: GOBM/21-22/W-29.
Qtty. Re	: 3.0 kg	Quantity Represented : Not Mentioned
Sample I	: Md. Habibullah, Sr. AE, Kishoregonj,	Sampled Date: 15.03.22
Probabl	: 60-70 Peneration Graded Bitumen	
Lab. Reg	: LGED/QCU/02/	Date of Test: 30.03.22

Trial No	Test No.-1	Test No.-2	Test No.-3
Pycnometer No.	P-1	P-2	P-3
Wt. of Pycnometer with stopper, (A) gm	27.568	28.681	28.598
Wt. of Pycnometer filled with water, (B) gm	56.908	55.987	55.415
Wt. of Pycnometer partially filled with Asphalt , ((	52.240	52.835	51.542
Wt. of Pycnometer, Asphalt & Water (D), gm	57.405	56.510	55.935
Actual Temperature, (T) °C	25	25	25
Density of water at T° C, (W_T) gm/cc	0.9971	0.9971	0.9971
Specific Gravity, = [(C-A) / (B A) (D C)]	1.021	1.022	1.023
Density of Asphalt, (Sp. Gravity x W_T gm/cc)	1.018	1.019	1.020

Specific Gravity of the Bituminous Specimen = 1.022

Tested by: Md. Yusuf Ali, LT

Comments: Sample were received in sealed condition

(Md. Yusuf Ali) Lab. Technician (QC)	(S M Zakaria Rafe) Assistant Engineer (QC)	(Md. Enamul Hoque Khan) Executive Engineer (QC)

TEST REPORT 12

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

LOCAL GOVERNMENT ENGINEERING DEPARTMENT

CENTRAL QUALITY CONTROL UNIT

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

Determination of Bitumen Content by Centrifuge Extractor

Client : Project Director, DDIRWSP, LGED   Ref. 46.02.0000.965.99.013.22.920, date: 09.11.22

Scheme Widenning and strengthening of Nimtala NHW Mdhukhali GC Road. ch.7+990km to 15+220km under Sadar upazila, District: Rajbari. Package No. DDIRWSP/Rajbari/Sadar/20-21/RD-03

Chainage : 8+990 KM   Sampled by : XEN Rajbari, UE Sadar& CSE Consultant, [

Maximum Size of Aggrega 25mm down graded   Type of Specimen : Bituminous Carpeting

Receiving Date: 10.11.22   Date of Test : 17.11.22

Lab Registration No. : LGED/QCU/02/

Description	Weight of Sample
Weight of mix of Bituminous sample before extraction, (A), gm	698.5
Weight of Filter before use , gm	20.8
Weight of Filter After use, gm	23.3
Weight of material adhesion with filter, gm	2.5
Weight of Aggregate after extraction, gm	668.6
Total weight of material after extruction,(B) gm	671.1
Weight of Bitumen, (A-B), gm	27.4
Bitumen Content, (A-B)/A*100 (%)	3.9

Tested by : Md. Yusuf Ali, LT.

(Md. Yusuf Ali)
Lab. Technician (QC)

(Rabiul Haque)
Assistant Engineer (QC)

(Md. Tariquzzaman)
Executive Engineer (QC)

TEST REPORT 13

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
CENTRAL QUALITY CONTROL UNIT
Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

PROCTOR DENSITY TEST FOR MDD & OMC DETERMINATION

Client : | Ref. No. & Date :
Scheme : | Location :
Quantity Collected from Field : | Quantity represented :
Sample No : | Soil Parameter :
Sampled By : | Sampled Date :
Lab. Registration No. : | Date of Test :
Description of Sample & Test Specimen :

Type of Test : | Method of Test :
Mold Dia : Wt. of rammer : | No. of Layer : Blow/Layer :

Determination no.	01	02	03	04	05
Assumed Moisture Content (%)	16	18	20	22	24

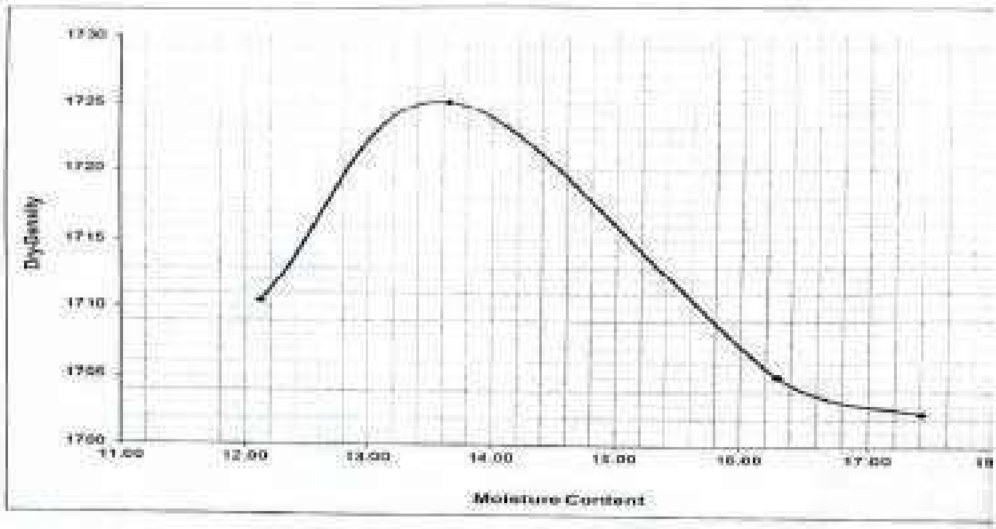
Moisture Content Determination

Moisture Can No.	8	1	6	14	28	39	20	7	40	31
Wt. of Can + Wet of specimen (A), gm	93.10	104.50	95.75	106.80	126.80	121.50	128.90	108.80	183.30	201.9
Wt. of Can + dry of specimen (B), gm	83.7	93.80	103.00	94.20	110.30	104.80	112.2	94.3	156.80	172.20
Wt. of Water (A-B), gm	9.40	10.70	12.75	12.60	16.5	16.70	16.70	14.5	26.50	29.7
Wt. of Can (C) gm	25.40	27.40	30.30	24.80	27.40	22.90	34.50	27.40	40.70	40.00
Wt. of dry Specimen (B-C), gm	58.30	66.40	72.70	69.40	82.70	81.90	77.70	66.90	116.10	132.20
Moisture Content m = (A-B)/(B-C), %	16.13	16.11	17.34	18.16	19.95	20.39	21.49	21.67	22.83	22.47
Average Moisture Content %	16.12		17.45		20.17		21.58		22.65	

Density Determination

Wt. of Wet Material + Mold (X), Kg	5.92	5.99	6.10	6.12	6.07
Wt. of Mold (Y), Kg	4.284	4.284	4.284	4.284	4.284
Wt. of Material in Mould (W=X-Y), Kg	1.64	1.71	1.82	1.84	1.79
Volume of Mould (V), m^3	0.000941	0.000941	0.000941	0.000941	0.000941
Wet Density (γ_{wet} =W/V) Kg/m^3	1743.64	1818.06	1935.01	1956.28	1903.12
Dry Density γ_{dry} = (γ_{wet})/(1+m/100), kg/m^3	1501.58	1546.76	1613.18	1607.86	1553.95

NOTE : 1 kg/m^3 = 0.06243 lb/cft, 1 Kg = 2.2046 lb, 1 m^3 = 35.3147 cft.


1730
1725
1720
1715
1710
1705
1700
DryDensity
11.00
12.00
17.00
Moisture Content

TEST REPORT 14

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
CENTRAL QUALITY CONTROL UNIT
Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

FIELD DENSITY AND % COMPACTION DETERMINATION BY SAND-CONE TEST

Client : Managing Director, PDL | Ref. No. & Date : Nil
Scheme : Finishing Shed | Location : Grid line 12&13
Description of Materials : | Test Date : 26.8.17
Apparatus No. : 1 Sand Cone # 1 | Base Plate # 1
Lab. Reg. No. : lged/c-Lab/ | Road layer:

Location of test	Station/Chainage		Grid 12& 1	460m	265m	202m	51m			
	Offset		L/S	C/L	R/S	C/L	L/S			
	Depth below		900 mm	0.375m	0.5m	0.6m	top			
	Area/Length represented	From	below PL							
		To								
Tests No.			1	2	3	4	5			
Wt. of Jar + Sand (Initial)		(kg)	8.602	8.322	8.250	8.218	8.152			
Wt. of Jar + Sand (Final)		(kg)	4.764	4.260	4.496	3.903	4.417			
Wt. of Sand in Hole+Con		(kg)	3.838	4.062	3.754	4.315	3.735			
Wt. of Sand in Cone & Pl		(kg)	1.226	1.226	1.226	1.226	1.226			
Wt. of Sand in Hole		(kg)	2.612	2.836	2.528	3.089	2.509			
Unit Wt. of Calibrated Sa		(kg/m	1291	1291	1291	1291	1291			
Volume of Hole		(m3)	0.00202	0.00220	0.00196	0.00239	0.00194			
Wt.of Wet Soil + Can		(kg)	3.820	4.190	3.299	4.395	3.306			
Wt. of Can		(kg)	0.000	0.000	0.000	0.000	0.000			
Wt. of Wet Soil		(kg)	3.820	4.190	3.299	4.395	3.306			
Wt. Unit Wt. of Soil		(kg/m	1888.1	1907.4	1684.7	1836.8	1701.1			
Can No.			2	7	6	11	8			
Wt. of Can + Wet Soil		(gm)	364.6	217.6	152.4	194.0	161.2			
Wt. of Can + Dry Soil		(gm)	307.1	189.0	133.1	164.6	151.0			
Wt.of Water		(gm)	57.5	28.6	19.3	29.4	10.2			
Wt. of Can		(gm)	51.6	24.1	28.0	27.0	25.0			
Wt. of dry Soil		(gm)	255.5	164.9	105.1	137.6	126.0			
Moisture Content		(%)	22.5	17.3	18.4	21.4	8.1			
Optimum Moisture Conte		(%)	17..5	17..5	17..5	17..5	17..5			
Dry density		(kg/m	1541	1625	1423	1513	1574			
Max. Dry Density		(kg/m	1725	1725	1725	1725	1725			
Degree of Compaction.		(%)	89	94	83	88	91			

Tested by : Md. Yusuf Ali

Supervised by :

(Md. YUSUF Ali)
Laboratory Technician (QC)
Central Quality Control Unit, LGED

(Md. Khorshad Alam)
Assistant Engineer (QC)
Central Quality Control Unit, LGED

(Md. Maniruzzaman)
Executive Engineer (QC)
Central Quality Control Unit, LGED

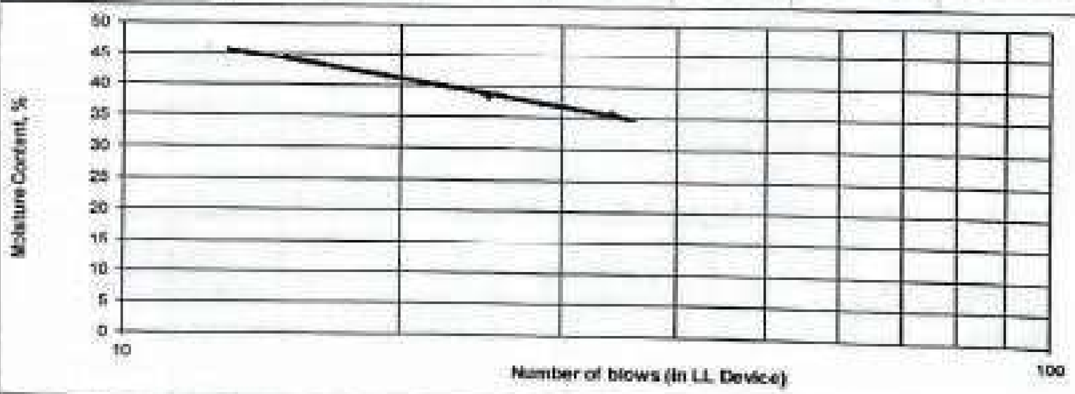
TEST REPORT 15

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
CENTRAL QUALITY CONTROL UNIT
Agargaon, Sher-e-Bangla Nagar, Dhaka-1207

ATTERBERG LIMIT TEST, IDENTIFICATION OF SOIL & IT'S NATURE

Client : Additional Chief Engineer (Imp.)		Ref. No. :	Date
Scheme : Juniadah GPS ,Kushtia		Location :	Brahmanpara
Borehole No : 2	2 m	Sampled by : UE/	
Visual Identification :		Soaking : Soaked (Overnight).	
Specimen Preparation : Dry-Prep.		Type of Test : 3-Point / LL Device	
Test Performed on Material : Passing No. 40 Sieve		Sampled Date : Not mention	
Lab. Reg. No. : LGED/C-Lab		Test Date:	9.7.19

TEST	LIQUID LIMIT TEST				Plastic Limit Test	
Moisture Can No.	10	0	22		40	33
Wt. of Can + Wet Specimen (A), gm	42	47.6	37.3		34.9	22.6
Wt. of Can + Dry Specimen (B), gm	35.8	41.9	31.9		34.0	21.9
Wt. of Water (A-B), gm	6.2	5.7	5.4		0.9	0.7
Wt. of Can (C), gm	18.4	27	19.7		27.8	16.5
Wt. of Dry Specimen (B-C), gm	17.4	14.9	12.2		6.2	5.4
Moisture Content (w={(A-B)/(B-C)}x100), %	35.6	38.3	44.3		14.5	13.0
Penetration in Cone Penetrometer (D), mm					Average Moisture Cont	
Blows in the Liquid Limit Device (N), No.	34	25	15		= 14%	



Liquid Limit :	38%	Natural Moisture Content :
Plastic Limit :	14%	Over Consolidation Ratio :
Plasticity Index :	24%	Nature : Normally-Consolidated / Over-Consolidated.

Tested by: Al- Amin, Lab. Technician

(Al -Amin)
Laboratory Technician
Consultant Part

(Md. Khorshed Alam)
QC & Material Engineer
Consultant Part

(Md. Tarikuzzaman)
Executive Engineer (QC)

TEST REPORT 16

যন্ত্রকৌশল বিভাগ
বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়
ঢাকা-১০০০, বাংলাদেশ

Department of Mechanical Engineering
Bangladesh University of Engineering and Technology
Dhaka-1000, Bangladesh

010050
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TEST REPORT OF ELASTOMERIC BEARING PAD

06 June 2017

Sample Supplied by : Mirza Md. Iftekhar Ali, Executive Engineer, LGED, Magura.
Supplier's Reference : স্মারক নং- [illegible] Dated: 18.05.2017
University Reference : BRTC NO. 1101-36524/ME/16-17; Dated: 21.05.2017
Project Description : "বৃহত্তর যশোর জেলা অবকাঠামো উন্নয়ন (যশোর, ঝিনাইদহ, মাগুরা, ও নড়াইল জেলা) শীর্ষক প্রকল্প" এর আওতায় অত্র জেলার সদর উপজেলাধীন Construction of 54.00 m Long RCC Girder Bridge on Atharokhada Motban-Shibrampur Road Over Noboganga River at Ch. 75.00m কাজে ব্যবহার।

TEST RESULTS

1. HARDNESS TEST
Standard Used: ASTM D-2240

Surface of the Bearing Pad	Hardness at Different Points (Shore-A Durometer)	Hardness (Median Value) (Shore-A Durometer)	Acceptable Range of Hardness of Medium Category Elastomer (Shore-A Durometer)*	Remarks
Top	61, 62, 63, 63, 65	63	60 ± 5	Conforms to the general requirement criteria.
Bottom	62, 63, 64, 64, 65	64	60 ± 5	

2. TEST OF COMPRESSION SET FOR 22 HOURS AT 100°C
Standard used: ASTM D-395 (Method-B)

No. of Specimen	Average Compression Set (%)	Maximum Specified Limit (%)*	Remarks
2	45	35	Does not conform to the general requirement criteria.

3. TEST OF TENSILE STRENGTH
Standard used: ASTM D-412

Specimen	Tensile Strength (MPa)	Average Tensile Strength (MPa)	Minimum Specified Strength (MPa)*	Remarks
3	30.4, 30.4, 30.9	30.6	15.5	Conforms to the general requirement criteria.

4. TEST OF ULTIMATE ELONGATION
Standard used: ASTM D-412

Specimen	Ultimate Elongation (%)	Average Ultimate Elongation (%)	Minimum Specified Elongation (%)*	Remarks
3	692, 733, 740	722	350	Conforms to the general requirement criteria.

5. TEST OF SHEAR MODULUS
Standard used: ASTM D-4014

No. of Specimen Tested	Average Shear Modulus (MPa)	Specified Acceptable Range (MPa)*	Remarks
2	1.21	0.93 – 1.43	Conforms to the general requirement criteria.

6. VULCANIZED BOND TEST (PEEL STRENGTH)
Standard Used: ASTM D-429, Method: B

Average Peel Strength (kN/m)	Minimum Specified Limit (kN/m)**	Remarks
10.5	7.0	Conforms to the general requirement criteria.

Contd. Page-2

Professor and Head
Mechanical Engg. Deptt.
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যন্ত্রকৌশল বিভাগ
বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়
ঢাকা-১০০০, বাংলাদেশ

Department of Mechanical Engineering
Bangladesh University of Engineering and Technology
Dhaka-1000, Bangladesh

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JUN 2017

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Supplier's Reference [illegible] Dated: 16.05.2017
University Reference BRTC NO. 1101-36524/ME/16-17, Dated: 21.05.2017

7. TEST OF HEAT PERSISTENCE
Standard used: ASTM D-573

(a) Heat Persistence Test of Hardness after thermal Aging at 100°C for 70 hours

Median Hardness after thermal aging (Shore-A Durometer)	Median Hardness at 23°C (Shore-A Durometer)	Change in Hardness due to thermal aging (Shore-A Durometer)	Maximum Specified Change in Hardness (Shore-A Durometer)*	Remarks
69	63	+6	±15	Conforms to the general requirement criteria

(b) Heat Persistence Test of Tensile Strength after thermal Aging at 100°C for 70 hours

No. of Specimen tested	Average Tensile Strength at 23°C (MPa)	Average Tensile Strength after thermal aging (MPa)	Change in Tensile strength due to thermal aging (%)	Maximum Specified Change in Tensile Strength (%)*	Remarks
3	20.5	21.4	+4.4	±15	Conforms to the general requirement criteria

(c) Heat Persistence Test of Ultimate Elongation after thermal Aging at 100°C for 70 hours

No. of Specimen	Average Ultimate Elongation at 23°C (%)	Average Ultimate Elongation after thermal aging (%)	Change in Ultimate elongation due to thermal aging (%)	Maximum Specified Change in Elongation (%)*	Remarks
3	722	692	-4.2	-40	Conforms to the general requirement criteria

* Acceptability limit is in accordance with the requirement of Bangladesh Railway (BR)/Jamuna Bridge Access Road Project.
** Acceptability limit is in accordance with ASTM D 2000.

Dr. M. Mahbubur Razzaque
Professor

Dr. Aloke Kumar Mozumdar
Professor

Professor and Head
Mechanical Engg. Dept.
BUET, Dhaka

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TEST REPORT 17

Concrete Mix Design

Location:

Mix Design for Superstructure

Design Strength =	30	Mpa
Safety Margin =	8.5	Mpa
Target Mean Strength =	38.5	Mpa

Cement = 490 kg/m3

Brand =

Specific Gravity = 3.15

Coarse Aggregate

Nominal Minimum size : 20mm down stone chips

SSD Bulk Specific Gravity:	2.7	
% of water Absorption Capacity:	0.8	%
Unit Weight :	1528	kg/m3

Fine Aggregate

SSD Bulk Specific Gravity =	2.6	
% of water Absorption Capacity:	2.1	%
Unit Weight :	1485	kg/m3
Fineness Modulus :	2.7	

Admixture

Admixture Name =

Specific Gravity = 1.22

Admixture Content = 0.5 % of Cement

Water

Water Type: Portable Water

Water/ cement ratio =	0.4

Mix Design Calculation:

SL No	Description	Specified Limit	Proposed Limit
1	Cement Content	490 Kg/m3	490 Kg/m3
2	Water Content	490* 0.4	196 Kg/m3
3	Air Void	2 %	0.02
4	Admixture	490* 0.5	2.450 Kg/m3

Mix Design Calculation:

Volume of Cement=	0.1556	m3
Volume of Water=	0.196	m3
Volume of Admixture=	0.0020	m3
* Volume of Entrapped Air =	0.02	m3
Total Volume of Paste in Concrete	0.3736	m3

Therefore Solid Volume of Aggregate : 0.6264 m3

Blending Proportion of FA:CA = 35 : 65

Volume of Fine Aggregate: 0.2193 m3

Volume of Coarse Aggregate: 0.4072 m3

Ingredients	Absolute Volume (m3)	Specifice Gravity	Specific Gravity *1000	Absolute Weight (kg)
Cement	0.1556	3.15	3150	490
Water	0.196	1	1000	196
Admixture	0.0020	1.22	1220	2.45
Fine Aggregate	0.2193	2.6	2600	570.06
Coarse Aggregate	0.4072	2.7	2700	1099.40

0.9800 0.9800

Ingredient	Cement	Fine Aggregate	Coarse Aggregate
Weight	490	570.06	1099.40
Proportion	1	1.16	2.24

Per cum concrete ingredient proportion (by volume)

cement= 1 bag =50 kg 0.0354 m3

Fine Aggregate : 0.0392 m3

Coarse Aggregate : 0.0734 m3

Ingredient	Cement	Fine Aggregate	Coarse Aggregate
Volume	0.0354	0.0392	0.0734
Proportion	1	1.11	2.07
	1.25	1.38	2.59

For laboratory Trial batch

Volume of One Cylinder = 0.0016 m3

No of Cylinder = 7

Concrete taken with 5% extra = 0.0115 m3

Cement	5.6544	kg
Water	2.2617	kg
Admixture	28.0000	ml
Fine Aggregate	6.5782	kg
Coarse Aggregate	12.6865	kg

For 1 bag cement total casting material

Cement	50.0000	kg
Water	20.0000	kg
Admixture	204.0000	ml
Fine Aggregate	69.0000	kg
Coarse Aggregate	129.0000	kg

TEST REPORT 17 (c)

Size of Ferra as per Mix Design Trial					
Fine Aggregate			**Coarse Aggregate**		
Length of Ferra =	300	mm	Length of Ferra =	300	m
Width of Ferra =	300	mm	Width of Ferra =	300	m
Height of Ferra =	H		Height of Ferra =	H	
Volume of Fine Aggregate =		0.0392	Volume of Coarse Aggregate =		0.
Height of Ferra =	0.4352		Height of Ferra =	0.8158	
Height of single ferra =	145.000	mm	Height of single ferra =	135.000	m
No of Ferra required =	3		No of Ferra required =	6	

TEST REPORT 18

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET

DEPARTMENT OF CIVIL ENGINEERING

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BRTC Bureau of Research, Testing & Consultation

STRENGTH OF MATERIALS LABORATORY

Calibration of Hydraulic Jack

BRTC No.: 1103-45047/CE/24-25 — Date: 22.02.2025

Reference : Letter — Date: 21.02.2025

Client: Alliance Trading Corporation

Project: Baraiyarhat Heanko - Ramgarh Road

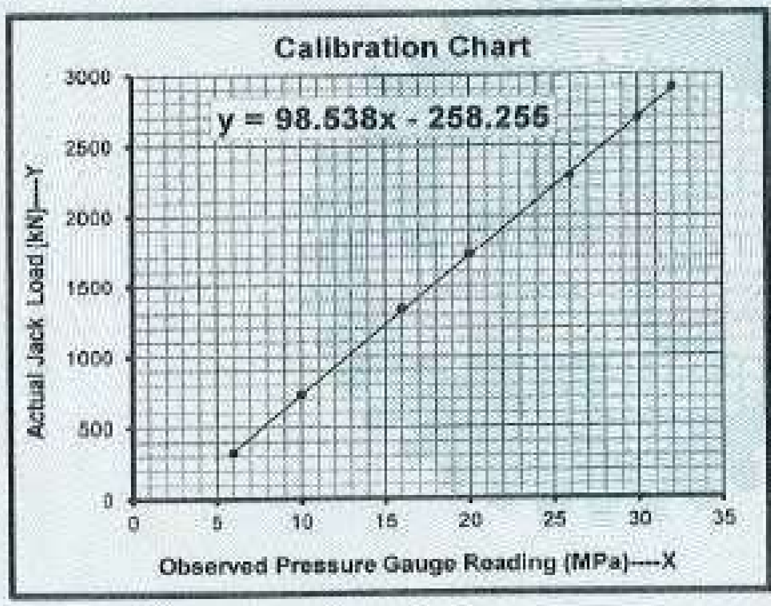
Machine: Hydraulic Jack, ID: L806046 (Capacity: 500 Ton)

Jack Information: Piston Diameter: 340 mm; Body Diameter: 495 mm; Body Height: 435 mm

Pressure Gauge: Range: 0-100 MPa **Gauge ID:** HC 68610688213 (HONGQI)

Calibration Device: Load Column: ELE 1052-10-6096 (3000 kN)

Date of Calibration: 24.02.2025 **Pump:** Motorized **Pump ID:** 806396



Pressure Gauge Reading (MPa)	Actual Jack Load (kN)	Calibrated Jack Load (kN)
6	322.30	332.97
10	730.84	727.13
16	1334.61	1318.35
20	1718.32	1712.51
26	2282.59	2303.73
30	2694.51	2697.89
32	2904.42	2894.96

Note: Note: 1 Ton (long) = 9.96402 kN, 1 ton (short) = 8.89644 kN & 1 tonne (metric ton)= 9.80665 kN;

Warning: Calibration is valid only when the above mentioned **Jack and Pressure Gauge** pair are used together as they are calibrated. Re-calibration shall be needed if any of the above Jack or Pressure Gauge is changed/replaced or repaired.

Countersigned by :

Prof. Dr. Moazzem Hossain
Test-in-Charge
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Calibrated by :

R Mutsuddy 25/2/2025

Dr. Rupak Mutsuddy
Associate Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

BUETCE 0531540

TEST REPORT 18 (a)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)

DEPARTMENT OF CIVIL ENGINEERING

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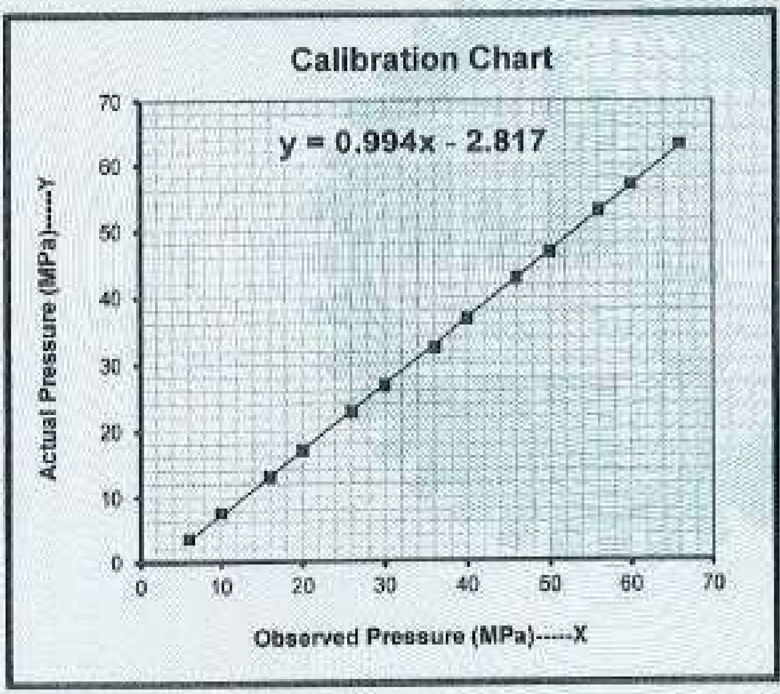
BRTC Bureau of Research, Testing & Consultation

STRENGTH OF MATERIALS LABORATORY

Calibration of Pressure Gauge

BRTC No.:	1103-45047/CE/24-25	Date: 22.02.2025
Reference:	Letter	Date: 21.02.2025
Sent By:	Alliance Trading Corporation	
Project:	Baraiyarhat Heanko-Ramgarh Road	
Equipment:	Pressure Gauge: MC/HONGQI, ID: HC68610688213 (Inscribed on dial)	
Range:	0-100 MPa	
Date of Calibration:	23.02.2025	



Observed Pressure (MPa)	Actual Pressure (MPa)	±% Error
6	3.50	71.43%
10	7.50	33.33%
16	13.00	23.08%
20	17.00	17.65%
26	22.85	13.79%
30	26.75	12.15%
36	32.55	10.6%
40	36.65	9.14%
46	42.85	7.35%
50	46.75	6.95%
56	53.00	5.66%
60	56.95	5.36%
66	63.10	4.91%

Note: Pressure Gauge was received in unsealed condition.

Countersigned by :

Prof. Dr. Moazzem Hossain
Test-In-Charge
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Calibrated by :

RMutsuddy 26/2/2025

Dr. Rupak Mutsuddy
Associate Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Department of Civil Engineering BUET, Dhaka-1000, Bangladesh

TEST REPORT 18 (b)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)

DEPARTMENT OF CIVIL ENGINEERING

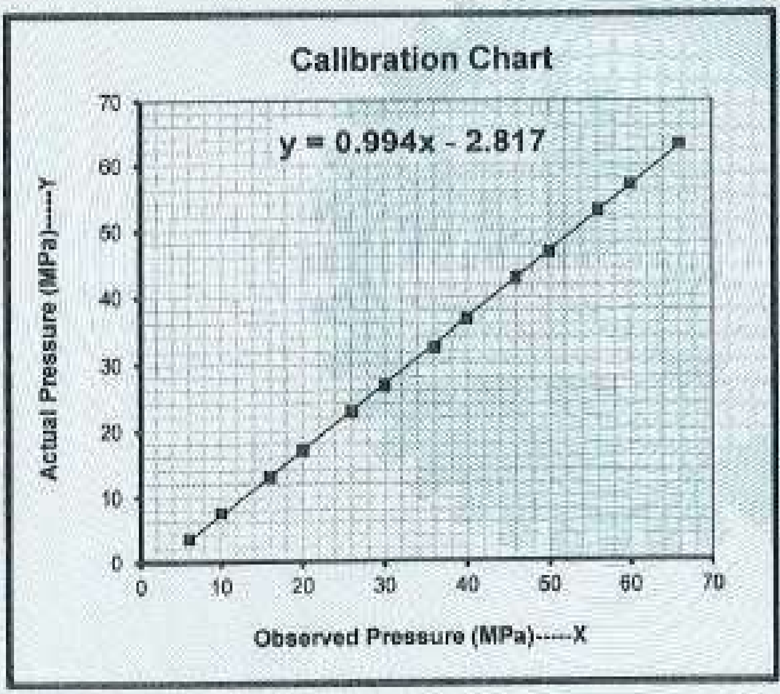
Mobile: 01819 557 964; PABX: 906 5650-80 Ext. 7226; www.buet.ac.bd/ce/

BRTC
Bureau of Research, Testing & Consultation

STRENGTH OF MATERIALS LABORATORY

Calibration of Pressure Gauge

BRTC No.:	**1103-45047/CE/24-25**	Date: **22.02.2025**
Reference:	Letter	Date: **21.02.2025**
Sent By:	Alliance Trading Corporation	
Project:	Baraiyarhat Heanko-Ramgarh Road	
Equipment:	Pressure Gauge: MC/HONGQI, ID: HC68610688213 (inscribed on dial)	
Range:	**0-100 MPa**	
Date of Calibration:	**23.02.2025**	



Observed Pressure (MPa)	Actual Pressure (MPa)	±% Error
6	3.50	71.43%
10	7.50	33.33%
16	13.00	23.08%
20	17.00	17.65%
26	22.85	13.79%
30	26.75	12.15%
36	32.55	10.6%
40	36.65	9.14%
46	42.85	7.35%
50	46.75	6.95%
56	53.00	5.66%
60	56.95	5.36%
66	63.15	4.51%

Note: Pressure Gauge was received in unsealed condition.

Countersigned by :

Prof. Dr. Moazzem Hossain
Test-In-Charge
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Calibrated by :

RMutsuddy 26/2/2025

Dr. Rupak Mutsuddy
Associate Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Department of Civil Engineering BUET, Dhaka-1000, Bangladesh

TEST REPORT 19

BUETCE 0406.250

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)
DEPARTMENT OF CIVIL ENGINEERING
Mobile: 01819557964; PABX: (8802) - 55167100, 55167228-57 Ext. 7226, Info: http://brtcbuet.ac.bd/
STRENGTH OF MATERIALS LABORATORY

BRTC Bureau of Research, Testing & Consultation

TENSION TEST OF 7-WIRE PRE-STRESSING STRAND (ASTM A416/A416M)

BRTC No.: 1102-88210/ 22-23 / CE; Date: 5/4/2023

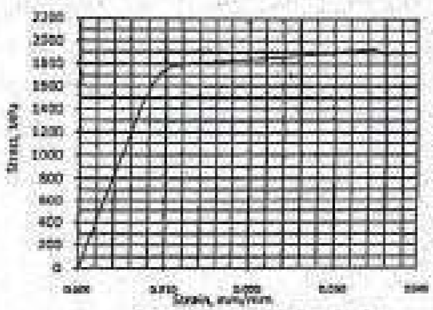
Sent by: Md. Feyjul Haque
Executive Engineer, LGED, Manikganj

Reference: Memo No-46.02.5600.000.14.01.23-1090; Date: 27/3/2023
Date of Test: 5/4/2023

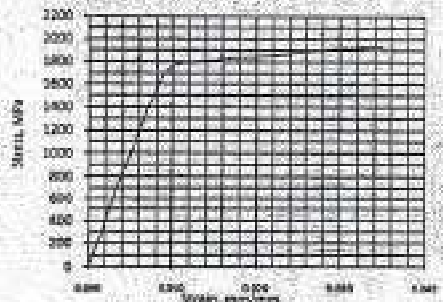
Project: Construction of 90m Prestressed Girder Bridge under GDP-3 Project (Package No-GDP-3/MA-32)

Contractor/Supplier/Manufacturer: -

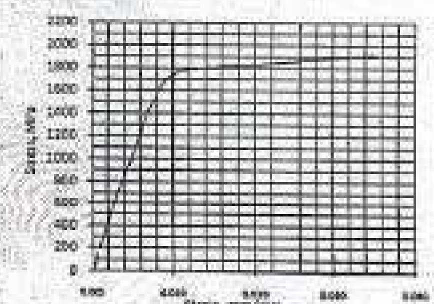
Serial Number	Identification Mark	Nominal Diameter	Cross Sectional Area	Actual Unit Weight	Average Actual Unit Weight	Yield or Proof Load	Average Yield or Proof Load	Ultimate Load / Breaking Load	Average Ultimate / Breaking Load	Elongation (%) (Gauge Length = 600 mm)
		mm	mm^2	kg/m	Kg/m	KN	KN	KN	KN	
1	-	12.70	101.00	0.753		177		198		3.5+
2	-	12.70	101.00	0.752	0.793	177	177	198	198	3.5+
3	-	12.70	101.00	0.753		176		198		3.5+



Stress-Strain Curve for Sample - 1



Stress-Strain Curve for Sample - 2



Stress-Strain Curve for Sample - 3

Sample	Young's Modulus (MPa)	Average Young's Modulus (MPa)
1	198000	
2	198000	197800
3	197500	

Standard Requirements of ASTM A416/A416M

Grade	Nominal Diameter (mm)	Minimum Yield Strength at 1% Extension (kN)	Minimum Breaking Strength (kN)	Minimum Elongation (%)
250	12.70	144.1	160.1	3.5
270	12.70	165.3	183.7	3.5

Note: Samples were received in sealed condition

Countersigned by:

Prof. Dr. Hasib Mohammed Ahsan
Test-In-Charge, Dept. of Civil Engg.

Test Performed by:

09/04/2023

Dr. S. M. Faisal Mahmood
Assistant Professor, Dept. of Civil Engg.

Important Notes: Samples as supplied to us have been tested in our laboratory. BRTC does not have any responsibility as to the representative character of the samples required to be tested. It is recommended that the samples are sent in a secure and sealed cover/packet/container under signature of the competent authority. In order to avoid fraudulent fabrication of test results, it is recommended that all test reports be collected by duly authorized person, and not by the Contractor/Supplier.

TEST REPORT 20

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)

DEPARTMENT OF CIVIL ENGINEERING

Mobile: 01819557964; PABX: (8802) - 55167100, 55167228-57 Ext. 7225, Info: http://brtc.ce.buet.ac.bd/#/home; Report verification: http://verify.ce.buet.ac.bd

BRTC Bureau of Research Testing & Consultation

STRENGTH OF MATERIALS LABORATORY

TENSION TEST OF 7-WIRE PRE-STRESSING STRAND(ASTM A416)

BRTC No.: 1102-52063/ 20-21 / CE; Date: 19/1/2022

Reference: Memo No.: 46.02.2600.000.99.005.18-292; Date: 13/1/2022

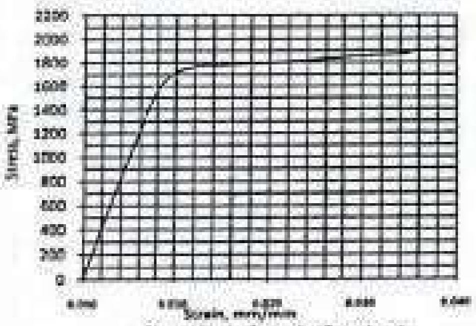
Date of Test: 24/1/2022

Contractor/Supplier: SEL-UDC (JV), Monipura, Tejgaon, Dhaka

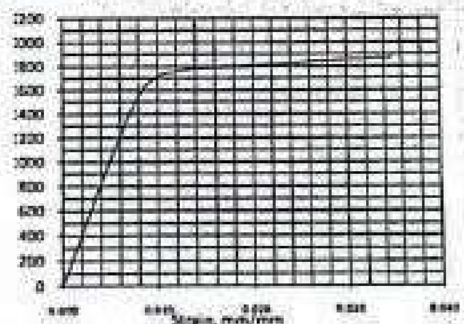
Sent by: জনাব বি. এম. মুজিবর রহমান,
নির্বাহী প্রকৌশলী, [illegible] (এলজিইডি), ৬২, পশ্চিম আগারগাঁও, ঢাকা-১২০৭।

Project: [illegible] ''[illegible]-২'' প্রকল্পের আওতায় ৪) [illegible] মিটার [illegible] ৪২ মিটার দীর্ঘ পিসি গার্ডার ব্রীজ নির্মাণ কাজ। (সূত্র: [illegible], তারিখ: [illegible])

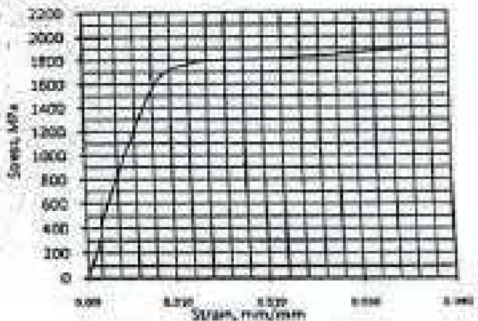
Serial No.	Identification Mark	Nominal Diameter	Cross Sectional Area	Actual Unit Weight	Average Actual Unit Weight	Yield or Proof Load	Average Yield or Proof Load	Ultimate Load	Average Ultimate Load	Elongation (%) (Gauge Length = 600 mm)
		mm	mm^2	kg/m	kg/m	kN	kN	kN	kN	
1	-	15.24	142.3	1.117	1.118	244	245	274	274	3.5+
2	-	15.24	142.7	1.121		245		275		3.5+
3	-	15.24	142.1	1.116		245		274		3.5+



Stress-Strain Curve for Sample - 1



Stress-Strain Curve for Sample - 2



Stress-Strain Curve for Sample - 3

Sample	Young's Modulus (MPa)	Average Young's Modulus (MPa)
1	197900	198400
2	198000	
3	199400	

Standard Requirements of ASTM A416/A416M

Grade	Nominal Diameter (mm)	Minimum Yield Strength at 1% Extension (kN)	Minimum Breaking Strength (kN)	Minimum Elongation (%)
250	15.24	216.2	240	3.5
270	15.24	234.6	260	3.5

Note: Samples were received in sealed condition

Department of Civil Engineering • BUET, Dhaka-1000, Bangladesh

Countersigned by:

Dr. A. B. M. Badruzzaman
Professor, Dept. of Civil Engg.

Test Performed by:

30/01/2022

Md. Ruhul Amin
Assistant Professor, Dept. of Civil Engg.

Important Notes: Samples as supplied to us have been tested in our laboratory. BRTC does not have any responsibility as to the representative character of the samples required to be tested. It is recommended that the samples are sent in a secure and sealed cover/packet/container under signature of the competent authority. In order to avoid fraudulent fabrication of test results, it is recommended that all test reports be collected by duly authorized person, and not by the Contractor/Supplier.

TEST REPORT 21

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)
DEPARTMENT OF CIVIL ENGINEERING
Mobile: 01819 557 964; PABX: 966 5650-80 Ext. 7226; www.buet.ac.bd/ce/

STRENGTH OF MATERIALS LABORATORY

BRTC Bureau of Research Testing & Consultation

TEST OF DEFORMED M.S. BARS [ASTM A 615M-16]
Sent by: Executive Engineer,LGED, 62 West Agargon, Dhaka

Project: Vumi Unnayan Office at Fulharia and Bagdania Union

BRTC No.: 1101-63032/CE/17-18; Date: 6/6/2018
Ref.: 46.02.2600.000.99.176.17/3584; Date: 5/6/2018
Date of Test: 26/6/2018

Samples were received in sealed condition.

Sl. No.	Frog Mark / Identification	Bar Desig./ Nominal dia.	Actual bar dia.	Unit Weight	Average Unit Weight	Yield or Proof Load	Yield or Proof Strength	Average Yield or Proof Strength (YS)	Tensile Load	Tensile Strength	Average Tensile Strength (TS)	TS/YS	Elongation (%) (G. length = 200 mm)	Average Elongation (%)	Bend Test (Separate samples)
		mm	mm	kg/m	kg/m	kN	MPa	MPa	kN	MPa	MPa				
1	ANWARS.60G.400	20	20.1	2.489	2.489	161	510	510 (74000 psi)	210	665	670 (97600 psi)	1.31	14	15	-
2	ANWARS.60G.400	20	20.1	2.491		162	515		212	675			15		-
3	ANWARS.60G.400	20	20.1	2.488		160	510		210	665			15		-
1	ANWARS.60G.400	16	16.0	1.583	1.577	89.4	445	448 (65000 psi)	121	605	610 (88500 psi)	1.36	19	18	-
2	ANWARS.60G.400	16	16.0	1.574		89.4	445		121	605			18		-
3	ANWARS.60G.400	16	16.0	1.575		91.4	455		125	625			17		-
1	ANWARS.60G.400	12	11.8	0.855	0.844	50.2	444	439 (63530 psi)	68	600	595 (86040 psi)	1.36	16	17	-
2	ANWARS.60G.400	12	11.6	0.833		49.3	436		66.6	590			17		-
3	ANWARS.60G.400	12	11.7	0.843		49.3	436		66.6	590			17		-
1	ANWARS.60G.400	10	10.0	0.612	0.615	36.4	461	467 (68500 psi)	46.2	585	575 (83000 psi)	1.28	10	10	-
2	ANWARS.60G.400	10	10.0	0.616		35.5	450		45.3	575			11		-
3	ANWARS.60G.400	10	10.0	0.616		36.4	461		44.4	560			10		-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-		-	-		-	-	-		-		-
-	-	-	-	-		-	-		-	-	-		-		-

Conversion factor: 1.0 MPa = 1.0 N/mm² = 145 psi

ASTM A615M-16 Weight Requirements and Nominal Area of bars (Table A1.1)

Bar desig./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 A1.1
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. [200 mm], 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

32

D7EXEHfbr

Countersigned by:
Prof. Dr. Abu Siddique, Test-in-Charge
Dept. of Civil Engg., BUET

Authenticity of the ... verifiable ... with the QR code ...

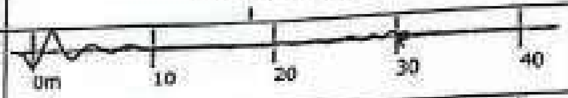
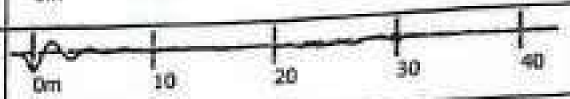
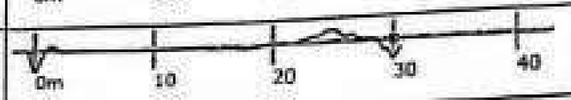
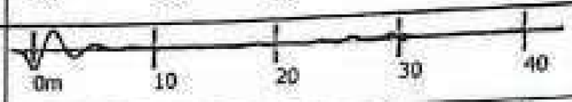
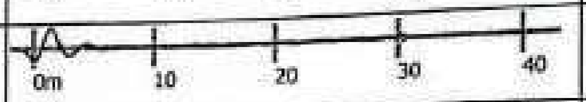
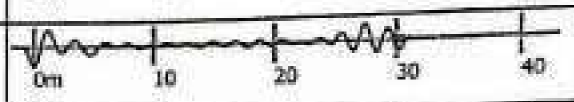
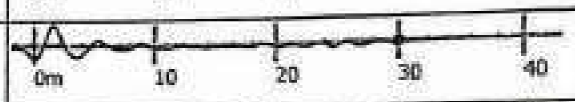
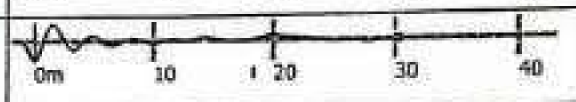
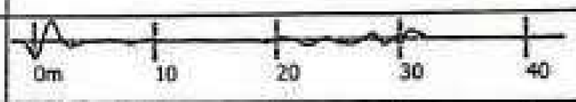
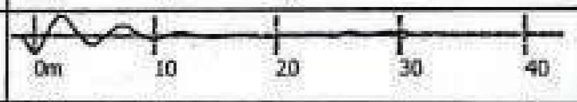
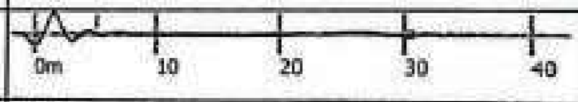
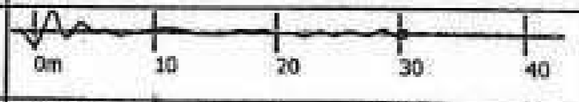
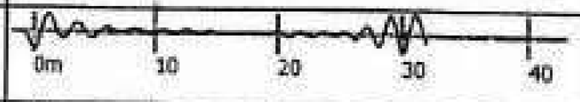
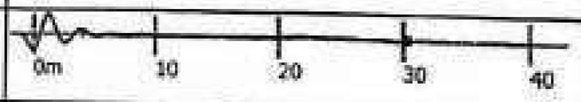
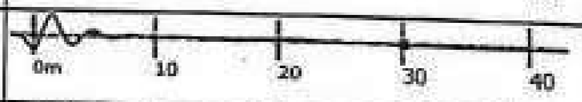
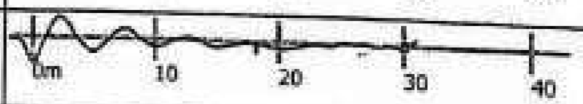
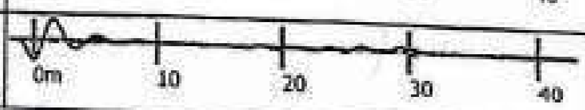
Test performed by:
Dr. M. Zakaria Ahmed
Professor, Dept. of Civil Engg.

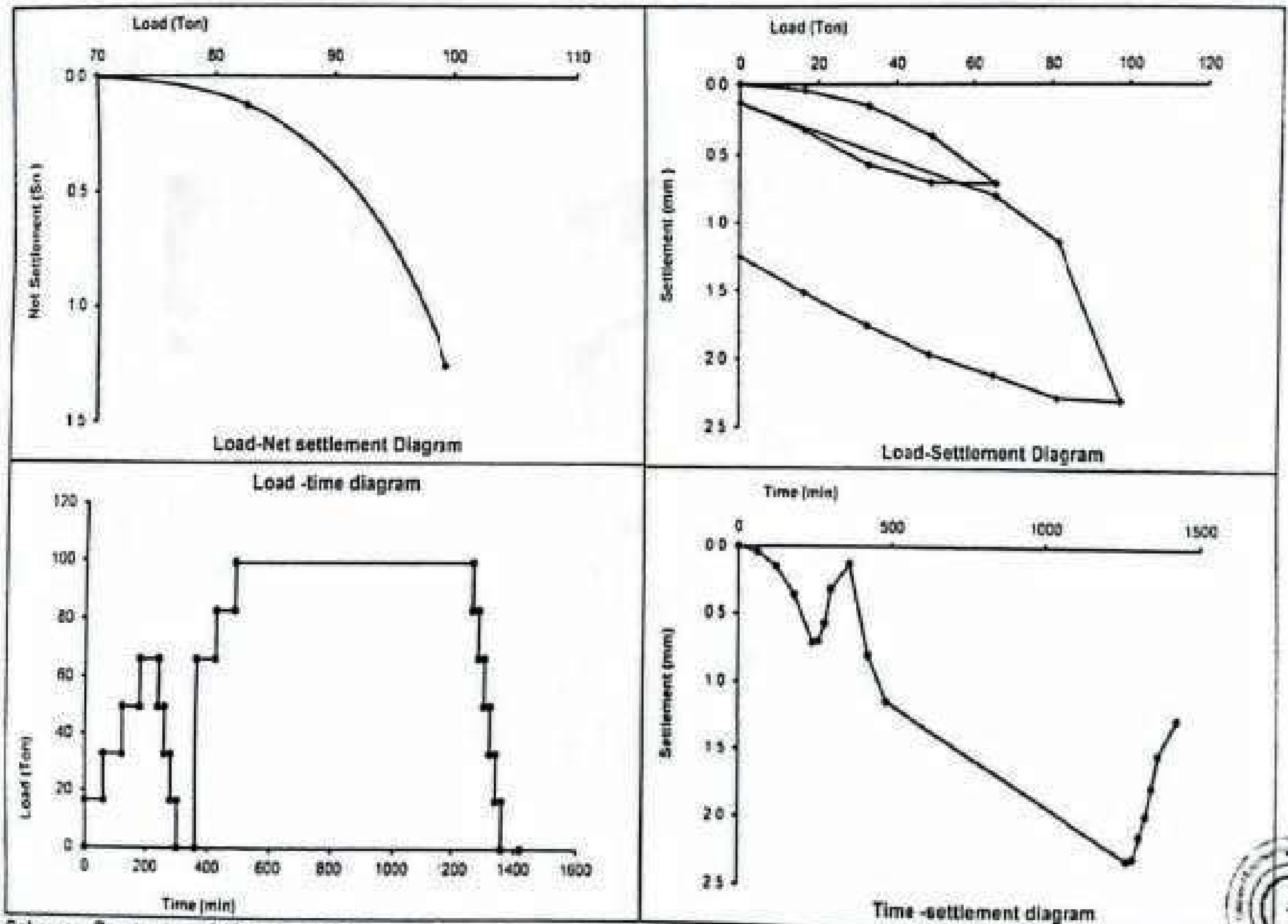
3/7/18

Important Note: Samples as supplied to us have been tested. BRTC does not have any responsibility as to the representative character of the samples required to be tested. It is recommended that the samples are sent in a secure and sealed cover/packet/container under the signature of a competent authority. In order to avoid fraudulent fabrication of test results, this report has been provided for a security purpose. It is also recommended that the test results be collected by a duly authorized person.

BUETCE 0095671

PILE INTEGRITY TEST RESULTS

Depth (m)	Details	Pile	Reflectogram	Remarks
30.6	17/07/2023 Amp:100	A1P1		
30.0	17/07/2023 Amp:100	A1P2		
30.0	17/07/2023 Amp:100	A1P3		
30.1	17/07/2023 Amp:100	A1P4		
30.1	17/07/2023 Amp:100	A1P5		
30.1	17/07/2023 Amp:100	A1P6		
30.0	17/07/2023 Amp:100	A1P7		
30.2	17/07/2023 Amp:100	A1P8		
30.0	17/07/2023 Amp:100	A1P9		
30.1	17/07/2023 Amp:100	A1P10		
30.5	17/07/2023 Amp:100	A1P11		
30.1	17/07/2023 Amp:100	A1P12		
30.1	17/07/2023 Amp:100	A1P13		
30.3	17/07/2023 Amp:100	A1P14		
30.1	17/07/2023 Amp:100	A1P15		
30.0	17/07/2023 Amp:100	A1P16		
30.1	17/07/2023 Amp:100	A1P17		



Scheme: Construction of 15.0m long RCC Girder Brdge on Tualatoli R & H to Morjal GC Road at Ch 3+387km under Raipura Upazila, District Narsingdi
Road ID 368642005

Design load 66 Ton   Test Load 99 Ton

Field View of Load Test

[illegible]	[illegible] Reading	[illegible] (min)	[illegible]	Gauge Reading (Bar)	[illegible]			[illegible]
					[illegible]	[illegible]	Average	
21.05.23	6.00 PM	--	56.00	162.9	0.80	0.70	0.75	[illegible] of Design load
		15			0.82	0.72	0.77	
		30			[illegible]	[illegible]	[illegible]	
		45			0.85	0.75	0.80	
		60			0.85	0.75	0.80	
	7.00 PM	--	62.50	188.9	1.10	1.02	1.06	125% of Design load
		15			1.14	1.06	1.10	
		30			1.16	1.08	1.12	
		45			1.17	1.09	1.13	
		60			1.18	1.10	1.14	
	8.00 PM	--	90.00	224.8	1.80	1.84	1.82	150% of Design load
		15			1.84	1.88	1.86	
		30			1.88	1.95	1.92	
		45			1.93	1.99	1.96	
		60			1.96	2.02	1.99	
		90			2.01	2.07	2.04	
		120			2.06	2.12	2.09	
		180			2.10	2.16	2.13	
22.05.23	12.00 AM	240			2.18	2.20	2.19	
		300			2.24	2.22	2.23	
		360			2.28	2.24	2.26	
		420			2.30	2.24	2.27	
		480			2.32	2.24	2.28	
		540			2.33	2.25	2.29	
		600			2.33	2.25	2.29	
		660			2.33	2.25	2.29	
		720			2.33	2.25	2.29	
		780			2.23	2.25	2.24	
	9.00 AM	--	62.50	188.9	2.21	2.23	2.22	125% of Design load
		10			2.21	2.23	2.22	
		20			2.21	2.23	2.22	

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Scanned with CamScanner

8.0 CLEANING UP

As construction work proceeds the works should be maintained in a tidy condition Surplus materials should be regularly removed from the site.

After completion of the bridgeworks, all temporary works, building, workshops and equipment which have been constructed or bought on to the site must be removed, except for those items which are needed for the performance of the maintenance and remedial work.

Temporary concrete slabs placed in work areas during construction must be broken up and removed and areas disturbed by access roads must be restored. Excess soil should be spread evenly on the site and used to fill local depressions. Topsoil and turf should be replaced if specified.

Damage fences must be reinstated to the condition at commencement of the works.

Where temporary fill has been placed as an aid to construction, especially in waterways ,the material must be recovered ,Disposed of ,and the banks returned as close as possible to the condition existing at the time of commencement of the work. Likewise, temporary anchors placed in waterways for maneuvering Floating plant must be recovered and removed from site. Temporary piles must be withdrawn or cut off at an appropriate level and removed from the site.

All parts of the work must be left in a neat and tidy condition.

9. QUALITY CONTROL CHECK LIST FOR BRIDGE CONSTRUCTION

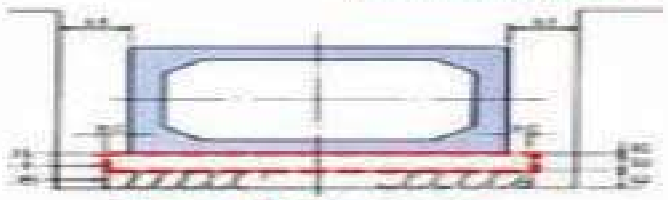
Quality Control Checklist for Bridge Construction (Annexure 2)

1. Inspector Details			
Name		Inspection Date	
Designation		Signature	
Agency			
2. Representative from Contractor			
Name		Inspection Date	
Designation		Signature	
Contractor			
3. Bridge Details			
Bridge Name		Carriageway Width	
Bridge Span		Loading Capacity	
Bridge Type		Road Name	
4. Works Inspected			
Work Description			
Remarks/Comments			

1. Substructure (Earthworks & Pile Boring)

Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
1.1	Preparatory Work	(1) Did you confirm the construction work plan? (2) Did you confirm the construction schedule?				
		(3) Did you check the benchmark of survey?				
1.2	Excavation	(1) Is the excavation slope appropriate?				
		(2) Is the disposal of excavated soil appropriate?				
		(3) Is the removal of water appropriate?				
1.3	Foundation Ground	(1) Is the foundation base firm? (2) Did you check the foundation depth? (Check the abutment top and bottom level and fill in the annexure 2.1)				

Verified By: Further Instructions Given, If Any:	
Signature:	

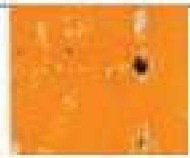
Items		Checklist	Explanatory chart	Judgment: Yes	Judgment: No	Remarks
1.6	Backfill	(1) Did you check the backfill material? (2) Is there any organic matter, such as plants, stumps, roots, mixed into the backfill material? (3) Did you confirm the soil density test results? (4) Did you confirm the compacted thickness?	  Sand Replacement Test  compacted thickness			
17.	Foundation	(1) Did you check the dimension of the foundation ground? (2) Are the compaction and gradation of stone soling sufficient? (3) Is the lean concrete (Leveling PCC) surface finished flat?	  Lean Concrete			

Verified By:

Further Instructions Given, If Any:

Signature:

2. Substructure (Formworks and Reinforcements)

Items		Checklist	Explanatory chart	Judgment		Remarks
				Yes	No	
2.1	Preparatory Concrete Work	(1) Did you confirm the concrete work plan? (2) Did you confirm the concrete mix plan? (3) Did you confirm the quality control plan? (4) Did you check the quality of cement?	 Concrete mix plan  Certificate of Cement			
2.2	Supporting	(1) Is the strength of bearing ground sufficient? (Check the firmness of the ground) (2) Are the materials being used not damaged, deformed, corroded, etc.? (3) Did you check the timing, method and procedure for removal of the support?	  Strength of bearing ground / Not damaged, deformed, corroded, etc. / Refer to the formwork for the rough judgment of the removal time.			
2.3	Formwork	(1) Are the quality and thickness of the formwork material appropriate? (2) Are there no holes, rotting or warping in the formwork? (3) Was the formwork completely cleaned, so that rust and concrete are not adhered to it?	 No Warping  No Hole  Cleaning with the brush			
		(4) Is the release agent sufficiently applied to the inner surface of the formwork? (5) Is the formwork clamping fitted appropriately? (6) Are there no asperity or gap in the formwork?	 No Warping  Clamping metal feting  Hole			

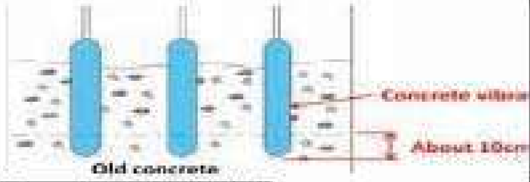
Type of Structure		Compressive strength (N/mm2)
[illegible]	Side of Footing	3.5
[illegible]	Side of pier, wall and beam	5.0
[illegible]	[illegible]	[illegible]

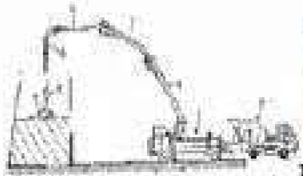
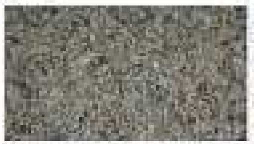
Removal Timing of Formwork source, Standard specification for concrete structures in Japan

		(7) Has the frame been constructed so that the finished shape dimensions satisfy the dimensional accuracy?				
		(8) Did you check the timing, method and procedure for removal of the formwork?				
2.4	Transport	(1) Is the supply of fresh concrete being carried out smoothly?				
		(2) Has the mixer drum been continuously rotated during transportation and standby?				
2.5	Preparation of Casting	(1) Has the formwork, rebar and concrete surface been cleaned sufficiently and kept moist? (2) Have the foot boards been properly placed so that the workers do not stand directly on the reinforcing bars or formwork during concrete casting? (3) Has the sheeting been prepared for when rain is expected? (4) When night-time concrete casting is assumed, has night lighting equipment been prepared?	 Cleaning  Watering  Concrete casting on the foot board			

Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
2.6	Reinforcing Bar	(1) Did you confirm the quality of rebar? (2) Has the rebar been stored properly? (3) Has the rebar been thoroughly cleaned? (4) Is the thickness of cover concrete been secured with an appropriate spacer? (5) Has the rebar been fixed sufficiently with binding wire? (6) Is the lap joint length appropriate?	 Rebar Certificate  Mill Sheet  Rebar does not touch the gerund  Clean the mortar attached to the rebar  Concrete Spacer  Joint Length			
		(7) Are there any other fittings not shown in the shop drawing? (8) Have joints/splices of rebar been point-welded? (9) For future additions of rebar, is the protection of exposed rebar from the structure appropriate? (10) Are the number and diameter of rebar correct?	 Check the number and diameter of rebar  Check the position and interval of rebar			
		(11) Are the position and interval of rebar appropriate? (12) Are workers not standing directly on the rebar while working?	Rebar Inspection			
		Fill the checklist form attached as annexure 2.2				
Verified By: Further Instructions Given, If Any: Signature:						

3. Substructure (Concrete)

Items		Checklist		Explanatory chart	Judgment		Remarks
					Yes	No	
3.1	Casting	(1)	Did you check the class of concrete before concrete casting?	 Certificate of delivery			
		(2)	Is the capacity and number of concrete casting machines appropriate?				
		(3)	Is the chief engineer taking control of the whole work?				
		(4)	Is the capacity and number of vibration compaction machines appropriate?				
		(5)	Are the number of workers appropriate?	As a general rule, the time from concrete mixing to the end of concrete casting must not exceed 1.5 hours when the outside temperature exceeds ℃ and not more than 2 hours when the outside temperature is below 25℃. Source: Standard specifications for concrete structures in Japan			
		(6)	Has concrete work been done in the proper time from complete of mixing to complete of concrete casting?				
		(7)	Is the location of dropping for fresh concrete appropriate?				
		(8)	Has the concrete been caste in horizontal layers when casting concrete for tall structures?				
		(9)	Is the concrete vibrator inserted in the next layer inserted up to the old concrete?	Concrete vibrator Inserted			
		(10)	Is the falling height of fresh concrete appropriated?	 Casting by Hopper  Casting by Shoot  Casting by Hose Falling height of fresh concrete			
		(11)	Has the casted concrete been sufficiently compacted with a vibrator?				

Items		Checklist	Explanatory chart	Judgment		Remarks
				Yes	No	
3.2	Casting by the Pump	(1) Is the diameter of the concrete conveying pipe appropriate? (2) Is the type of the concrete conveying pipe appropriate? (3) Has the concrete conveying pipe not been placed on rebar or formwork?				
		(4) Before concrete casting, has the mortar that passed through the concrete conveying pipe been discarded?	 Concrete pump car  Do not Plance pipers on rebar  Do not use damaged pipes			
		(5) If the transport pipe is blocked, has the fresh concrete of concrete conveying pipe been discarded?				
3.3	Casting by the Chute	(1) When using the inclined chute, is the gradient uniform and appropriate? (2) Are the location and interval of the inclined chute appropriate?	  Laitance remove by wire brushing / Laitance remove by high-pressure washing   Concrete joint face pitching			
3.4	Horizontal Concrete Joint	(1) Has the laitance been removed in the horizontal concrete joint face? (2) Is the position and direction of the concrete joint face appropriate?				
3.5	Vertical Concrete Joint	(1) Was the concrete joint face pitching carried out?				

		(2) Is the position and direction of the concrete joint face appropriate?				
3.5	Quality Control	(1) Did you check the slump, air content and temperature at concrete casting site? (2) Did you take sample pieces for concrete strength testing? (3) Does the concrete strength satisfy the reference value? (4) Is the strength of the concrete properly managed?	 Slump test Temperature check Air content test  Sample pieces for concrete strength testing Concrete compressive test			
3.6	Curing	(1) Has curing of concrete in moist conditions been carried out soon after concrete casting? (2) Has a suitable method been used for curing of concrete in moist conditions?	Average daily temperature / Curing time: More than 15°C — More than 5 days More than 10°C — More than 7 days More than 5°C — More than 9 days Curing Time Source: Standard specifications for concrete structures in Japan  Sheet Cover Curing Wet Sheet Curing Water Curing			
3.7	Winter Concreting	(1) Has the concrete casting being properly constructed when constructing in the winter?				
		(2) Has snow and ice adhered to rebar and formwork been removed before concrete casting?				
		(3) After casting concrete, are the method, period, temperature and management of curing appropriate?				
3.8	Hot Weather Concreting	(1) Is concrete casting of fresh concrete done within 1 hour after mixing?				

Verified By: Further Instructions Given, If Any: Signature:	

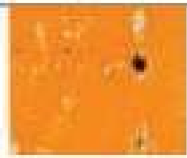
4. Substructure (Bearing)

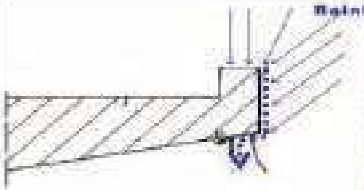
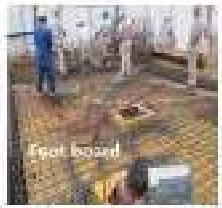
Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
4.1	Bearing					
4.2	Material	(1) Did you confirm the quality of material?	The quality of material should be confirmed by certificate.			Confirm by the certificate of quality
4.3	Production	(1) Is the dimension in accordance with the shop drawings?	 Bearing  Block out  Block out fixing			Check by the survey
4.4	Blockout	(1) Did you check the position and the size of the blockout?				Check on the site
		(2) Is the blockout firmly fixed so that it will not be pulled out easily?				Check on the site
4.5	Shoe Seat	(1) Did you check the arrangement of reinforcing bars of the shoe seat?	 Reinforcing bars of the shoe seat  Check the height & position of bearing			Compare with the shop drawing
4.6	Installation	(1) Did you check the height and position of bearing?				Check by the survey
		(2) Did you check the direction of bearing?				Check by the survey
		(3) Is the type of bearing (fixed bearing / movable bearing) in accordance with the shop drawings?	 Bearing clearance			Compare with the shop drawing
		(4) Is the bearing clearance appropriate?				Check by the survey

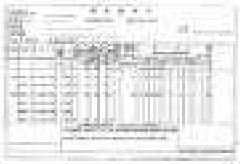
4.7	Shrinkage-compensating Mortar	(1) Is the material of shrinkage-compensating mortar in accordance with the specification? (2) Did you check whether the inside of the blockout had been cleaned? (3) Is the quality of shrinkage-compensating mortar in accordance with the specification? (4) Is the casting timing of shrinkage-compensating mortar appropriate?	The quality of material should be confirmed by certificate.  Completed shrinkage-of compensating mortar  Completed installation bearing			Confirm by the certificate of quality Check on the site Check on the site Confirm by the test result Check on the site
		(5) Is the casting method of shrinkage- compensating mortar appropriate?				Check on the site
4.8	Anchor Bolt	(1) Have the anchor bolt and set bolt been tightened sufficiently?				Check on the site

Verified By: Further Instructions Given, If Any:	
Signature:	

5. Superstructure-Concrete Bridges (Formworks and Reinforcements)

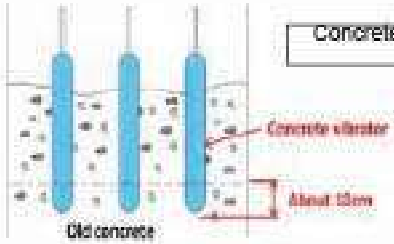
Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
5.1	Preparatory Concrete Work	(1) Did you confirm the concrete work plan? (2) Did you confirm the concrete mix plan?	 Concrete mix plan  Certificate of Cement			
		(3) Did you confirm the quality control plan? (4) Did you check the quality of cement?				
5.2	Supporting	(1) Is the strength of bearing ground sufficient? (Check the firmness of the ground)	 Strength of bearing ground   Not damaged, deformed, corroded, etc.			
		(2) Are the materials being used not damaged, deformed, corroded, etc.? (3) Is the volume of cambers allowance appropriate ? (4) Did you check the timing, method and procedure for removal of the support?				
5.3	Formwork	(1) Are the material and thickness of the form work materials appropriate? (2) Are there no holes, rotting or warping in the formwork?	 No Warping  No Hole  Cleaning with the brush			
		(3) Was the formwork completely cleaned, so that rust and concrete are not adhered to it? (4) Is the release agent sufficiently applied to the inner surface of the formwork? (5) Is the formwork clamping fitted appropriately? (6) Are there no asperity or gap in the formwork?	 No Warping  Clamping metal feting  Hole			

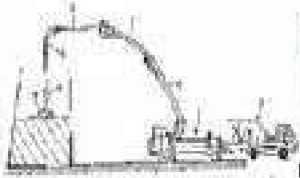
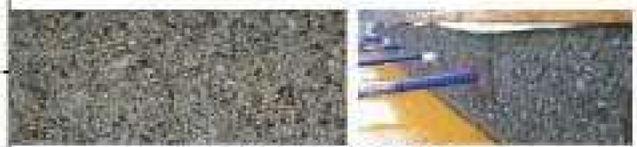
			 Removal Timing of Formwork source, Standard specification for concrete structures in Japan			
		(7) Did you check the timing, method and procedure for removal of the formwork?				
5.4	Slab Formwork	(1) Has the frame been constructed so that the finished shape dimensions satisfy the dimensional accuracy	 			
		(2) Does the undersides of the overhanging porting of the slab have a structure for the dripping water?	Structure for the dripping water			
5.5	Transport	(1) Is the supply fresh concrete being carried out smoothly?				
		(2) Has the mixer drum been continually rotated during transportation and stand by?				
5.6	Preparation of Casting	(1) Has the formwork, rebar and concrete surface been cleaned sufficiently and kept moist? (2) Have the foot boards been properly placed so that the workers do not stand directly on the reinforcing bars or formwork during concrete casting? (3) Has the sheeting been prepared for when rain is expected? (4) When night-time concrete casting is assumed, has night lighting equipment been prepared?	 Cleaning  Watering  Concrete casting on the foot board			

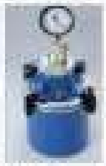
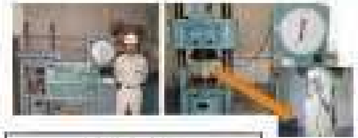
Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
5.7	Reinforcing Bar	(1) Did you confirm the quality of rebar? (2) Has the rebar been stored properly? (3) Has the rebar been thoroughly cleaned? (4) Is the thickness of cover concrete been secured with an appropriate spacer?	 Rebar Certificate  Mill Sheet  Rebar does not touch the gerund			
		(5) Has the rebar been fixed sufficiently with binding wire? (6) Is the lap joint length appropriate? (7) Are there any other fittings not shown in the shop drawing?	 Clean the mortar attached to the rebar  Concrete Spacer  Joint Length			
		(8) Have joints/splices of rebar been point-welded? (9) For future additions of rebar, is the protection of exposed rebar from the structure appropriate? (10) Are the number and diameter of rebar correct? (11) Are the position and interval of rebar appropriate? (12) Are workers not standing directly on the rebar while working?	 Check the number and diameter of rebar  Check the position and interval of rebar Rebar Inspection			

	Fill the checklist form attached as annexure 2.2
Verified By: Further Instructions Given, If Any: Signature:	

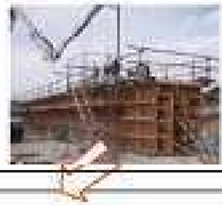
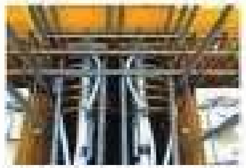
6. Superstructure-Concrete Bridges (Concrete Works)

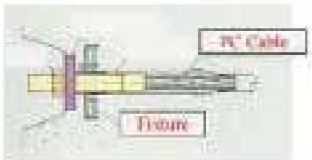
Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
6.1	Casting	(1) Did you check the class of concrete before concrete casting?	 Certificate of delivery			
		(2) Is the capacity and number of concrete casting machines appropriate? (3) Is the chief engineer taking control of the whole work? (4) Is the capacity and number of vibration compaction machines appropriate? (5) Are the number of workers appropriate?	As a general rule, the time from concrete mixing to the end of concrete casting must not exceed 1.5 hours when the outside temperature exceeds ℃ and not more than 2 hours when the outside temperature is below 25℃. Source: Standard specifications for concrete structures in Japan			
		(6) Has concrete work been done in the proper time from complete of mixing to complete of concrete casting? (7) Is the location of dropping for fresh concrete appropriate? (8) Has the concrete been caste in horizontal layers when casting concrete for tall structures? (9) Has the vibrator been inserted to the previous layer when casting the next layer of concrete? (10) Is the falling height of fresh concrete appropriate? (11) Has the casted concrete been sufficiently compacted with a vibrator?	 Concrete vibrator inserted  Casting by Hopper  Casting by Shoot  Casting by hose Falling height of freshy concreate			

6.2	Casting by the Pump	(1) Is the diameter of the concrete conveying pipe appropriate? (2) Is the type of the concrete conveying pipe appropriate? (3) Has the concrete conveying pipe not been placed on rebar or formwork? (4) Before concrete casting, has the mortar that passed through the concrete conveying pipe been discarded? (5) If the transport pipe is blocked, has the fresh concrete of concrete conveying pipe been discarded?	 Concrete pump car  Do not Plance pipers on rebar  Do not use damaged pipes			
6.3	Casting by the Chute	(1) When using the inclined chute, is the gradient uniform and appropriate?				
		(2) Are the location and interval of the inclined chute appropriate?	 Laitance remove by wire brushing  Laitance remove by high-pressure washing			
6.4	Horizontal Concrete Joint	(1) Has the laitance been removed in the horizontal concrete joint face? (2) Is the position and direction of the horizontal concrete joint face appropriate?				
6.5	Vertical Concrete Joint	(1) Is the vertical concrete joint face pitching carried out? (2) Is the position and direction of the vertical concrete joint face appropriate?	 Concrete joint face pitching			
6.5	Quality Control	(1) Did you check the slump, air content and temperature at concrete casting site? (2) Did you take sample pieces for concrete strength testing?				

		(3) Does the concrete strength satisfy the reference value? (4) Is the strength of the concrete properly managed?	   Slump test / Temperature check / air content test   Sample pieces for strength concrete testing / Concrete compressive test			
6.6	Curing	(1) Has curing of concrete in moist conditions been carried out soon after concrete casting? (2) Has a suitable method been used for curing of concrete in moist conditions?	Average daily temperature: More than 15℃ / More than 10℃ / More than 5℃; Curing time: More than 5 days / More than 7 days / More than 9 days Curing Time Source: Standard specifications for concrete structures in Japan    Sheet Cover Curing / Wet Sheet Curing / Water Curing			
6.7	Winter Concreting	(1) Has the concrete casting being properly constructed when constructing in the winter? (2) Has snow and ice adhered to rebar and formwork been removed before concrete casting? (3) After casting concrete, are the method, period, temperature and management of curing appropriate?				
6.8	Hot Weather Concreting	(1) Is concrete casting of fresh concrete done within 1 hour after mixing?				
Verified By:						
Further Instructions Given, If Any:						
Signature:						

7. Superstructure-Prestressed Bridges (Formworks and Reinforcements)

Items		Checklist		Explanatory chart	Judgment Yes	Judgment No	Remarks
7.1	Supporting	(1)	Is the structure not constraining the elastic modulus of concrete when prestressed?	 Supporting			
		(2)	When introducing prestressing, is it structured to withstand the change of the load state sufficiently?				
		(3)	When using a support with a large potential for elastic deformation, can it be adjusted with a wedge?				
		(4)	Is the volume of sinking allowance appropriate?	The camber amount is collated with calculated value and field survey value.			
7.2	Girder Production Table	(1)	Is the girder production table sufficiently solid? Has the structure been constructed such that unequal settlement does not occur due to concrete placement and the ground does not loosen due to curing water or rain?	Girder production table 			
		(2)	Is the girder production table in accordance with the construction plan?				
7.3	Formwork	(1)	Is the bottomed form a structure that does not constrain the elastic deformation of concrete during prestressing?	 Bottomed Form			
		(2)	Is the volume of sinking allowance appropriate?	The camber amount is collated with calculated value and field survey value.			
		(3)	Does the formwork have a structure that prevents mortar from leaking from joints and holes?	 			
		(4)	Is the fixing form firmly attached to the formwork?	Be Careful ul of concrete leaking from the gap; The fixing from should be firmly attached to the formwork			

		(5)	Are the time of removal of the bottomed form and inner form of box girder appropriate?				
		(6)	Is the cleaning of cross beam and/or slab concrete and girder joints appropriate?				
		(7)	Is the girder clearance appropriate?				
		(8)	Has the frame been constructed so that the finished shape dimensions satisfy the dimensional accuracy?				
7.4	PC Steel Work						
	Material	(1)	Is the material as per the standard?	The quality of material should be confirmed by certificate.			
		(2)	Is the storage of PC cable materials, fixtures and sheaths appropriate?				
		(3)	Are there significant rust and harmful scratches on the PC cable?				
		(4)	Is stacking pattern for the PC cable wire in storage area appropriate?	Storage of PC steel materials			
		(5)	Is the structure of sheath such that it is hardly being damaged during concrete casting?				
		(6)	Is the structure of the sheath water-tight during concrete casting?	 			
		(7)	Is the structure of the sheath flexible during concrete casting?				
7.5	Bending	(1)	Is the bending radius appropriate?				
7.6	Assembly [illegible] of PC Steel	(1)	Does the fixture fix at a right angle to the axis of PC cable?	Fixture should be fixed a right angle to the axis of the PC cable			
		(2)	Is the position and quantity of the PC cable in accordance with shop drawing?				
		(3)	Is the PC cable installed with a smooth curve?				

10. COMPLETION AND CLOSURE OF THE CONTRACT

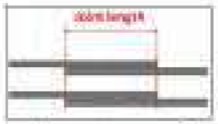
10.1. COMPLETION PROCEDURE

The completion procedures include the following main contractual events: Taking Over upon completion of the Works, Hand Over of the project to ultimate beneficiary, Defect Liability Period and Final Closure of contract.

A. Taking Over

When the Contractor considers that the Works are substantially completed he should notify the Project Manager that the works are ready for final inspection and apply for Completion

		(4)	Is the retention interval of PC cable wire appropriate?	 PC cable installed  Binding between the sheath and the holding member			
		(5)	Is the binding between the sheath and the holding member appropriate?				
		(6)	Are the connecting parts between the joint of the sheath and the fixture treated so that the mortar does not leak at the time of concrete casting?				
		(7)	Are the connecting parts between the joint of the sheath and the fixture treated so as not to be crushed at the time of concrete casting?				
		(8)	Is the PC cable not welded?	Welding for drawing, cutting and machining of PC cable wire will result in significant deterioration of the material, so it must never be done.			
		(9)	Is the sheath steel not welded?	The sheath steel should be not welded.			
		(10)	Has sufficient rebar been arranged in the fixing part?				
		(11)	Are grout injection pipes and air vent pipes securely attached to the sheath?	It is necessary to confirm that the installation position is as shown in the drawing.			
		(12)	Is the above arrangement appropriate?	It is necessary to confirm that the installation position is as shown in the drawing.			

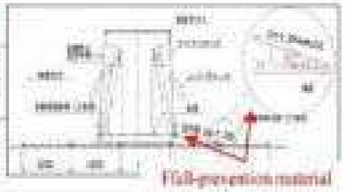
Items		Checklist		Explanatory chart	Judgment Yes	No	Remarks
7.7	Reinforcing Bar	(1)	Did you confirm the quality of rebar?	  			
		(2)	Has the rebar been stored properly?				
		(3)	Has the rebar been thoroughly cleaned?				
		(4)	Is the thickness of cover concrete been secured with an appropriate	Rebar Certificate; Mill Sheet; Rebar does not touch the ground			
		(5)	Has the rebar been fixed sufficiently with binding wire?	  			
		(6)	Is the lap joint length appropriate?				
		(7)	Are there any other fittings not shown in the shop drawing?	Clean the mortar length attached to rebar; Concrete Spacer the; Joint			
		(8)	Have joints/splices of rebar been point-welded?				
		(9)	For future additions of rebar, is the protection of exposed rebar from the structure appropriate?	 			
		(10)	Are the number and diameter of rebar correct?				
		(11)	Are the position and interval of rebar appropriate?	Check the number and diameter of rebar; Check the position and Interval			
		(12)	Are workers not standing directly on the	Rebar Inspection			

8. Superstructure-Prestressed Bridges (Prestressing and Concrete Works)

Items		Checklist		Explanatory chart	Judgment		Remarks
					Yes	No	
8.1	Concrete Work		Refer to the Common Edition (Concrete)	Refer to Concrete Edition	—	—	
8.2	Material	(1)	Is the salt concentration of fine aggregate below the specified value?				
8.3	Casting	(1)	Has concrete work been done in the proper time from completion of mixing to completion of concrete casting?	It is desirable that the time until the completion of concrete placement be within one hour.			
		(2)	During concrete casting, has there been no damage to the formwork, rebar or sheath?				
		(3)	Has the laitance been removed from the contact face between the main girder and the cross beam?				
		(4)	Has chipping of the contact face between the main girder and the cross beam been carried out?				
		(5)	Is the casting order of the concrete and the casting method appropriate?				
8.4	Curing	(1)	In the winter, is the curing method appropriate?				
		(2)	In the summer, is the curing method appropriate?				
8.5	Prestressing Work				—	—	
8.6	Preparation	(1)	Does the strength of the concrete reach the predetermined strength?				
		(2)	Is the maintenance and inspection of machine tools for tensioning appropriate?	Check the jack's ability. If the hydraulic pressure becomes unstable or the reading of the gauge cannot be determined during the tension work, stop the work immediately and perform the inspection.			
		(3)	Is the calibration performed as specified?				

Items		Checklist		Explanatory chart	Judgment Yes	Judgment No	Remarks
			(a) Just before the first pressing				
			(b) After repairing the jack and pump (c) After changing the combination of the jack and the pump				
			(d) After prestressing of 50 to 60 cables (e) When prestressing work is suspicious (f) In addition, when the supervisor instructs				
		(4)	Are the personnel necessary for tension work secured?	At least one person who has the appropriate capacity for each operation of jack / pump operation, PC steel material elongation measurement load and elongation recording will be assigned.			
8.7	Prestressing	(1) (2)	Is the order of tensioning correctly carried out? Is the prescribed tension introduced?	 Tension work			
8.8	Tension Control	(1) (2) (3)	Is the control method for tensioning properly carried out? Is the number and type of cables subject to tension testing appropriate? Does the friction coefficient of each PC cable material not exceed the control limit?	PC cable materials should be managed individual and in groups.			
		(4) (5)	Are the design elongation amount and the amount of actual elongation amount not quite different? Is the frictional loss of PC cable not abnormally large?				
8.9	Safe Control	(1)	Are there people standing behind the tension jack during tensioning?	No person should be behind the jack during or immediately after straining.			

8.10	Grouting Work						
8.11	Job Mix and Material	(1)	Is the prescribed job mix properly carried out?				
		(2)	Is the prescribed quality control test properly carried out? (under construction)	Consistency: Every 5 batches, Breathing rate: 1 time / day (3 pieces / time), Compressive strength: 1 time / day (6 pieces / time)			
		(3)	Is the admixture used of proper quality?	 Input order is water →admixture →cement →(other fine powder)			
		(4)	Does the mixing water contain harmful substances?				
		(5)	Is order of materials being added the mixer appropriate?	Consistency test of grout			
8.12	Grouting	(1)	Is grouting promptly done after prestressing?				
		(2)	Has the grout been passed through a sieve before prestressing?				
		(3)	Has the sheath been cleaned before grouting? Also, is the inside of the sheath wet enough?				
		(4)	Is the grouting pressure and grouting rate appropriate?	If the construction is done rapidly, grout will not spread and there is a risk that airspace will remain.			
		(5)	Is the grouting carried out continuously?				
		(6)	Has the backflow prevention measures been taken?				
		(7)	Is the sheath not blocked?				
		(8)	Is the grouting carried out from the lower side?	In the case of a vertical cable or a slanted cable, it is done from a low level to facilitate are bleeding.			

8.13	Curing	(1)	In winter, is the curing method appropriate?				
8.14	Storage, Transportation, Erection	(1)	Does the completed girder have a hazardous warping or twisting?				
		(2)	Is the girder storage location appropriate?				
		(3)	Is the storage method of girder appropriate?	Storage method of girder			
		(4)	When storing for a long time, are storage measures taken for the rebar and sheath holes?	Apply cement paste or the like to the reinforcing bars connected to the floor slabs and cross beams. Provide a drain hole in the cable hole in advance, or use a wooden stopper or rubber stopper to prevent water from collecting.			
		(5)	Are jack supporting brackets, hanging brackets, etc., provided on the girder?	 			
		(6)	Has the fall-prevention material and the brake been installed when moving the girder sideways?				
		(7)	Has sufficient consideration been taken for when moving the girder sideways on the upper part of the substructure? (a) Installation position of jacking bracket (b) Anchor for side movement (c) The size of the bridge seat face				
			(d) Replacement at the time of jacked down				
		(8)	Is the slope of the drawer track appropriate?	Be careful when the orbit gradient is 2% or more.			
		(9)	Are the measures for fall prevention and braking sufficient?				
		(10)	Are safety measures at the time of erection sufficient? (a) Fulcrum position of the girder (b) Transverse stability of the girder				

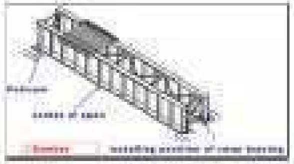
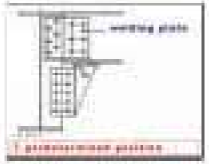
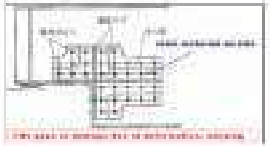
			(c) Longitudinal cant when lifting the girder				
		(11)	Are the measures for fall prevention after erection of girders sufficient?				

Verified By: Further Instructions Given, If Any: Signature:	

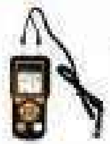
9. Superstructure-Steel Bridge

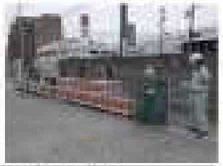
Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
9.1	Installation					
9.2	Surveying	(1) Has the center line (planar linear) been checked? (2) Has the span been checked? (3) Has the planned height been checked? (4) Has the bearing position been checked?				
9.3	Staging	(1) Are the materials being used in accordance with the construction plan? (2) Is the position appropriate? (3) Is the strength of bearing ground sufficient? (4) Is there any fear of subsidence? (5) Is there any fear of falling? (6) Is the verticality appropriate?				
9.4	Truck Crane	(1) Are the type of vehicles being used on site in accordance with the construction plan?				
		(2) Is the ground of the work yard sufficient?				

Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
9.5	Cable Crane	(1) Are the track wire, hanging wire, backstay wire, tower and crane in accordance with the construction plan? (2) Has a performance test been conducted for cranes?				
		(3) Is there any risk of subsidence of towers? (4) Is there any risk of falling/overturning of towers?				
9.6	Construction of Scaffolding	(1) Are the materials being used in accordance with the construction plan? (2) Has the scaffolding been installed in accordance with the construction plan? (3) Has the pipe joints and intersecting parts been firmly fixed? (4) Is the spacing of hanging chains appropriate? (5) Is the installation width of scaffolding appropriate?				
		(6) Is the safety net installed? (7) Is the installation of scaffolding board appropriate?				
9.7	Lateral Transfer	(1) Has the lateral transfer been done in accordance with the construction plan?				
9.8	Prevention from Side Buckling of Girders	(1) Has the prevention method for side buckling of girders been done in accordance with the construction plan?				

Items		Checklist		Explanatory chart	Judgment		Remarks
					Yes	No	
9.9	Erection Inspection	(1)	Before releasing the support work after completing temporary tightening, inspect the following items. (a) Has the cambers been checked? (fulcrum, center of span, installing position of sway bracing)	 	—	—	
			(b) Are there no gaps or damage due to deformation, warping, etc. on joint materials on site? (c) Is the welding plate in its predetermined position? (d) Has an inspection for hole misalignment been carried out?	 			
9.10	Inspection of Completed Erection	(1)	After releasing the support work and completing tightening, inspect the following items.		—	—	
		(2)	Has the cambers been checked? (fulcrum, center of span, installing position of sway bracing)				
		(3)	Rivet tightening inspection (a) Is rivet tightening appropriate? (b) Are there no pocks or cracks on rivet heads? (c) Are there no gaps between welding plate and welding plate?		—	—	
9.11	On-site Tightening of High-strength Bolts	(1)	Has the axial force gauge, torque wrench and impact wrench been used according to the construction plan?				
		(2)	Has the on-site tightening management been performed in accordance with the construction plan?				
		(3)	Have the high-strength bolts been stored and handled in accordance with the construction				

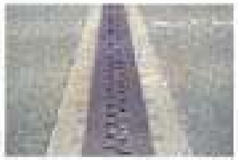
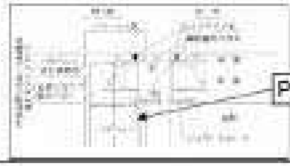
9.12	Factory Coating					
9.13	Inspection of Work Management Record	(1) Has the condition of used coating materials been checked?				
		(2) Has the work environment been checked? (3) Has the condition of coated surfaces been checked? (4) Has the appearance of coating film been checked? (5) Has the coating interval been checked? (6) Has the coating film thickness been checked?				
9.14	Appearance Inspection	(1) Appearance inspection of the parts carried on site shall be performed. (2) Is the coated surface in the factory appropriate?		——	—	
		(3) Are the parts which have not been coated in factory appropriate? (4) Are the parts which have only been coated with a primer in the factory appropriate?				
9.15	Coating on the Site			——	—	
		(4) Is the work environment in accordance with the construction plan? (5) Has the tightening for the high-strength bolts been inspected?				

Items		Checklist		Explanatory chart	Judgment		Remarks
					Yes	No	
9.16	Confirmation of Coating Materials	(1)	Do the coating materials conform to the prescribed standard?	 Certificate of Coating Material			
9.17	Inspection of Coating Film Condition before Construction	(1)	Are the condition of the surfaces coated in the factory appropriately clean?				
		(2)	Have any damaged parts of surfaces coated in the factory been appropriately repaired?				
9.18	Work Environment	(1)	Is the working environment suitable for carrying out coating work?	**Working environment** - Environmental conditions must observe the temperature paint and humidity specified for each each paint. - Do not paint in case of rain, snow or strong winds. **coating interval (re-coating)** - In the case of repeated coating of paints, the intervals specified for paint must be observed.			
		(2)	Does the coating interval (re-coating) conform to the prescribed standard?				
9.19	Inspection of Coating Film Situation after Construction	(1)	Has an inspection of the coating film and confirmation that there are no defects been carried out?	 Inspection of coating film situation after construction			
9.20	Inspection of Coating Film Thickness	(1)	Is the dried film thickness of coating film appropriate?	  Inspection of coating film thickness			

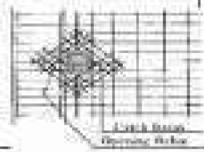
9.21	Confirmation of Used Amount of Coating Materials	(1)	Has the amount of coating materials on used site been checked?	  Coating material inspection			

Verified By: Further Instructions Given, If Any:	
Signature:	

10. Bridge-Ancillary Structure

Items		Checklist	Explanatory chart	Judgment Yes	Judgment No	Remarks
10.1	Expansion Joint					
10.2	Steel Expansion Joint					
10.3	Material	(1) Did you confirm the certificate of quality of material?	The quality of material should be confirmed by certificate.			
10.4	Production	(1) Is the dimension in accordance with shop drawing? (2) Is there no defect in welding? (3) Has the product been damaged during transportation?	  Steel expansion joint			
10.5	Installation	(1) Is the finger clearance appropriate? (2) Are the installation height and profile in accordance with shop drawing? (3) Is the paint of expansion joint appropriate? (4) Is rust removal on the concrete contact surface of the expansion joint appropriate? (5) Are the slab rebar and parapet rebar in accordance with shop drawing?	 Finger clearance  Installation height  Parapet rebar			
10.6	Concrete	(1) Did you check the class of concrete before concrete casting?				
		(2) Have the concrete joint faces been chipped, cleaned and water sprayed?	Refer to Concrete Edition			
10.7	Quality Control	(1) Did you check the slump, air content and temperature at concrete casting site?				
		(2) Did you take sample pieces for concrete strength testing? (3) Does the concrete strength satisfy the reference value?	Refer to Concrete Edition			
		(4) Is the strength of the concrete properly managed?				

Items		Checklist	Explanatory chart	Judgment		Remarks
				Yes	No	
		(5) Is the curing of concrete appropriate?				
10.8	Shrinkage-compensating Mortar	(1) Is the quality of shrinkage-compensating mortar in accordance with the specification? (2) Is the casting timing of shrinkage-compensating mortar appropriate? (3) Is the casting method of shrinkage- compensating mortar appropriate?	The quality of material should be confirmed by certificate.			
10.9	Butt, Rubber Joint					
10.10	Material	(1) Did you confirm the certificate of quality of material?	The quality of material should be confirmed by certificate.			
10.11	Production	(1) Is the dimension in accordance with the shop drawings?				
10.12	Pavement	(1) Are you protecting the finger clearance and the floor slab with steel plate, sand, etc., before paving?	Butt type rubber joint			
10.13	Removal of Pavement	(1) Are you accurately marking the cutting position? Are you accurately marking the cutting position before removing the pavement?				
10.14	Cleaning the Butt Joint	(1) Is the floor slab chipped and cleaned?	Floor slab hipped and cleaned			
10.15	Installation of Formwork	(1) Is the level adjustment bracket installed?				
10.16	Resin Mortar Layer	(1) Has the floor slab been dried enough before applying the primer?	 Resin mortal layer			

		(2) Did you confirm the resin mortar job mix? (3) Did you check the finishing height of resin mortar?	 Height of Sealing Rubber Check the height			
10.17	Set of Sealing Rubber	(1) Did you check the height of sealing rubber?				
10.18	Rubber Joint					
10.19	Installation	(1) Is the concrete joint face chipped and cleaned? (2) Did you check the installation height of the joint installation fixture?	 			
		(3) Did you check the arrangement of reinforcing bars and anchors? (4) Has the joint installation fixture been fixed firmly so as not to be displaced during concrete casting?	Rubber joint Floor slab chipped and cleaned			
10.20	Concrete	(1) Is the quality of concrete appropriate? (2) Is the curing of concrete appropriate?	Refer to Concrete Edition			
10.21	Set of Sealing Rubber	(1) Has the tightening nut been sufficiently tightened?	 			
		(2) Did you check the finishing height of sealing gum?	Joint Installation fixture a arrangement of reinforcing bars and anchors			
10.22	Drainage Apparatus					
10.23	Catch Basin					
10.24	Material	(1) Did you confirm the quality of the catch basin material?	The quality of material should be confirmed by certificate.			
10.25	Production	(1) Is the dimension in accordance with the shop drawings?	  			
10.26	Installation	(1) Did you check the position and height of the catch basin?				

Arrangement of the opening rebar

		(2) Did you check the arrangement of the rebar?				
		(3) Before paving, is catch basin sufficiently covered so that asphalt mixture cannot enter it?				
10.27	Drain Pipe					
10.28	Material	(1) Did you confirm the quality of the material?	The quality of material should be confirmed by certificate.			
10.39	Production	(1) Are the dimensions in accordance with the shop drawings?	 Drain pipe			
10.40	Installation	(1) Is the drain slope in accordance with the shop drawings?				
		(2) Is the fitting bracket painted or hot-dip galvanized? (3) Did you carry out a water flow test after completion?				
10.41	Curbstone					
10.42	Concrete	(1) Is the quality of concrete appropriate? (2) Is the curing of concrete appropriate?	Refer to Concrete Edition			
10.43	PC Products	(1) Are there no breakages, cracks or defective products in the curb installation? (2) Is the installation position in accordance with the shop drawings?				
10.45	Guard Fence					
10.46	Material	(1) Did you confirm the quality of material?	The quality of material should be confirmed by certificate.			
10.47	Production	(1) Are the dimensions in accordance with the shop drawings? (2) Is the curing of concrete appropriate?	 Guard fence			
		(3) Have no joint bolts been left out? (4) Is the installation position in accordance with the shop drawings?				
10.48	Wall Balustrade					
10.49	Concrete	(1) Is the quality of concrete appropriate? (2) Is the curing of concrete appropriate?	Refer to Concrete Edition Wall balustrade 			

10.50 Verified By:		(3) Is the installation position in accordance with the shop drawings?				
Further Instructions Given, If Any: Signature:						

11. COMPLETION AND CLOSURE OF THE CONTRACT

10.1. COMPLETION PROCEDURE

The completion procedures include the following main contractual events: Taking Over upon completion of the Works, Hand Over of the project to ultimate beneficiary, Defect Liability Period and Final Closure of contract.

A. Taking Over

When the Contractor considers that the Works are substantially completed he should notify the Project Manager that the works are ready for final inspection and apply for Completion Certificate. Project Manager and inspection team will carry out inspection and if assessed that the works are completed in accordance with a contract, Project Manager issue Completion Certificate (Form 11/1) stating the date on which the Works or Section were completed. For the purpose of taking over inspection the Form 11/2 should be used.

Project Manager should not issue the Completion Certificate for the purpose of taking over until the Contractor shall supply the various technical documentation including as-built drawings, operational manuals, spares and guarantees/warrantees as detailed within the Contract. To assist in identifying, monitoring and recording the submission and approval of the required submittals.

After the issuance of Certificate for Completion LGED releases the Performance Security and keep Retention Money for potential correction of defect during the Defect Liability Period.

If the Project Manager decides to reject to issuance of Completion Certificate, he/she should notify the Contractor by giving the reasons for such decision and specify the work required to be done by the Contractor to enable the Completion Certificate to be issued. The Contractor shall then complete this work before issuing a further notice under this Sub Clause.

The LGED should take over the Site and the Works within **seven (7)** days of the Project Manager's issuing a Certificate of Completion.

B. Hand over the Project to Ultimate Beneficiaries

As good practice, the hand over process should be planned in a way that LGED immediately pass on the works to the end user/ client. This will alleviate LGED from risk in having possession of the works for any period.

Project Manager should plan the hand over process well in advance with the client and user such that they are prepared to take over possibly on the same day as LGED take over the site and the Works.

C. Defect Liability Period

It is important that a procedure is established for managing defect notification and carrying out repair works during the contract defects Liability period. Clear lines of communication between the End User, LGED and the Contractor are required for any defect notification and a protocol for access to carry out investigations, remedial works and inspection of repaired works will need establishing.

1) The Project Manager shall give notice to the Contractor, with a copy to PE and others concerned, of any Defects before the end of the Defects Liability Period, which begins at Completion Date, and is defined in the PCC. The Defects Liability Period shall be extended for as long as Defects remain to be corrected.
2) The Project Manager should use the Form 11/3 to notify Contractor of any defect and specify the timescale when the defect needs to be remediated. The Project Manager will also monitor and track the defects throughout the Defects Liability Period.
3) Every time a notice of Defect is given, the Contractor shall correct the notified Defect within the length of time specified by the Project Manager's notice.

4) When all obligations under the Contract have been completed, including those required to be performed during the Defects Liability Period; the Project Manager will issue a Defects Correction Certificate (FORM 11/4).

5) Between the date of issue of the certificate of Completion of the Works and the issue of the Defects Correction Certificate, the Project Manager will ensure all outstanding matters of the Contract have been completed. These include:

a) Finalization of all repairs, rectification of defects, omissions etc. as instructed by the Project Manager;

b) Clean up and removal of all site facilities erected by the Contractor; and

c) Restoration and rehabilitation of all areas as required under the Contract.

6) As good practice, a 12 month Defect Liability Period should be included.

11. Closure of the Contract

After the Defect Liability Period has passed, the Project Manager will make sure that the Contractor has corrected any defect during the DLP. If so, the LGED upon confirmation by the Project Manager, will return the percentage of money kept as security for correction of defects. Contract will be considered closed only after the Defect Liability Period has passed and all defects are corrected by the Contractor (if any) and upon confirmation by Project Manager. Upon closure of the contract, Project Manager will make sure that all contract's documents are filed and maintained following the standard filing system

FORM 15: COMPLETION CERTIFICATE FORM 10/1

Memo no: ____________________ Date ____________________

01	Name of PE"s Office	:		
02	Name of Upazila Office (if any)	:		
03	Name of Works	:		
04	Budget Head	:		
05	Contract No.	:		
06	Contractor's Legal Title	:		
07	Contractor's Contact Details	:		
08	Contractor's Trade License/Enlistment/Registration Details			
09	Reference to NOA with Date	:		
10	Type of Bill & Work Progress	:		
11	Original Contract Price as in NOA	:		
12	Revised Contract Price(if applicable)	:		
13	Original contract period			
	(a) Date of Commencement	:		
	(b) Date of Completion	:		
14	Actual Implementation Period			
	(a) Date of Actual Commencement	:		
	(b) Date of Actual Completion	:		
15	Days/Months Contract Period Extended	:		
16	Amount of Bonus for Early Completion	:		
17	Amount of LD for Delayed Completion	:		
18	Description of Works	Contract amount	Work done amount	Comments on work done
(i)	Earth Works			
(ii)	Pavement &Surfacing Works			
(iii)	Drainage structure			
(iv)	Protective Works			
(v)	Road Safety Works			
19	Total BDT			
20	Days Contract Period Extended	:		
21	Reason for delay (if any)	:		
22	Amount of LD for Delayed Completion	:		

Certified that the Works under the Contract has been executed and completed in all respects in strict compliance with the provisions of the Contract including all plans, designs, drawings, specifications and all modifications thereof as per direction and satisfaction of the Project Manager. All defects in workmanship and materials reported during construction have been duly corrected.

Comments:

____

Name and Signature of the Issuing Authority

FORM 16: TAKING OVER INSPECTION FORM 10/2

Project title:	
Contract number:	
Contractor:	
Location inspected:	
Inspection Date:	
Inspection sheet Nr.:	

Item	Inspection Issue	Contractor's Submissions (e.g. as build drawings, manuals, warrantees, spare parts, other documents)	Comments, Remedial Action, Non Conformance, Remarks (incl. photo reference)	Date to be completed	Sign Off Complete and Dated

LGED Representative:	Contractors Representative:	Other Inspection
Name:…………………….. Signature:……………….. Date:…………………….....	Name:…………………….. Signature:……………….. Date:…………………….....	Name:…………………….. Signature:……………….. Date:…………………….....

FORM 17: DEFECT NOTIFICATION FORM 10/3

Project title:			
Contract number:		Date:	
Contractor		**Defect notification No.**	

Details of Defect:(Note specifications, drawings, standards, procedures etc. departed from, attach photos if applicable) **Describe Type of Defect:** 1. Material Fault:
2. Civil:
Mechanical:
Electrical
3. Safety & Environmental
☐ Other*(specify)*
Defect Classification: ☐ Critical (creates direct risk to proper operation of the facility or safety – to be fixed ASAP) ☐ Operational (no direct risk to operation of facility or safety – fix date to be agreed)

Remedial Works Required: To be completed By Date:____________________ Input and Approval required by Design Consultants: Yes ☐ No ☐	
SIGNED BY: __________________________ **DATE:**_______________________	
CLOSE OUT **CONFIRMED DATE:** ___________________	**BY:**________________________

Form 18: DEFECT CORRECTION CERTIFICATE Form 10/4

Project title:		
Contract number:	**Date:**	
Contractor	**Defect notification No.(reference)**	

S/N	**Type of defect corrected**	**Procuring Entity's/PM comments**		
		Defect corrected		**Additional comments**
		Yes	No	
1	Material Fault			
2	Civil			
3	Mechanical			
4	Electrical			
5	Safety & Environmental			
6	Other*(specify)*			

Procuring Entity's/PM overall comments on the works corrected:

____

____

____

____

Certified that all defects have been duly corrected in line with Defect Notification submitted on______________________

ISSUED BY: ______________________ **DATE:** ______________________

B. BRIDGE CONSTRUCTION SUPERVISION TECHNICAL ASPECTS

12. CONCRETE

12.1 Concrete and its class (Practiced in LGED)

The following grades/types of concrete are practiced in LGED for Bridge, Road and Building works.
Table-A: Types of concrete for **Reinforced Cement Concrete** (RCC) Work in LGED Bridges Works.
Table-B: Types of concrete for **Reinforced Cement Concrete** (RCC) Work in LGED Road Works.
Table-C: Types of concrete for **Reinforced Cement Concrete** (RCC) Work in LGED Building Works.
The grades/types of concrete and properties of concrete raw materials applicable to the concrete in various parts of infrastructures (Road, Bridge and Building) are shown in the following table:

Table A: Following 8 types of Cement Concrete for normal RCC work and 3 types of Cement Concrete for RCC Work in marine environment and another 6 types of Cement Concrete for PSC work are practiced in LGED Bridge Works. Further, there are more 8 types of Cement Concrete used for cast in situ and pre-cast concrete pile

Concrete Types	28 days strength	Mix Ratio (By Volume) (Only indicative)	Properties of ingredients
8 types of concrete for RCC work in Bridge			
(1) (4.09.01) RCC-17BCCM (Retail)	f'cr=24MPa f'c=17MPa	1:2:4	• Sand Minimum FM 1.8 • Coarse Aggregate 20mm downgraded crushed picked brick chips (LAA & Water absorption not<=38 & 15% • Max^{m} .w/c 0.45. • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N. • Allowable Slump 50mm-100mm • Concreting with Mixer Machine
(2) (4.09.02) RCC-20SCCM (Retail)	f'cr=28.5MPa f'c=20MPa	1:2:4	• Sand of Min^{m} FM 2.2 • Coarse Aggregate 20mm down well graded crushed stone chips (LAA<=35) • Max^{m} .w/c 0.40. • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N. • Allowable Slump 75mm-100mm • Concreting with Mixer Machine
(3) (4.09.03) RCC-25SCBP (Retail)	f'cr =33.5MPa f'c=25MPa	1:1:5:3	• Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded crushed stone chips (LAA<=30) • Max^{m} .w/c 0.40. • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N. • High range water reducing admixture • Allowable Slump 75mm-100mm

			• Concreting with Mixer Machine
(4) (4.09.04) RCC-25SCBP (Bulk)	fcr =33.5MPa f'c=25MPa	1:1:5:3	• Sand of Min^{m} FM 2.5 • Coarse Aggregate well graded crushed stone chips 20mm down (LAA<=30) • Max^{m} .w/c 0.40. • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N. • High range water reducing admixture • Allowable Slump 75mm-100mm • Concreting using Batching Plant Transit Mixer & concrete pump
(5) (4.09.05) RCC-30SCBP (Retail)	fcr =33.5MPa f'c=30MPa	Mix Ratio (By lab mix design)	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded stone chips (LAA<=30) • Water Cement Ratio as per lab 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. • High range water reducing admixture • Allowable Slump 100mm-150mm • Concreting using Batching Plant, Transit Mixer & Concrete pump Transit Mixer & concrete pump
(6) (4.09.05) RCC-30SCBP (Bulk)	fcr =38.5MPa f'c=30MPa	Mix Ratio (By lab mix design)	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded stone chips (LAA<=30) • Water Cement Ratio as per lab 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. • High range water reducing admixture • Allowable Slump 100mm-150mm • Concreting using Batching Plant, Transit Mixer & Concrete pump Transit Mixer & concrete pump
(7) (4.09.05) RCC-30SCBP (Bulk)	fcr =45MPa f'c=35MPa	Mix Ratio (By lab mix design)	Sand of Min^{m} FM 2.8 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab 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. • High range water reducing admixture

			• Allowable Slump 100mm-150mm • Concreting using Batching Plant, Transit Mixer & Concrete pump Transit Mixer & concrete pump
(8) (4.09.05) RCC-30SCBP (Bulk)	f'cr =50MPa f'c=40MPa	Mix Ratio (By lab mix design)	Sand of Min® FM 2.8 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab 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. • High range water reducing admixture • Allowable Slump 100mm-150mm • Concreting using Batching Plant, Transit Mixer & Concrete pumps Transit Mixer & concrete pump
3-type of Marine Concrete for Bridge Works			
(1) (4.09.9) Marine Concrete - RCC-30SCCM (Retail)	f'cr =40MPa f'c=30MPa	Mix Ratio (By lab mix design)	Sand of Min® FM 2.5 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab mix design (Dose of admixture to be fixed by the mix design) • Cement conforming to BDS EN 197-1: 2003 CEM-II,B-V 42.5N (70% CEM I +30% Silicious Fly Ash or CEM III/A (60% CEM + 40% Blast Furnace Slag) • High range water reducing admixture • Allowable Slump 100mm-150mm • Concreting using Batching Plant, Transit Mixer & Concrete pump Transit Mixer & concrete pump
(2) (4.09.10) Marine Concrete - RCC-30SCBP) (Bulk)	f'cr =40MPa f'c=30MPa	Mix Ratio (By lab mix design)	Sand of Min® FM 2.5 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab mix design (Dose of admixture to be fixed by the mix design) • Cement conforming to BDS EN 197-1: 2003 CEM-II,B-V 42.5N (70% CEM I +30% Silicious Fly Ash or CEM III/A (60% CEM + 40% Blast Furnace Slag) • High range water reducing admixture • Allowable Slump 100mm-150mm

			• Concreting using Batching Plant, Transit Mixer & Concrete pump Transit Mixer & concrete pump
(3) (4.09.11) Marine Concrete - RCC-30SCBP (Bulk)	f'cr =45MPa f'c=35MPa	Mix Ratio (By lab mix design)	Sand of Min^m FM 2.5 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab mix design (Dose of admixture to be fixed by the mix design) • Cement conforming to BDS EN 197-1: 2003 CEM-II,B-V 42.5N (70% CEM I +30% Siliceous Fly Ash or CEM III/A (60% CEM + 40% Blast Furnace Slag) • High range water reducing admixture • Allowable Slump 100mm-150mm • Concreting using Batching Plant, Transit Mixer & Concrete pump Transit Mixer & concrete pump
^ types of Concrete for PSC Works in Bridge			
(1) (4.10.01) Marine Concrete - PSC-35SCCM (Retail)	f'cr =45MPa f'c=35MPa	Mix Ratio (By lab mix design)	Sand of Min^m FM 2.8 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab 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 • High range water reducing admixture • Allowable Slump 75mm-100mm • Concreting using Concrete Mixer Machine
(2) (4.10.02) Marine Concrete - PSC-35SCBP (Retail)	f'cr =45MPa f'c=35MPa	Mix Ratio (By lab mix design)	Sand of Min^m FM 2.8 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab 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 • High range water reducing admixture • Allowable Slump 125mm-150mm • Concreting using Batching Plant, Transit Mixer Concrete pump
(3) (4.10.03) Marine Concrete - PSC-35SCBP	f'cr =50MPa f'c=45MPa	Mix Ratio (By lab mix design)	Sand of Min^m FM 2.8 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25)

(Retail)			• Water Cement Ratio as per lab 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 • High range water reducing admixture • Allowable Slump 125mm-150mm • Concreting using Reversible Drum Mixer/Batching Mix Plant,
(4) (4.10.04) Marine Concrete - PSC-35SCBP (Bulk)	f'cr =50MPa f'c=40MPa	Mix Ratio (By lab mix design)	Sand of Min^m FM 2.8 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab 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 • High range water reducing admixture • Allowable Slump 125mm-150mm • Concreting using Batching Plant, Transit Mixer Concrete pump
(5) (4.10.05) Marine Concrete - PSC-35SCBP (Bulk)	f'cr =50MPa f'c=45MPa	Mix Ratio (By lab mix design)	Sand of Min^m FM 2.8 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab 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 • High range water reducing admixture • Allowable Slump 75mm-100mm • Concreting using Batching Plant, Transit Mixer Concrete pump
(6) (4.10.06) Marine Concrete - PSC-35SCBP (Bulk)	f'cr =60MPa f'c=50MPa	Mix Ratio (By lab mix design)	Sand of Min^m FM 2.8 • Coarse Aggregate 20mm down well graded stone chips (LAA<=25) • Water Cement Ratio as per lab 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 • High range water reducing admixture • Allowable Slump 75mm-100mm • Concreting using Batching Plant, Transit Mixer Concrete pump
8 types of concrete for Cast-in_Situ Piles & Pre-Cast Piles			

(1) (4.07.03) RCC-25SCCM (Retail)	f'cr =33.5MPa f'c=25MPa	1:1.5:3	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded stone chips (LAA<=30) • Max^{m} W/c 0.4 • Cement conforming to BDS EN 197-1: 2003 CEM-II/L/M/V/W42.5N • High range water reducing admixture • Allowable Slump 150mm-200mm • Concreting with Mixer Machine
(2) (4.07.04) RCC-25SCBP (Cast-in-Situ pile) (Bulk)	f'cr =33.5MPa f'c=25MPa	1:1.5:3	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded stone chips (LAA<=30) • Max^{m} W/c 0.4 • Cement conforming to BDS EN 197-1: 2003 CEM-II/L/M/V/W42.5N • High range water reducing admixture • Allowable Slump 150mm-200mm • Concreting using Batching Plant, Transit Mixer, Concrete pump
(3) (4.07.05) RCC-30SCBP (Cast-in-Situ pile) (Bulk)	f'cr =38.5MPa f'c=20MPa	1:1.5:3	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded stone chips (LAA<=30) • Max^{m} W/c as per mixed design • Cement conforming to BDS EN 197-1: 2003 CEM-I, 52.5N/ASTM 150 Type 1 • High range water reducing admixture • Allowable Slump 150mm-200mm • Concreting using Batching Plant, Transit Mixer, Concrete pump
(4) (4.07.09) RCC-17BCCM (Pre cast pile) (Retail)	f'cr =24MPa f'c=17MPa	1:2:4	Sand of Min^{m} FM 1.8 • Coarse Aggregate 20mm down well graded crushed brick chips (LAA not more than 38 & Water absorption not more than 15%) • Max^{m} w/c 0.4 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N/ASTM 150 Type 1 • High range water reducing admixture • Allowable Slump 50mm-100mm • Concreting with concrete Mixer,
(5) (4.07.10) RCC-25SCCM (Pre cast pile) (Retail)	f'cr =33.5MPa f'c=25MPa	1:1.5:3	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded crushed brick chips (LAA not more than 30) • Max^{m} w/c 0.4

			• Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N/ASTM 150 Type 1 • Water reducing admixture • Allowable Slump 50mm-100mm • Concreting with concrete Mixer,
(6) (4.07.11) RCC-25SCBP (Pre cast pile) (Bulk)	f'cr =33.5MPa f'c=25MPa	1:1.5:3	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded crushed brick chips (LAA not more than 30) • Max^{m} w/c 0.4 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-L/M/V/W 42.5N/ASTM 150 Type 1 • Water reducing admixture • Allowable Slump 50mm-100mm • Concreting using Batching Plant, Transit Mixer, Concrete pump,
(7) (4.07.12) RCC-30SCBP (Pre cast pile) (Bulk)	f'cr =38.5MPa f'c=30MPa	Mixed design	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded crushed brick chips (LAA not more than 30) • Max^{m} w/c as per mixed design • Cement conforming to BDS EN 197-1: 2003 CEM-I/52.5N/ASTM 150 Type 1 • Water reducing admixture • Allowable Slump 50mm-100mm • Concreting using Batching Plant, Transit Mixer, Concrete pump,
(8) (4.07.21) RCC-30SCCM (Pre cast driven micro pile) (Retail)	f'cr =38.5MPa f'c=30MPa	Mixed design	Sand of Min^{m} FM 2.5 • Coarse Aggregate 20mm down well graded crushed brick chips (LAA not more than 30) • Max^{m} w/c as per mixed design • Cement conforming to BDS EN 197-1: 2003 CEM-I/52.5N/ASTM 150 Type 1 • Water reducing admixture • Concreting with concrete Mixer, machine,

Table B: Following 11-types of reinforcement Cement Concrete (RCC) are practiced in LGED Road Works

Concrete Types	28 days strength	Mix Ratio (By volume) (only indicative)	Properties of ingrendients
Concrete for Road Works			
(1) (3.07.2.1) RCC-17BCCM(RW) (Retail)	f'cr =24MPa f^1c=17MPa	1:2:4	• Sand (50% sand FM 1.2+50% sand FM 2.2) • Coarse Aggregate 25mm down well graded crushed brick chips (LAA & water absorption not <=38 & 15%) • $Max^{m.}$ w/c 0.45 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-M 42.5N • Concreting with concrete Mixer machine,
(2) (3.2.1.01) RCC-17BCCM(RW) (Bulk)	f'cr =24MPa f^1c=17MPa	1:2:4	• Sand (50% sand FM 1.2+50% sand FM 2.2) • Coarse Aggregate 20mm down well graded crushed brick chips (LAA & water absorption not <=38 & 15%) • $Max^{m.}$ w/c 0.45 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-M 42.5N • Concreting with concrete Mixer machine,
(3) (3.07.2.2) RCC-20BCCM(RW) (Retail)	f'cr =28MPa f^1c=20MPa	1:1.5:3	• Sand of Minimum F.M 2.2 • Coarse Aggregate 25mm down well graded crushed brick chips (LAA & water absorption not <=38 & 15%) • $Max^{m.}$ w/c 0.40 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-M 42.5N • Concreting with concrete Mixer machine,
(4) (3.07.2.2.01) RCC-20BCCM(RW) (Bulk)	f'cr =28MPa f^1c=20MPa	1:1.5:3	• Sand of Minimum F.M 2.2 • Coarse Aggregate 25mm down well graded crushed brick chips (LAA & water absorption not <=38 & 15%) • $Max^{m.}$ w/c 0.40 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-M 42.5N • Concreting with concrete Mixer machine,
(5) (3.07.3.1) RCC-20BCBP(RW) (Retail)	f'cr =28MPa f^1c=20MPa	1:2:4	• Sand of Minimum F.M 2.5 • Coarse Aggregate 25mm down well graded crushed brick chips (LAA <=30) • $Max^{m.}$ w/c 0.40

			• Cement conforming to BDS EN 197-1: 2003 CEM-II/A-M 42.5N • High range Water reducing admixture • Concreting with concrete Mixer machine,
(6) (3.07.3.1.01) RCC-20BCBP(RW) (Bulk)	f'cr =28MPa f'c=20MPa	1:2:4	• Sand of Minimum F.M 2.5 • Coarse Aggregate 25mm down well graded crushed brick chips (LAA <=30) • Max$^{m.}$ w/c 0.40 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-M 42.5N • High range Water reducing admixture • Concreting with concrete Mixer machine,
(7) (3.07.3.2) RCC-25BCBP(RW) (Retail)	f'cr =33.5MPa f'c=25MPa	1:1.5:3	• Sand of Minimum F.M 2.5 • Coarse Aggregate 25mm down well graded crushed brick chips (LAA <=30) • Max$^{m.}$ w/c 0.40 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-M 42.5N • High range Water reducing admixture • Concreting with concrete Mixer machine,
(8) (3.07.3.20.1) RCC-30BCBP(RW) (Bulk)	f'cr =33.5MPa f'c=25MPa	1:1.5:3	• Sand of Minimum F.M 2.5 • Coarse Aggregate 25mm down well graded crushed brick chips (LAA <=30) • Max$^{m.}$ w/c 0.40 • Cement conforming to BDS EN 197-1: 2003 CEM-II/A-M 42.5N • High range Water reducing admixture • Concreting using Batching Plant, Transit Mixer & Concrete pump,
(9) (3.07.3.20.1) RCC-30BCBP(RW) (Retail)	f'cr =38.5MPa f'c=30MPa	Mix Ratio (By mix design)	• Sand of Minimum F.M 2.5 • Coarse Aggregate 25mm down well graded crushed brick 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 • High range Water reducing admixture • Concreting using Batching Plant, Transit Mixer & Concrete pump,
(10) (3.07.3.3.01) RCC-30BCBP(RW) (Bulk)	f'cr =38.5MPa f'c=30MPa	Mix Ratio (By mix design)	• Sand of Minimum F.M 2.5 • Coarse Aggregate 25mm down well graded crushed brick 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 • High range Water reducing admixture • Concreting using Batching Plant, Transit Mixer & Concrete pump,
(11) (3.07.3.6) Marine Concrete RCC-30BCBP(RW) (Retail/Bulk)	f'cr =40MPa f'c=30MPa	Mix Ratio (By mix design)	• Sand of Minimum F.M 2.8 • Coarse Aggregate 25mm down well graded crushed brick 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 • High range Water reducing admixture • Concreting using Batching Plant, Transit Mixer & Concrete pump,

Note: RW (Road Work), SC (Stone Chips), BC (Brick Chips), BP (Batching Plant), CM (Concrete Mixture)

Nominal rate would be used if package cost is less than 5 crore and Bulk rate for more than 5 crore

Table-C: Types/Grades of Cement Concrete usually practiced in RCC work in LGED Building Works:

1.	**RCC Works : 1:2:4 with minimum f'c=19 Mpa** and minimum f'cr=28 Mpa with 20mm down well graded Brick chips and F.M of Sand 1.2 and 2.2 in equal proportion. Minimum w/c ratio: 0.45
2.	**RCC Works : 1:2:4 with minimum f'c=22 Mpa** and minimum f'cr=30.5 Mpa with 20mm down well graded Stone chips and 100% F.M of Sand 1.2 and 2.2 Maximum w/c ratio: 0.40
3.	**RCC Works : 1:1.5:3 with minimum f'c=25 Mpa** and minimum f'cr=33.5 Mpa with 20mm down well graded Stone chips and 100% F.M of Sand 1.2 and 2.2 Maximum w/c ratio: 0.40
4.	**RCC Works : 1:1.25:2.5 with minimum f'c=32 Mpa** and minimum f'cr=40.5 Mpa with 20mm down well graded Stone chips and High range water reducing admixture (tType G) and 100% F.M of Sand 2.2 and Maximum w/c ratio: 0.40
5.	**RCC Works : 1:1:2 with minimum f'c=40 Mpa** and minimum f'cr=50 Mpa with 20mm down well graded Stone chips and High range water reducing admixture (tType G) and 100% F.M of Sand 2.2

Structural Engineers generally specify the strength of concrete at different ages for the strucyure 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.

12.2 Production of Fresh 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 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 from 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 srt 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 maner 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 surfaces of forms shall be removed.
h) Where concrete is required to be placed against undisturbed ground, the entire space between the finished concrete surfaces 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 is 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 practices.

The following methods are adopted for compact the concrete:

a) Hand compaction
b) Compaction by vibration

i. **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.

ii. **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 1m (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 distance 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 surface 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.

12.3 Properties of Fresh Concrete:

Workability:

Workability is the property of concrete which determines the amount of internal work necessary to produce full compaction. It is a measure with which concrete can be handled from the mixer stage to its final fully compacted stage.

Factors affecting workability of concrete:

a) Water Content of the Concrete Mix:

Water content will have important influences on the workability in given volume of concrete. The higher the water content per cubic meter of concrete, the higher will be the fluidity of concrete, which affect the workability.

Water requirement is mainly associated with absorption by aggregates surface & filling up the voids between aggregates.

- The strength of the concrete may get reduced.
- More quantity of water comes out from the surface of concrete resulting into bleeding.
- Cement slurry also escapes through the joints of formwork resulting into the loss of cement from concrete.

b) The size of Aggregates:

Workability is mainly governed by the maximum size of aggregates. Water and paste require, will be not less if a chosen size of aggregates for concrete is bigger. Consequently, for a given quantity of water content & paste, bigger size aggregate will give higher workability.

Note: On the site, the maximum size of aggregate to be used will depend upon the many factors such as the handling, mixing and placing equipment, the thickness of section and quantity of reinforcement.

Later two are very important.

c) The Shape of Aggregates:

Angular, flaky & elongated aggregate reduces the workability of concrete.

Rounded or sub-rounded aggregates increase the workability due to the reduction of surface area for a given volume or weight. Therefore, an excess paste is available to give better lubricating effect.

Rounded shape aggregate has less frictional resistance and gives a high workability as compared to angular, flaky or elongated aggregates.

Note: River sand & gravel provide greater workability to concrete than crushed sand.

d) Surface Texture of Aggregates:

The roughly textured aggregates have more surface area than smoothly rounded aggregates of the same volume. Smooth rounded or glassy aggregates will give better workability than roughly textured aggregates. A reduction of inter particle frictional resistance offered by smooth aggregates also contributes to higher workability.

e) The Porosity of Aggregates: Porous and non-saturated aggregate will require more water than non-absorbent aggregates. For the same degree of workability, latter will require less water. Overall, this factor is only of secondary importance.

f) Grading of Aggregates:

Grading of aggregates has the greatest influence on workability. The better the grading of aggregates, the less is the amount of void in concrete so well-graded aggregates should be used. When total voids are less in concrete, the excess paste is available to give better lubricating effect.

With excess amount of concrete paste present in the mixture, it becomes cohesive and fatty that prevents segregations of particles & least amount of compacting efforts is required to compact the concrete.

For a given workability, there is one value of coarse aggregate/Fine aggregate ratio, which needs the lower water content.

g) Uses of Concrete Admixtures:

This is one of the commonly used methods to enhance the workability of concrete. Concrete admixtures such as plasticizer and super plasticizers greatly improve the workability.

Air entraining agents are also used to increase the workability. Air entraining agents creates a large number of very tiny air bubbles. These bubbles get distributed throughout the mass of concrete and act as rollers and increase the workability.

Mineral admixtures like pozzolanic materials are also used to improve the workability of concrete.

h) Ambient Temperature:

In hot weather, if temperature increases, the evaporation rate of mixing water also increases and hence fluid viscosity increases, too. This phenomenon affects the flow ability of concrete and due to fast hydration of concrete; it will gain strength earlier, which decreases the workability of fresh concrete.

i) Segregation:

The tendency of separation of coarse aggregates grains from the concrete mass is called segregation.

With a correct method of handling, transporting and placing, the likelihood of segregation can be greatly reduced.

a) Concrete should always be placed direct in the position in which it is to remain, and
b) Must not be allowed to flow along the form.
c) Must not use a vibrator to spread heap of concrete over a larger area.
d) The danger of segregation due to an improper use of a vibrator is increased. This is particularly so when vibration is allowed to continue too long. Separation of coarse aggregate toward the bottom of the form and of the cement paste toward the top may result.

j) Bleeding:

The tendency of water to rise to the surface of freshly laid concrete is known as bleeding.

Effects of Bleeding:

a) As a bleeding, the top of every lift may become too wet, and if the water is trapped by superimposed concrete, porous, weak, and non-durable concrete will result.

b) If the bleeding water is remixed during finishing of the top surface, a weak wearing surface will be formed. This can be avoided by
   I. Delaying the finishing operations until the bleeding water has evaporated, and also
   II. By the use of wood floats and avoidance of overworking the surface.

The tendency to bleeding depends largely on the properties of cement. Rich mixes are less prone to bleeding than lean ones. Reduction in bleeding is obtained by the addition of pozzolanas or of aluminum powder.

12.4 Use of admixtures in Concrete:

Admixtures are materials other than cement, aggregate and water that are added to concrete either before or during its mixing to alter its properties, such as workability, curing temperature range, set time or color.

Admixtures are available in the form of powder or fluids. In normal use, admixture dosages are less than 5% by mass of cement, and are added to the concrete at the time of batching/mixing.
Concrete Admixtures ASTM categories:
ASTM C494 specifies the requirement for seven chemical admixture types.
They are:

1. Type A: Water-reducing admixtures
2. Type B: Retarding admixtures
3. Type C: Accelerating admixtures
4. Type D: Water-reducing and retarding admixtures
5. Type E: Water-reducing and accelerating admixtures
6. Type F: Water-reducing, high range admixtures
7. Type G: Water-reducing, high range and retarding admixtures.

Water Reduction in the Mix:
Water reducers have become so important in concrete, that they could be considered the "fifth" ingredient.
They can be used to:
1) Increase slump,
2) Lower the water-cement ratio, or
3) Reduce cement content.

Water reduces come as:
a) Low Range,
b) Mid-Range, and
c) High range super-plasticizers

In general, they provide the required slump with less water in the mix, and may provide higher strength concrete without increasing the amount of cement.

Conventional water reducers:

Are required to achieve a minimum 5% water reduction. A conventional water reducer can reduce slump by about 1 to 2 inches without the addition of water.

Mid-Range water reducers

Can reduce water content by at least 8% and as much as 15%. They tend to be stable over a wider range of temperatures and tend to give more consistent setting times.

High-Range water reducers (super-plasticizers):

Can reduce water content from 12% to as much as 40% and are typically used in concretes designed to either increase slump (by 4 to 8 inches) or lower the water content of hot weather concrete mixes. Used to increase flow ability.

Some Admixtures:

a. Hydroplast
b. Hydroplast Super
c. SICA
d. BASF
e. Daracem
f. Doctor fixit etc.

12.5 Curing Compound:

Concrete corning compound is a compound, which helps to prevent the loss of moisture content from the concrete. So, concrete is properly cured which results the full development of strength of concrete.

Types of Concrete Curing Compounds:

- Synthetic Resin Compound
- Acrylic Compound
- Wax Compound
- Chlorinated Rubber Compound

Synthetic Resin Concrete Curing Compound: Synthetic resins will seal the concrete by forming a membrane. If we want to provide plastering, the membrane can be removed by washing it with hot weather.

Acrylic Concrete Curing Compound: Acrylic is made of polymers of acrylic acid. It also seals the concrete in good manner. It is having properly of adhesion to the subsequent plaster. No need to wash the surface of acrylic with hot water if we want to provide plastering.

Wax Concrete curing Compound: Wax compound have similar properties like resin compound.

Chlorinated Rubber Curing Compound: Chlorinated rubber type curing compound will form thick layer when we applied. It seals the concrete tightly and also fills the minute pores present in the concrete. But the film cannot stay for longer period. It is wear out in the long run.

Process of Applying Concrete Curing Compound:

Concrete curing compounds formed a membrane when we applied to fresh concrete. This member does not allow the inside moisture to come out of concrete hence, curing occurs. This curing compounds possess waxes, natural resins, synthetic resins and solvents of high volatility. Generally white or gray colors are appeared when we apply curing compound on fresh concrete. These pigments are provided heat reflectance and also useful to check the area of curing complete.

Curing compound is applied when the finishing is complete and free water present on the surface gets disappeared. The curing compound is applied through spraying pipe as shown in figure with constant rate of pressure. Generally, one liter of curing compound can be sprayed for 0.20-0.25m^2 surface area of fresh concrete. The sprayer pressure is usually 0.5-0.7 MPa. In small areas, we can also use brushes or paint rollers to apply curing compounds. Curing compound should not be applied on surface which receive additional concreting.

12.6 Ready-Mixed Concrete (RMC) and Central Batching Plant:

If instead of being batched and mixed on site, concrete is delivered for placing from a central plant, it is referred to as ready mixed or pre-mixed concrete. This type of concrete is used extensively as it offers numerous advantages in comparison with orthodox methods of manufacture:

a. Close quality control of batching which reduces the variability of the desired properties of hardened concrete.
b. Use on congested sites or in highway construction where there is little space for a mixing plant and aggregate stockpiles;
c. Use of agitator trucks to ensure care in transportation, thus preventing segregation and maintaining workability.
d. Convenience when small quantities of concrete or intermittent placing is required.

The cost of ready mixed concrete, since it is a bought commodity may be somewhat higher than that of site-mixed concrete. But this is often offset by savings in site organization, in supervisory staff, and in cement content.

There are two principle categories of ready-mixed concrete: central-mixed and transit-mixed or truck mixed. In the first category, mixing is done at a central plant and then the concrete is transported in an agitator truck. In the second category, the materials are batched at a central plant but are mixed in the truck either in transit or immediately prior to discharging the concrete at the site. Transit-mixing permits a longer haul and is less vulnerable in case of delay. But the truck capacity is smaller than that of the same truck which contains pre mixed concrete. To overcome the disadvantage of a reduced capacity, sometimes concrete is partially mixed at the central and the mixing is completed on the way.

Concrete Batching Plant: A Concrete batching plant, also known as a concrete mixing plant, is a machine that combines various ingredients to form concrete. It plays a crucial role in modern construction projects, providing ready-mixed concrete for buildings, bridges, roads, and other infrastructure.

A concrete batching plant consists of several components, including:

- **Aggregate Bins:** These bins store different types and sizes of aggregates, such as sand, gravel, and crushed stone.
- **Conveyor Belts:** The aggregates are transported from the bins to the mixer using conveyor belts.
- **Cement Silos:** Cement is stored in silos and dispensed into the mixer as needed.
- **Water and Additive Tanks:** Water and additives, such as admixtures and coloring agents, are stored in tanks and added to the mixer in controlled quantities.
- **Mixing Unit:** The mixing unit, often equipped with twin shaft or planetary mixers, combines the aggregates, cement, water, and additives to produce the desired concrete mix.
- **Control Panel:** The control panel allows operators to monitor and control the batching plant's operations, including the mixing process, ingredient proportions, and discharge.

Concrete batching plants can be stationary or mobile. Stationary plants are set up in a fixed location and are suitable for large-scale construction projects, while mobile plants are portable and can be easily transported to different job sites.

Concrete Pump and Transit Mixture:

Nowadays, large quantities of concrete can be transported by means of pumping through pipelines over quite large distances to locations which are not easily accessible by other.

The system consists essentially of a hopper into which concrete is discharged from the mixer, a concrete pump, and the pipes through which the concrete is pumped.

Concrete is fed into the pump by gravity and, partly, by suction due to the movement of the piston, whilst the valves open and close intermittently so that the concrete moves in a series of impulse but the pipe always remain full; the use of two pistons produces a steadier flow.

Outputs of up to 60m3 per hour can be achieved through 220mm (9in) diameter pies.

Types of Concrete pumps:

Concrete pumps are tools used to convey fresh concrete from the source of concrete to the place of casting. The basic principles, the types, and selection of concrete pumps based on work are explained briefly in this articles.

Based on the pumping pressure, ease of working and developing technologies different concrete pumps has been developed. The main classifications of concrete pumps are :

1. Boom Concrete Pumps
2. Line Concrete Pumps

Boom Concrete Pumps:

Boom concrete pumps stay at one particular position for the entire time of concrete pouring on a construction project. Hence these are stationary concrete pumps. They have a larger dimension which is placed on the ground. These have crane or boom arm attached to it in different lengths. The concrete pumping to different heights like in the construction of high-rise building can be performed by boom concrete pumps.

Fig.1.Boom concrete Pumps

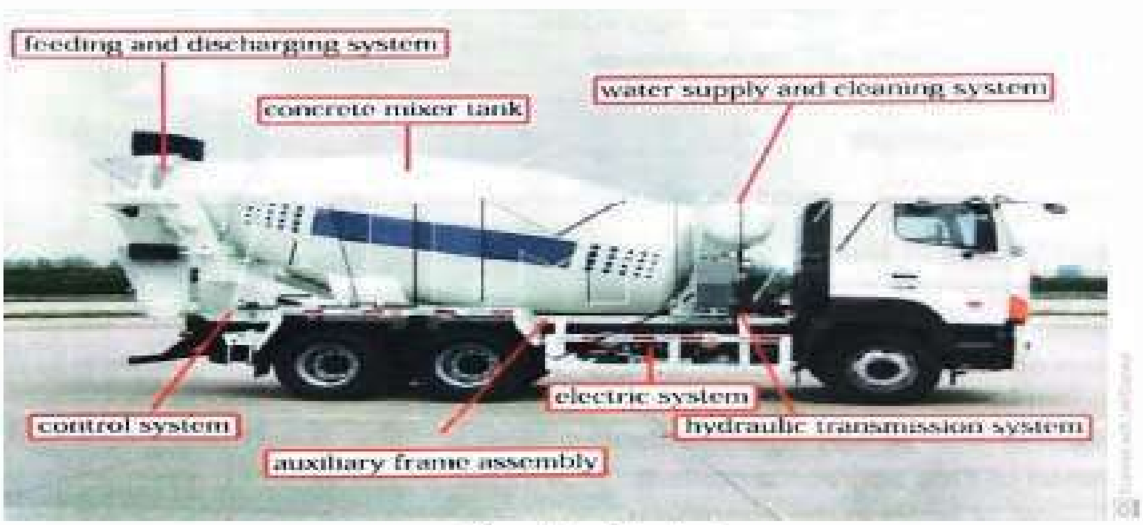
Boom concrete pumps allow the pipeline to reach along, upwards and below. Hence tight spots can be cast by these pumps. Obstacles during the concrete casting path can be easily overcome by such pumps.

Line Concrete Pumps:

Line concrete pumps are compact units that are mainly used for small construction projects. The arrangement has a line pump attached to the back of the truck or the trailer. Hence the arrangement is also called as trailer mounted concrete pump or truck mounted concrete pump. This pump requires steel or flexible concrete placing hoses to be manually attached to the outlet of the machine. Those hoses are linked together and lead to wherever the concrete needs to be placed.

Transit Mixer:

The Transit Mixer is otherwise known as concrete mixer truck that transports ready-mixed concrete. It consists of mixing drum and a transport truck. Usually, it keeps the mixing drum rotating when transporting concrete to delay the concrete solidification time, increases the concrete transportation distance, and ensures the concrete quality. Currently, the transit mixer is widely used in various commercial concrete plants and large and medium-sized concrete projects.



Concrete mixture truck

12.7 Methods of concrete mixed design:

The mix design methods being followed in different countries are mostly based on empirical relationships, charts and graphs developed from extensive experimental investigations. Following methods are in practice:

1. ACI Mixed design method
2. USBR Mix design method
3. British Mix design method
4. Mix design method according to indian standard

Since ACI Mix design method is an originator for all other methods, including indian standard method, wherein every table and charts are fully borrowed from ACI, so we follow the ACI Mix design method in practice.

ACI Method of Mix Design:

i. **Design Data**
   a) Characteristic compressive strength of concrete required at end of 28 days: Say M 25.
   b) Nominal maximum size of aggregate: Say 20mm
   c) Shape of coarse aggregate: Angular
   d) Required workability at site: Say 50mm (slump value)
   e) Type of cement used
   f) Methods of concrete mixing

ii. **Material testing data (determined in the laboratory)**
   a) Specific gravity of cement.
   b) Specific gravity and Unit Weight of FA (Stand)
   c) Specific gravity and Unit Weight of Coarse Aggregate
   d) Aggregates are assumed to be having surface dry conditions
   e) Water absorption capacity of Coarse Aggregate
   f) Water absorption capacity of Fine Aggregate
   g) Specific gravity of Admixture

ACI mix design procedure

The standard ACI mix design procedure can be divided into 9 basic steps:

1. Selection/choice of slump
2. Maximum aggregate size selection
3. Estimation of Mixing water
4. Selection of Water-cement ratio
5. Calculation of Cement content
6. Estimation of Coarse aggregate content
7. Calculation of Fine aggregate content
8. Adjustments of water in the aggregate
9. Trial Batch Adjustment

Table 6.17: Grading Requirements for Coarse Aggregates for Concrete

Size Number	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square-Openings), Weight Percent												
		4 in. (100 mm)	3½ in. (90 mm)	3 in. (75 mm)	2½ in. (63 mm)	2 in. (50 mm)	1½ in. (37.5 mm)	1 in. (25.0 mm)	¾ in. (19.0 mm)	½ in. (12.5 mm)	⅜ in. (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)	No. 16 (1.18 mm)
1	3½ to 1½ in. (90 to 37.5 mm)	100	90 to 100	...	25 to 60	...	0 to 15	...	0 to 5	...	...	...	...	...
2	2½ to 1½ in. (63 to 37.5 mm)	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...
3	2 to 1 in. (50 to 25.0 mm)	...	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...
357	2 in. to No. 4 (50 to 4.75 mm)	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	...	0 to 5	...	...
4	1½ to ¾ in. (37.5 to 19.0 mm)	...	...	...	...	100	90 to 100	20 to 55	0 to 15	...	0 to 5	...	...	...
467	1½ in. to No. 4 (37.5 to 4.75 mm)	...	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	0 to 5	...	...
5	1 to ½ in. (25.0 to 12.5 mm)	...	...	...	...	...	100	90 to 100	20 to 55	0 to 10	0 to 5	...	...	...
56	1 to ⅜ in. (25.0 to 9.5 mm)	...	...	...	...	...	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	...	...
57	1 in. to No. 4 (25.0 to 4.75 mm)	...	...	...	...	...	100	95 to 100	...	25 to 60	...	0 to 10	0 to 5	...
6	¾ to ⅜ in. (19.0 to 9.5 mm)	...	...	...	...	...	...	100	90 to 100	20 to 55	0 to 15	0 to 5	...	...
67	¾ in. to No. 4 (19.0 to 4.75 mm)	...	...	...	...	...	...	100	90 to 100	...	20 to 55	0 to 10	0 to 5	...
7	½ in. to No. 4 (12.5 to 4.75 mm)	...	...	...	...	...	...	...	100	90 to 100	40 to 70	0 to 15	0 to 5	...
8	⅜ in. to No. 8 (9.5 to 2.36 mm)	...	...	...	...	...	...	...	...	100	85 to 100	10 to 30	0 to 10	0 to 5

Step 1. Selection/Choice of Slump

The choice of slump is actually a choice of workability. A concrete satisfying following conditions is said to be workable:

- Ease of mixing
- Ease of placing
- Ease of compaction
- Ease of finishing
- Without segregation

Typically slump is specified, but Table 1 shows general slump ranges for specific applications.

Table 1. Slump Ranges for Specific Applications

Recommended Slumps for Specific Applications of Concrete			
SI No		Slump Range	
	Types of Application	Inches	mm
1	Reinforced foundation and footings	1-3	25-75
2	Plain footings, caissons and sub-structure walls	1-3	25-75
3	Beams and reinforced wall	1-4	25-100
4	Building Columns	1-4	25-100
5	Pavements for highways, Airport, Slabs	1-3	25-75
6	Mass Concrete	1-3	25-75
7	Dry laen concrete	No	-

Step 2. Maximum Aggregate Size Selection

ACI recommends that maximum aggregate size be limited to 1/3 of the slab depth and ¾ of the minimum clear space between reinforcing bars. Aggregate larger than these dimensions may be difficult to consolidate and compact resulting in a honeycombed structure or large air pockets

Maximum Size of Aggregate:20mm

Step 3: Estimation of mixing water

Slump is dependent upon nominal maximum aggregate size, particle shape, aggregate gradation, PCC temperature, the amount of entrained air and certain chemical admixtures. Therefore, ACI provides a table relating nominal maximum aggregate size, air entrainment and desired slump to the desired mixing water quality (Table 3)

Note that the use of water-reducing admixtures can substantially reduce the amount of mixing water required to achieve a given slump.

Table 2: Approximate mixing water requirements for different slumps and sizes

Non Air-entrained Concrete					
Slump in mm	**Water in kg per cum of concrete for indicated maximum sizes of aggregate**				
	10mm	**12.5mm**	**20mm**	**25mm**	**40mm**
25 to 50	205	200	185	180	160
75 to 100	225	215	200	195	175

150 to 180	240	230	210	205	285
Approximate amount of entrapped air%	3	2.5	2	1.5	1
This may vary with the variation of shape of aggregate					

Water/cum of concrete: 185kg

Step 4: Selection of Water-Cement ratio

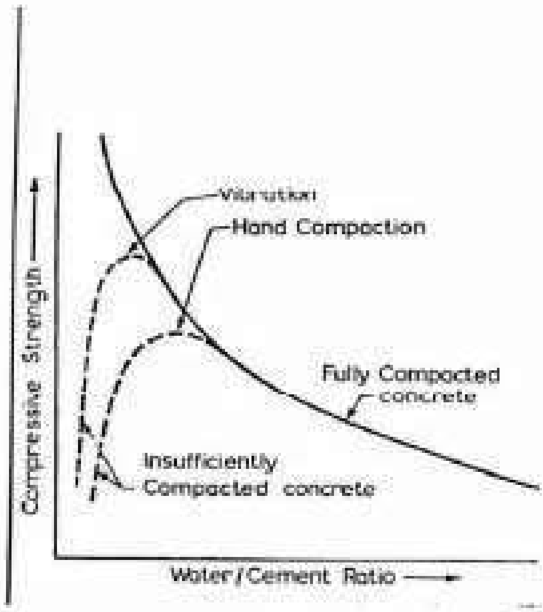
Water-Cement Ratio

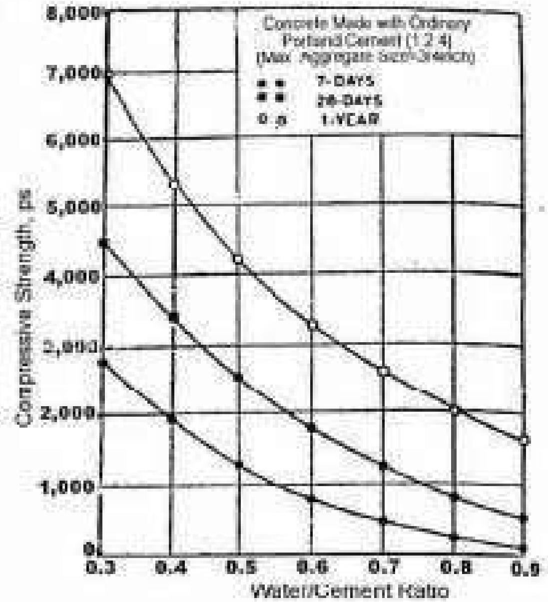
The water-cement ratio is the major single factor which influences PCC strength and durability. In general, lower water-cement ratios produce stronger, more durable PCC. If natural pozzolans are used in the mix (Such as fly ash) then the ratio becomes a water-cementitious material ratio (cementitious material=Portland cement + pozzolanic material). The ACI method bases the water-cement ratio selection on desired compressive strength and then calculates the required cement content based on the selected water-cement ratio.

Table below with graph shows general estimates of 28-days compressive strength vs. water-cement ratio (or water-cementitious ratio). Values in this table tend to be conservative. In most tend to set a maximum water-cement ratio between 0.40-0.50.

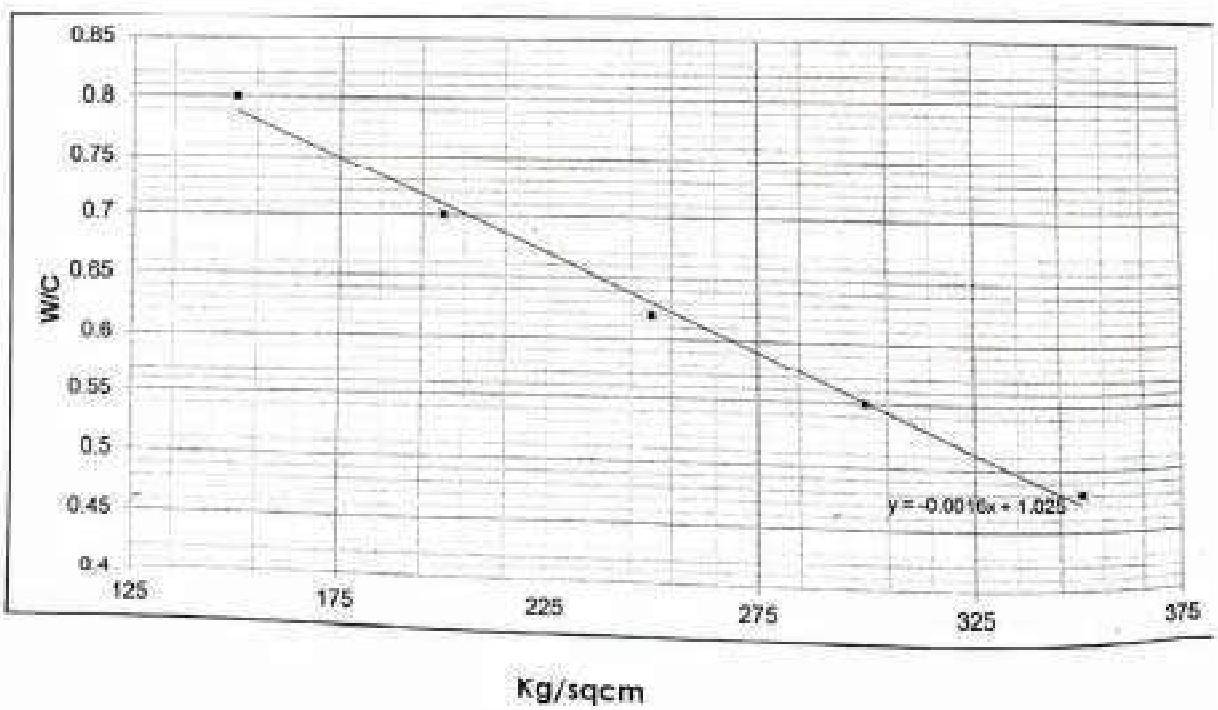
Table-3: Relationship between compressive strength and w/c ratio

Compressive strength at 28 days kg/cm^2	Water-cement ratio by weight (Non air entrained)
350	0.48
300	0.55
250	0.62
200	0.70
150	0.80





Strength vs. W/C ratio Chart



Step 5: Calculation of Cement Content

Cement content is determined by comparing the following two items:

- Based on the selected water-cement ratio. And
- The specified minimum cement content. Most case specify a minimum cement contents in the range of 300-360 kg/m^3.

Step 6: Estimation of Coarse aggregate content

Estimation of Coarse aggregate content is based on experimental workability of mixtures. ACI recommends the percentage (by unit volume) of coarse aggregate based on nominal maximum aggregate size and fine aggregate fineness modulus. This recommendation is based on empirical relationships to produce PCC with a degree of workability suitable for usual reinforced construction. Table below shows ACI recommended values.

Table-4: Estimation of Coarse aggregate content

Volume of Coarse Aggregate (CA) per unit volume of concrete				
Max. size mm	Volume of dry rodded Coarse Aggregate (CA) per unit volume of concrete for different module of sand			
	2.4	2.6	2.8	3.0
10	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
20	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
40	0.76	0.74	0.72	0.70

For sand having FM 2.5, volume of CA: 0.65cum

i.e. Dry weight of CA per cum of concrete: 0.65x1620 = 1053kg

Step 7: Calculation of Fine aggregate content

When absolute volume of water, cement and coarse aggregate per unit volume of concrete is established the sand content can be determined by absolute volume method.

V_{sand}=1 Cum - [$V_{water}+V_{cement}+V_{CA}+V_{air}$]

Cement	: 300 kg	=	300/ (3.15x1000)	=	0.095 cum
Water	: 185 kg	=		=	0.185cum
Coarse Aggregate	: 1053 kg	=	1053/ (2.6x1000)	=	0.405cum
	Air entrapped: (Say 2%)			=	0.020
			Total	=	**0.705cum**

12.8 Shotcrete, Micro Concrete, Polymer Concrete, High Strength Concrete & Marine Concrete (LGED Specification)

Shotcrete

This is the name given to mortar or concrete conveyed through a hose and pneumatically projected at high velocity onto a backup surface. The force of the jet impacting on the surface compacts the material so that it can support itself without sagging or sloughing even on a vertical face or overhead. Generally it is mortar rather than concrete, the maximum size of aggregate is 5mm.
Shotcrete is used for thin, lightly reinforced sections, such as shells or folded plate roofs, tunnel linings and prestressed concrete tanks. Shotcrete is also used in repair of deteriorated concrete and as thin overlay on concrete, masonry or steel. Since shotcrete is sprayed on a backup surface and then gradually built up to a thickness of up to 100mm, only one side of formwork needed. The cement content of shotcrete is high and require necessary equipment. The usual range of water/cement ratio is 0.35 to 0.5 and there is little bleeding. The usual mortar mix is 1:3:5 to 1:4:5, with sand of the same grading as for conventional mortar.
Curing of shotcrete is particularly important because of rapid drying in consequence of the large surface/volume ratio.

LGED Specifications of Micro Concrete as per Rate Schedule Item No. 4.6.05

Shotcrete/grunting concrete surface with 40mm thick (avg) cement mortar comprising of cement, graded sand conforming to ASTM C33, Coarser aggregate (20 to 40% of total aggregate for thick sections if adequate grunting equipment's is available), water and quick setting compound conforming to ASTM C1141 in the proportion as per guidance of central Quality Control Laboratory (CQCL), LGED or any approved laboratory instructed by Engineer-in-Charge, water cement ratio ranging from 0.35 to 0.5, density of shotcrete/gunite not less than 2000kg cum, strength not less than 25 MPa, applied with compressed air under pressure after cleaning removing old grunting/ part of defective concrete, cleaning the surface and exposed reinforcement thoroughly by sand blasting, spraying with epoxy conforming to ASTM C881 @ 67 kg/sqm including cost of wire mesh fabrics 50mm x 50mm x 10 BWG in first layer of guniting complete as per drawing & direction of E-I-C wherever the reinforcement have been corroded, the same shall be removed and replaced by additional reinforcement.

Micro Concrete

Micro concrete is a dry ready mix cementitious based composition formulated for use in repairs of areas where the concrete is damaged & the area is restricted in movement making the placement of conventional concrete difficult, it is supplied as a ready to use dry powder which requires only addition of clean water at site to produce a free flowing non shrink repair micro concrete. This is a cementitious material, with additives, which impart controlled expansion characteristics in the plastic state with reduced water demand.

Purpose: For the repair of damaged reinforced concrete elements like beams, columns, wall etc, where access is restricted and compaction is not possible. Also for jacketing of RCC columns to increase its load bearing capacity.

Usages: It is designed for use in medium & large volume repairs typically ranging from 5mm to 50mm thickness & deep. The product can be applied in sections generally ranging from 5mm to 50mm thick although greater thicknesses may be achievable depending on the configuration of the repair location and the volume of exposed reinforcing steel.

How to Apply Micro Concrete?

1. **Surface Preparation**

   The surface over which micro concrete needs to be applied is firstly prepared, which involves washing, cleaning, and removing dust, dirt, gravel, or chemicals. Water, acids, or water blasting can be used to clean to clean concrete surfaces. Corroded materials and steel bars should be cleaned and coated before the application of micro concrete.

2. **Mixing**

   Micro concrete mix can be prepared manually, but a mixing vessel should be considered if a large quantity is needed. The required water quantity may very based on the mix, but it is commonly around 1:8 water to micro concrete. The mixture is prepared by gradually adding micro concrete to the water while it is being stirred constantly.

3. **Pouring**

   This should be placed as soon as possible for the best consistency and flow. After that, use suitable tools to smoothen the mixture out and permit it to dry.

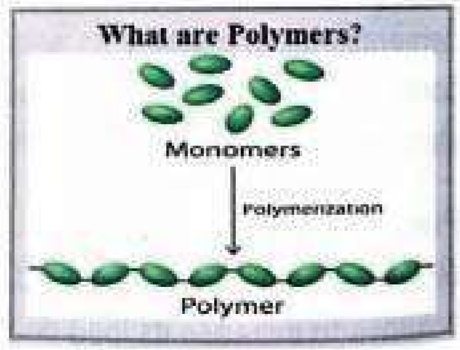
Advantages of Micro Concrete

1. Easy to apply; compaction is not required; hence, heavy machinery is not needed.
2. Creates a good bond with almost all surfaces.
3. Develop good strength once it is applied on a surface.
4. Does not suffer from shrinkage, which means no cracks or folds will occur.
5. Free from chloride and consequently provide a safe and durable surface.
6. Micro concrete has low permeability, making it a perfect choice for outside surfaces, kitchens and bathrooms.
7. No extra additives are required.

8. Excellent mold resistance.
9. It can be colored.

LGED specifications of Micro Concrete as per Rate schedule

Item No. 4.16.15



Micro concrete work; providing and in position Micro Concrete having minimum compressive strength 50 Mpa after 28 days (as per ASTM C 109), tensile strength 2MPa after 28 days (as per ASTM C 307) and flexural strength 5MPa after 28 days (as per ASTM C 580), cement based repacked single component, chloride free, non-shrink, free flow, self-compacting, ready to use after mixing water in specified proportion obtained from approved manufacture including water tight shuttering and scaffolding etc, complete as per specification and as per direction of Engineer-in-charge.

Polymer Concrete

Polymer concrete made by mixing cement, aggregates, water, and monomer, the plastic mixtures are poured into moulds, cured, dried, and polymerized, polymer concrete is polymerized either at room temperature or at elevated temperatures.

Through different research, it has been found that the addition of polymer in concrete brings high improvement in its compressive strength, toughness, fatigue resistance, impact resistance and durability. Polymer concrete is extraordinarily impermeable and resistive towards the attack of acids, alkalis and other different chemicals.

Types of polymer concrete

Polymer concrete can be classified into three types. They are:

a. Polymer impregnated concrete (PIC): PIC is a hardened Portland Cement Concrete which has been impregnated with a monomer (a low viscosity monomer is diffused through the pores of concrete) and finally polymerized in situ. This concrete is used in precast slab for bridge decks, marine structures, food processing buildings etc.
b. Polymer cement concrete (PCC): PCC is produced by incorporating an emulsion of a polymer or a monomer in ordinary Portland Cement Concrete. This concrete can be used in marine works.
c. Polymer Concrete (PC): In PC, polymer/monomer is employed to act as a binder in place of cement. This concrete is used in Nuclear Power Plant, Prefabricated structures, Precast slab for bridge decks, Marine structures, food processing buildings, Irrigation structure etc.

Advantages of polymer concrete:

1. Polymer concrete can be applied in very thin cross-sections.
2. It has high impact resistance and high compressive strength.
3. This concrete is highly durable.
4. Highly resistance to freezing and thawing.
5. Less permeability.

6. It reduces the infiltration of carbon dioxide, protects the concrete from carbonation hence the loss of alkalinity.
7. This concrete offers outstanding resistance against corrosion and chemical attack.
8. Polymer binders set very quickly and resist weathering effects, thus are useful for repairing existing structures.
9. It reduces shrinkage.

Disadvantages of polymer concrete:

1. Polymer concrete is costly than conventional concrete.
2. High skills and precision work are required when mixing polymers concrete.
3. Two-component materials may have an inappropriate ratio, thus proper mixing is required.
4. Chemicals utilized in polymers concrete could be dangerous, subsequently, it is necessary to make use of masks and hand gloves for skin safely.

LGED Specifications of polymer Mortar & Polymer Concrete as per Rate Schedule

Item Code: 4.16.06

Patching of damaged concrete surface with 25mm thick (avg.) polymer concrete and curing compounds, initiator and promotor, available in present formulations, to be applied as per instructions of manufacturer and as approved by the E-I-C. This item is a proprietary item available in market as pre-packed polymer concrete and is required to be applied as per instructions of the manufacturer. Unit: sqm.

Item Code: 4.16.07.01

Providing and applying 10mm thick (avg.) pre-packed cement based polymer mortar of strength 45Mpa at 28 days by trowels & float over the spalled concrete for bridge deck, pier cap etc. including scaffolding, shuttering, supplying required material including polymer etc. complete as per the specification & as directed by E-I-C. Primer coat by Nylon brush must be applied on the spalled out concrete location before applying polymer mortar. Average Thickness =10mm thick. Unit: sqm

Item Code: 4.16.07.02

Providing and applying 10mm thick (avg.) pre-packed cement based polymer mortar of strength 45Mpa at 28 days by trowels & float over the spalled concrete for bridge deck, pier cap etc. including scaffolding, shuttering, supplying required material including polymer etc. complete as per the specification & as directed by E-I-C. Primer coat by Nylon brush must be applied on the spalled out concrete location before applying polymer mortar. Average Thickness =25mm thick. Unit: sqm

Item Code: 4.16.19

SC: Providing and Applying average 1mm thick pre-packed polymer modified cement based skim-coat for filling blowholes, non-structural honeycomb and rectifying other surface imperfections in newly placed concrete surfaces and achieving a smooth finish on precast, cast in place, tilt up or other unfinished concrete surfaces; including cleaning the surface thoroughly using stiff brush to remove dust, loose particles, oil etc., neutralizing the surface by applying potable water, ensuring saturated surface dry (SSD) condition of the concrete surface, mixing powder with potable water in a drum by blending machine, spreading the mixture to any concrete surface using trowel to get smooth surface etc. all complete as per specification and direction of E-I-C. This is available in market as pre-packed and is required to be applied as per instruction of the manufacturer. Proper curing method should be applied for at least 3 days, all complete as per specification and direction of E-I-C. Unit: sqm

Concrete in Marine Environment

Marine Environment

Most seawaters are similar in composition, containing about 3.5% soluble salts (chlorides and sulfates) by weight. The pH of seawater varies from 7.5 to 8.4, averaging about 8.2. Concrete exposed to seawater may deteriorate from the combined effects of chemical and physical processes:

- Sulfate attack
- Leaching of lime (calcium hydroxide)
- Alkali-aggregate expansion
- Salt crystallization from alternate wetting and drying
- Freezing and thawing
- Corrosion of embedded reinforcing or prestressing steel
- Erosion and abrasion from waves

Attack by most of these processes is slowed by reducing **concrete permeability.** Low permeability helps to keep aggressive chemicals out of the concrete, slows leaching of soluble materials such as lime, and limits the depth of carbonation, better protecting reinforcing steel from corrosion. Any design and construction measures that reduce permeability will improve durability. Marine Concrete can be grouped into three exposure zones:

1. Submerged
2. Splash and
3. Atmospheric

The submerged zone is continuously covered by seawater, the splash zone is subject to continuous wetting and drying, and the atmospheric zone is above the splash zone and subject to occasional seawater spray.
Concrete in the submerged zone isn't as vulnerable as concrete in the other two zones. But concrete in all three zones exposed to some of the processes that cause damage. And deterioration in any of these zones tends to increase the concrete's permeability, making the concrete susceptible to more deterioration. Cracks, spalls, mortar erosion, and corrosion stains are visible signs of deterioration that causes increased porosity and decreased strength.

Designing Concrete in Marine Environments

The following practices are recommended to produce marine concrete of excellent durability.

- One, **proper mix proportion** using the optimum cement content will yield a dense, impervious and relatively unabsorbent concrete.
- Two, required water-cement ratio for sulfate resistance and corrosion protection. ACI 318 states a maximum water cement ratio of 0.45 by weight for moderate sulfate exposure. For corrosion

protection ACI requires the maximum water cement ratio to be 0.40 for concrete exposed to sea water. However, if the concrete cover is increased by 12.5mm ACI allows a slight increase in water cement ratio to 0.45. ACI 357 provides a maximum water-cement ratio for the different exposure zones in the table-1 below.

Table : Water-cement Ratios and Compressive Strength		
Zone	**Maximum w/c ratio**	**Minimum 28-days cylinder compressive strength**
Submerged	0.45	5000psi
Splash	0.4	5000psi
Atmospheric	0.4	5000psi

- Three, concrete cover over reinforcing steel is also important. In the Table-2 below, ACI 357 provides recommendations for concrete cover in each exposure zone.

Table: Recommended Concrete Cover		
Zone	**Cover over reinforcing steel, inches**	**Cover over post-tensioning ducts, inches**
Atmospheric zone not subject to salt spray	2	3
Splash & atmospheric zone subject to salt spray	2.5	3.5
Submerged	2	3
Cover of stirrups: 0.5 inch less than those listed above		
The designer also may set maximum limits on concrete cover during the design phase. Thicker concrete cover promotes wider cracks that allows more seawater penetration.		

- Four, type V cement with 5 percent tricalcium Aluminate (C3A) content produces the best results.
- Five, non-reactive aggregates should be used. The chloride ion content contributed from the aggregate must be less than that permitted for the concrete (<0.10% by weight of the cement for normal concrete and <0.06% for prestressed concrete)
- Six, an air entraining agent will reduce the danger of deterioration due to freezing and thawing (if any). Higher air contents are required for concrete containing aggregate with smaller nominal maximum size.
- Seven, Chemical admixtures. Water reducing and high-range water reducing admixtures are commonly used to enhance uniform cement distribution and to provide workable mixes at low water-cement ratio.
- Eight, especially at the tidal zone concrete should be placed in a continuous operation.

- Nine, concrete should be compacted thoroughly to avoid honeycombing and to provide a dense, homogenous mass. A 10% reduction in consolidation can reduce compressive strength by 50%, reduce bond by 75% and increase chloride permeability by 100%.

Developing a high strength, low permeability mix is a good start to ensure the maximum service life of the concrete structure.

Marine Concrete_RCC_30SCCM (Item Code:4.09.09) LGED Specifications based on laboratory testing:

Reinforced cement concrete work for Marine region with minimum cement content and maximum water cement ratio (WCR), as specified by the laboratory through mix design having minimum required average strength, f'cr =40.0 Mpa and satisfying a compressive strength f'c = 30 Mpa at 28 days on standard cylinders as per standard practice of Code AASHTO/ ASTM and Portland Composite cement conforming to BDS EN 197-1: 2003 CEM-II/B-V, high range water reducing admixture of complying type A or F under ASTM C 494 (Doses of admixture to be fixed by the mix design), sand of minimum FM 2.5 and 20mm down well graded crushed stone chips broken from boulders (LAA value not exceeding 25) conforming to ASTM C33 including breaking chips, screening through proper sieves, cleaning, placing shutter in position, making shutter water-tight properly, placing reinforcement in position, mixing in standard mixture machine with hoper, maintaining allowable slump of 100mm to 150mm, 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-I-C.

Note: Minimum cement content considered in M-30 is @ 450kg/cum relates to nominal mix ratio 1:1:25:2.4 and maximum WCR=0.4, Additional quantity of cement to be added if required to attain the required strength at the contractors own cost. The cost of reinforcement and its fabrication, welding, coupling, placing, binding etc. is not included but the cost of admixture & drinkable water with storage reservoir for concreting is included in Laboratory (CQCL), LGED or any other reputed laboratory approved by the competent authority before execution of the work.

Note: Using Concrete Mixer.

High-strength Concrete (HSC)

High-strength concrete (HSC) is a type of concrete with high compressive strength compared to normal-strength concrete (NSC). Although there is no exact limit of compressive strength that could distinguish HSC from NSC, the American Concrete Institute defines High strength concrete with a compressive strength of more than 6,000 psi.

Manufacture of high-strength concrete involves making optimal use of the basic ingredients that constitute normal-strength concrete. Producers of high-strength concrete know what factors affect compressive strength and know how to manipulate those factors to achieve the required strength. In addition to selecting a high-quality Portland cement, producers optimize aggregates, then optimize the combination of materials by varying the proportions of cement, water, aggregates, and admixtures.

When selecting aggregates for high-strength concrete, producers consider the strength of the aggregate, the optimum size of the aggregate, the bond between the cement paste and the aggregate, and the surface characteristics of the aggregate. Any of these properties could limit the ultimate strength of high-strength concrete.

It would be difficult to produce high-strength concrete mixtures without using chemical admixtures. A common practice is to use a superplasticizer in combination with a water-reducing retarder. The superplasticizer gives the concrete adequate workability at low water-cement ratio, leading to concrete with strength. The water-reducing retarder slows the hydration of the cement and allows workers more time to place the concrete.

High-strength concrete is specified where reduced weight is important or where architectural considerations call for small support elements. By carrying loads more efficiently than normal-strength concrete, high-strength concrete also reduces the total amount of material placed and lowers the overall cost of the structure. The most common use of high-strength concrete is for construction of high-rise buildings. At 969 feet, chicago's 311 South Wacker Drive uses concrete with compressive strengths up to 12,000 psi and is one of the tallest concrete buildings in the United States.

Advantages of High Strength Concrete (HSC) are:

- It reduces the cross-section of structural elements and therefore increases available space,
- It improves aesthetics due to slimmer cross-section,
- It reduces self-weight of the structure,
- It increases the modulus of elasticity of concrete and reduces creep (deformation under continuous loading) that controls short-term and long-term deflections, and
- It improves the long-term durability of structures, which is a key concern toward sustainable use of construction materials.
- High-strength concrete is a useful material for high-rise buildings, long-span bridges, heavy-duty industrial floors, pre-stressed concrete etc.

Concrete is a mixture of cement, water, coarse and fine aggregates with or without chemical and mineral admixtures. As aggregate covers 75 percent of the volume of concrete, for HSC, high-strength well-graded aggregate is essential.

The presence of different sizes of aggregate (well-graded) in appropriate proportions is important to reduce void. The maximum size of aggregate is also another important factor. Due to the internal bleeding of water in concrete, the bonding can be poor for large-sized aggregate.

20mm downgraded aggregate can be used for making concrete of strength of 6,000 psi or higher. However, it can be reduced to 12mm if the strength requirement is 10,000 psi or more.

The bonding with cement paste around aggregate is improved for smaller-sized coarse aggregate. For High Strength Concrete, the amount of cement is to be increased compared to normal strength concrete.

The amount of cement in High varies from 420 to 650 kg per cubic meter based on the strength requirement. As the amount of cement is increased, the size of the fine aggregate is also to be increased compared to normal strength concrete.

An increase in the sizes of fine aggregate will create adequate free space among aggregates for cement hydration products generated from a larger amount of cement compared to the normal strength concrete. Due to the use of more cement, the heat of hydration and plastic shrinkage of fresh concrete will be increased but can be controlled with the utilization of mineral admixtures with clinker, such as fly ash, slag, etc.

High strength Concrete is a durable concrete and, therefore, all construction works in marine exposure can be planned with HSC.

The stone chips produced at Maddhapara quarry are very strong (abrasion loss is less than 23 percent), and therefore can be utilized for making high strength concrete A mixture of concrete using Maddhapara hard rock with W/C of 0.30, CEM Type I cement of 460 kg per cubic meter, and silica fume of 40 kg per cubic meter produced compressive strength of 11,000 psi. The strength can be improved further by reducing the maximum size of coarse aggregate and increasing cement content.

12.9 Problem in Hot Weather Concrete

The success of many hot-weather concreting operations depends on the steps taken to slow the cement hydration reactions within the concrete and to minimize the rate of evaporation of moisture from the freshly mixed concrete. Potential concrete problems in hot weather are likely to include:

- Increased water demand
- Increased rate of slump loss
- Increased rate of setting
- Increased tendency for plastic-shrinkage cracking
- Increased difficulty in controlling entrained air content
- Decreased 28-day and later strengths
- Increased tendency for differential thermal-cracking
- Greater variability in surface appearance
- Increased permeability.

To prevent the above mentioned harmful effects of the hot weather on the quality of concrete the temperature of concrete shall not exceed the temperature shown in the table below:
Maximum allowable concrete temperature during placement of concrete

Relative humidity (%) during time of concrete placement	Maximum allowable concrete temperature (degree centigrade)
Greater than 60	33 C
40-60	30 C
Less than 40	27 C

12.10 Most Common Problem in Concrete during construction

The most common concreting issue is caused by excessive concrete mixing and carelessness when putting and handling it. The weather, on the other hand, plays a major role in worsening such issues that arise during concretion.

a) Bleeding

Bleeding in concrete occurs when the excess water comes to the surface of the concrete due to the settlement of heavier components like aggregates, cement. Excessive bleeding can do more harm as it lessens the strength of concrete.

Ways to reduce bleedings:

- Strictly maintaining water to cement ratio.
- Supplementary cementations materials to increase water absorption.
- Adding air entertaining admixtures.

b) Segregation

In this concrete problem, the cement paste comes to the top while aggregate settle down at the bottom of the concrete. Segregation affects the durability and strength of concrete as good concrete is always an even and homogenous mixture.

Ways to prevent segregation:

- Using the recommended proportion of cement and water.
- Avoiding over-vibration or compaction of concrete.
- Being cautious while handling, placing, or transporting concrete.
- Avoiding dropping concrete from long heights.

c) Plastic Shrinkage Cracking

Plastic shrinkage cracking occurs in the concrete when there is an excessive and rapid loss of water from concrete before it has even set. This occurs when the rate of evaporation of surface moisture is higher than the rate of bleeding of water in concrete. This problem is very common during hot weather conditions.

Here are the ways to avoid plastic shrinkage cracks in concrete:

- Avoiding over mixing of the concrete.
- Providing sunshades around the concrete in hot weather.
- Placing or constructing temporary walls to block or reduce wind velocity.
- Placing concrete either early in the morning or in the late afternoon to avoid hot temperatures.

d) Laitance

The consequence of the problems of segregation and bleeding leads to laitance in the concrete. During this concrete problem, a thin and weak layer of cement dust, sand, and lime appear on the surface. This condition further weakens the strength and durability of cement.

Prevent Laitance with these steps:

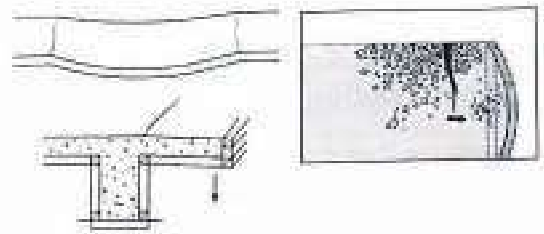
- Using water-reducing admixtures in concrete.
- Not doing are finishing steps till the water has evaporated from the surface.
- Removing clay, silt, dust content before mixing concrete.
- Using well-graded aggregates in the concrete mixture.

e) Types of Construction Defect in RCC Works:

Honeycomb and Rock Pockets

1. Defects due to Concrete Dimensional Errors

Dimensional errors in concrete structures occur either due to the poor centering of a structural member or due to deviation from the specifications.



2. Defects due to poor Formwork Installation
3. Defects due to Concrete Dimensional Errors

Dimensional errors in concrete structures occur either due to the poor centering of a structural member or due to deviation from the specifications.

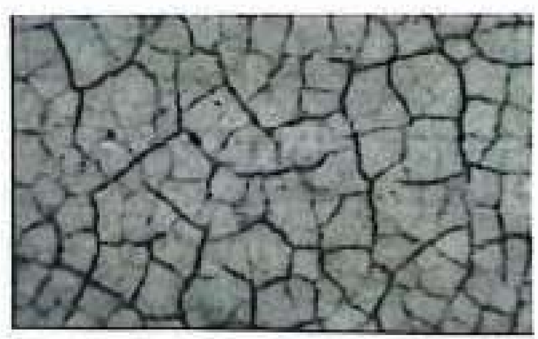
4. Defects due to Finishing Errors

Finishing errors in concrete structures can involve over-finishing of the concrete surface or addition of more water or cement to the surface during finishing of the concrete

5. Defects due to poor Reinforcement Placement

Errors during reinforcement installation could lead to serious concrete deterioration. For instance, inadequate chair bars and insufficient tying of reinforcement would cause rebar movement, which may lead to inadequate concrete cover and reduction in effect depth of the concrete section.

6. Bug holes or surface voids are small regular or irregular cavities formed due to the entrapment of air bubbles in the surface during placement and consolidation. They commonly occur in vertical cast-in-place concrete like walls and columns. Bugholes are considered as defects if their width and depth exceed 3.81 cm and 1.27 cm respectively.



7. Crazing

Crazing, alternatively referred to as pattern cracking or map cracking, is the uneven formation of closely spaced shallow cracks. Crazing occurs as a result of the top surface of concrete rapidly hardening due to high temperatures, an excess of water in the mix, or inadequate curing

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13. FOUNDATION OF BRIDGES & PILING WORKS

TYPES OF BRIDGE FOUNDATION

13.1 Guidelines for Bored Cast-in-Situ Pile Construction

Pile Foundation in Bridge Work:

- Mainly three types of piles are used in LGED Bridge foundation work.

a. Bored Pile (Cast-in-situ pile): Boring, casting and Setting at original pile layout position.

ii) RCC Pre-cast pile: Casting & curing other than original pile layout position and driving after matured period of concrete by Automatic diesel hammer or hydraulic push hammer.

iii) Spun pile: It is fabricated & pre-stress in Pile industry and driving after matured period of concrete by Automatic diesel hammer or hydraulic push hammer.

Bored Cast-in-Situ Pile

Important Issues:

- Is Pile layout position at dry ground?
- Is Pile layout position under water?
- Is Pier Cap casting position above water level?
- Is Pier Cap casting position below water level?
- Pile Dia is more than 800mm.

Considering the above situation, design, drawing and estimate of bored cast-in-situ pile will be different.

Steps followed for bored cast-in-situ pile construction/installation:

There are 4 main steps followed for Construction of Bored & Cast-in-situ Pile:

1) Making Stabilized Bore Hole: Using Drilling Equipment
2) Cleaning/Washing Bore Hole
3) Placing Reinforcement Cage: Using Lifting Equipment, Crane
4) Pouring Concrete: Using Tremie Pipe

There are 3 (three) basic method followed for making Bore Hole:

1. Dry Boring Method
2. All Casing Boring Method
3. Slurry/Wet Boring Method
   - Percussion Boring under DMC (Direct Mud Circulation)
   - Rotary Boring:
   a) Rotary by power auger
   b) Rotary boring under DMC
   c) Rotary boring under RCD (Reserve Circulation Boring)

13.1.1 Accessories for Cast-in-situ pile

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 pipe 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 pipe 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 5m from the underside of the pipe cap.

Tremie pipe

A tremie having a diameter of not less than 150mm, sufficiently long reach the end of pipe bottom and additional 500mm. Good tread at end and no leakage all over the pipe. 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 Parameter0Viscosity, Gel Strength and Type of flow

CHARACTERISTIC 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 50	32 to 60	32 to 50	Marsh funnel
Fluid loss	ml	<30	<50	n.a	Filter press
P^H		7 to 11	7 to 12	n.a	P^H meter
Sand content	%	n.a	n.a	<4	Sand content set

13.1.2 Boring Equipment:

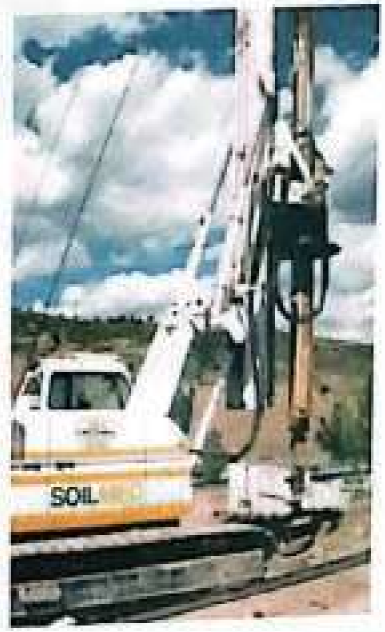
Based on Power System, Drilling Equipment are as Follows:

- Mechanical Powered System
- Hydraulic Powered System

5.2.2 Boring Equipment:

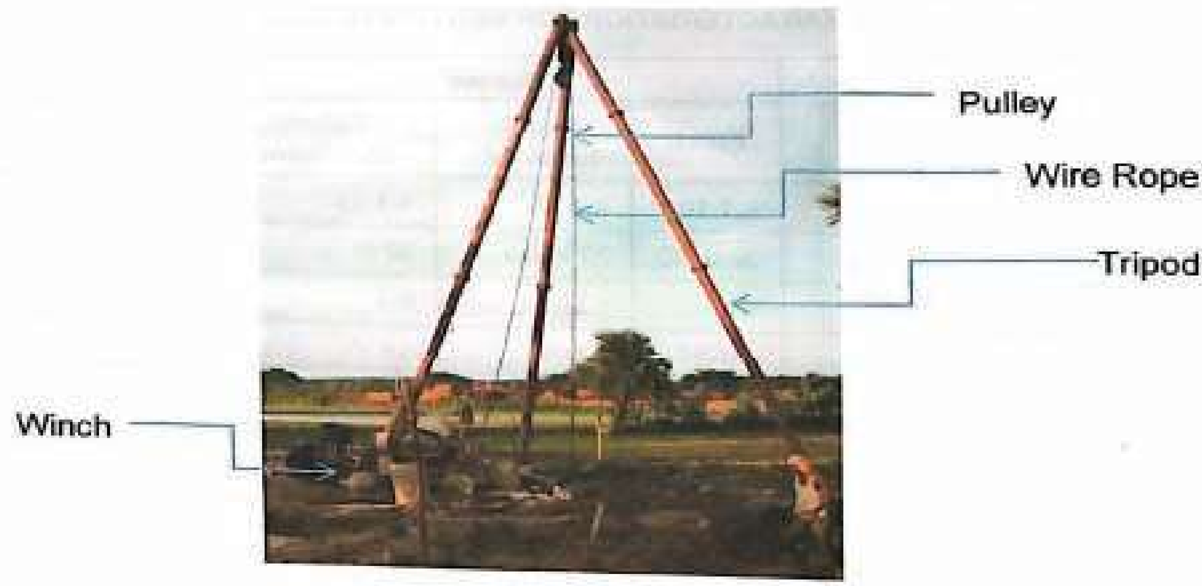
Based on Power System, Drilling Equipment are as Follows:

- Mechanical Powered System
- Hydraulic Powered System



Hydraulic Powered Rig

Double Fish Tail Type (Local Made)



Mechanical Powered Rig (Local)

13.1.3 Bore Hole Drilling System

Two type of boring system includes

1. Percussion drilling & 2. Rotary Drilling

Percussion Drilling: Percussion drilling involves the disintegration or breaking up to soil or rock by impact. The broken material may be removed with a bucket or other means such as slurry or air circulation.

Percussion Drilling Tools:

1. Double Fish Tail (Locally Made)
2. Clam-shell Buckets
3. Hammer Grabs Rock
4. Breakers and Drop Chisels
5. Down Hole Impact Hammers etc.

Rotary Drilling:

Rotary drilling involves the disintegration or breaking up to of soil or rock by rotating the cutting tools in the bore hole. The broken materials may be removed with the tools itself, with a bucket or other means such as circulation.

Rotary Drilling Tools:

1. Augers 2. Buckets 3. Core Barrels 4. Full Faces 5. Rotary Rock tool 6. Specialized Rotary tools etc.

AS per LGED Specification (Based on the drilling tools)

- Percussion Drilling is used for pile up to 800mm Dia. Under Direct Mud Circulation (DMC)
- Rotary Drilling is used for pile above 800mm Dia, Under DMC/Reserves Circulation Drilling (RCD)

Percussion Drilling System

Step to be followed for Percussion Boring:

1. Piling Party Selection shall be based on
   a) Must have good previous sufficient experience and proven record (If any)
   b) Sound and appropriate equipment in good working condition
   c) Drilling operator must have experience and responsibility for making good pile. Drilling operator must be a committed person, and should be interviewed and approved by the Engineer.
   d) Also have experience of preparation, testing and circulation of bentonite slurry for bore hole stabilization
   e) The sub-contractor (if any) shall submit to the Engineer detail methodology including equipment detail for good pile construction and should be approved by LGED officials.

2. Equipment Quality Check:

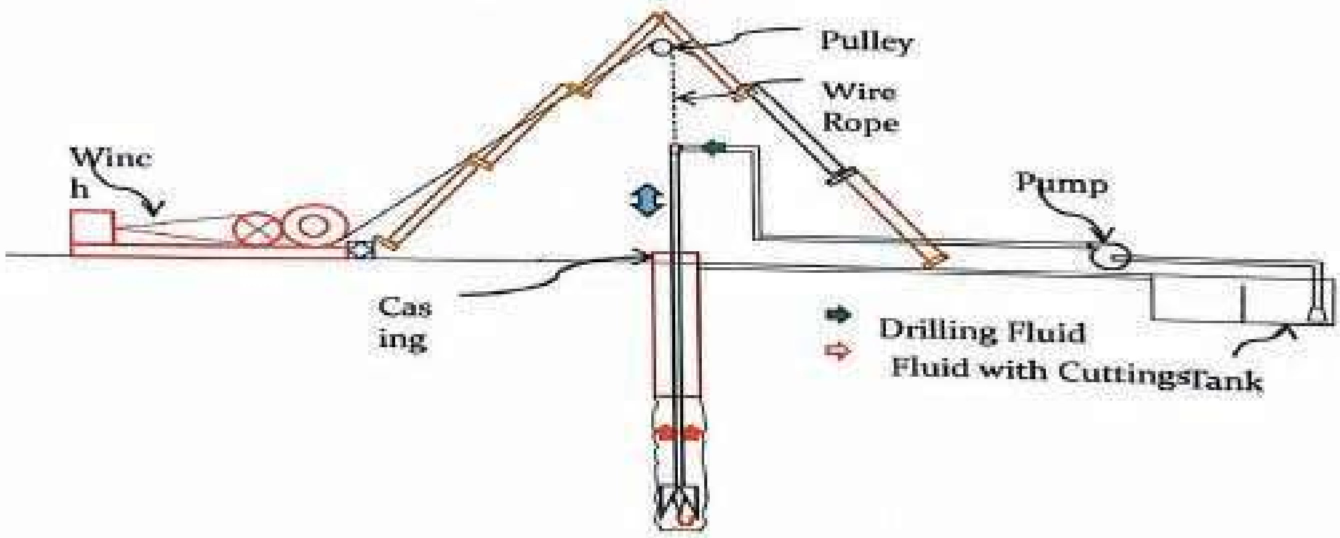
a) Diameter of double fish tail chisel/cutter should be equal or maximum 25mm less than the pile diameter and blade of the cutter should have sufficient thickness.
b) The hollow threaded drill shaft should have sufficient weight so that it can disintegrate hard soil strata if any.
c) The attachment of chisel and drilling shaft, drilling shaft and drilling pipes should be sound enough so that they never dropout during boring operation
d) The winch machine must have adequate capacity and good quality.
e) The equipment set should include baler to disintegrated hard soil layer.
f) The tripped should be enough strong and height to install reinforcement cage.
g) The pipe party should have mechanically operated slurry preparation tank (Cyclone) and circulation
h) Slurry circulation pump, generator, welding set and other tools be in sound working condition
i) The contractor/pile party must have bentonite slurry testing Kit

3. Setting out Pile and Initiate Boring:

a) Place Tripod stand at center pf the selected Pile location;
b) Attach chisel/cutter tools to drilling shaft, shaft to winch machine through pulley hanging from tripod. Also connect the drilling shaft at top slurry tank through flexible pipe.
c) Start boring and cutting soil by raising and dropping of chisel;
d) Circulate bentonite slurry to the hole through drilling shaft from slurry tank
e) Initial depth of boring shall be about 1.5m before placing of casing;

f) Boring of pile shall be done following the sequence of pile construction as shown in the drawing/design;

If not provided, boring for a pile shall not be commenced until 24 hours elapsed after completion of any pile within close proximity (radius of three times pile diameter). Boring



13.1.4 Bored Cast-in-Site Pile Construction

a) Setting out Pile and Initiate Boring:

a) Place tripod stand at the center of the selected pile Location
b) Attach chisel/cutting tools with Drilling Shaft (Thread and welding).
c) Start boring by raising and dropping of chisel.
d) Circulate Bentonite slurry to the hole
e) MS Casing pipe is installed in the bore hole to protect the bore hole wall from collapsing.
f) MS casing pipe is also required when bored pile is to be constructed in water or in very soft/very loose soil.
g) If provision of permanent casing is not kept in the design, temporary MS casing must be installed at the upper part of bore hole after initial boring.
h) The internal diameter of the permanent/Temporary MS casing shall be at least equal or 25mm higher than the specified diameter of pile.
i) Thickness and length of permanent casing shall be provided in accordance with the design provision. However, the length of temporary casing, when provided shall not be less than 4.0m.
j) The permanent casing must have uniform thickness and circular shape throughout its full length.
k) Installation of MS casing in the bore hole must be done by hammering the MS casing pipe so that the casing pipe is tightly attached with the soil.
l) The permanent casing pipe shall be of new MS sheet and must be free from any intermediate patch and segment shall be as high as possible
m) MS casing shall be installed after initial drilling (1.5m) of bore hole
n) The splicing of permanent casing pipe, if required, shall be continuously smooth welded around the pipe perimeter both outside and inside. The lifting hole in permanent casing must be closed during installation.
o) In case of boring carried out in dry land, the top level of casing pipe must be at least 0.3m above GL or 2.0m above GWL whichever is greater.
p) In case of boring carried out in water, the top level of casing pipe must be at least 2.0m above the water level outside the casing pipe.

b) Progressing of Boring:

a) After installation of casing the chisel attached with drilling shaft shall be placed inside the casing. Boring/cutting of soil shall be progressed by continuous raising and dropping of chisel using winch
b) Bentonite slurry of required density and viscosity shall be continuously supplied from the slurry tank to the bore hole through the drilling shaft.
c) Slurry shall stabilized the borehole and prevent from caving. It also loose the soil disintegrated by chisel due to raising and dropping. The slurry level inside the borehole shall be maintained at a level not less than 2.0m above the level of outside ground water.

d) Slurry shall be returned through the annular space between drilling shaft & borehole face and remove the cutting materials from the bore hole.
e) The returned slurry with the cutting soil shall be deposited t the receiving tank attached to the slurry supply yank for reuse.
f) The supplied slurry shall be tested after certain interval to confirm its properties (viscosity, density etc.). If required concentrated slurry from the reserve tank shall be mixed to ensure the required properties.
g) If any boulder, hard stratum or obstruction is observed in the hole disintegrate the layer by increasing the falling height of chisel dropping or use baler if required.
h) Continuously monitor the boring operation until achieving the pile toe level.
i) The boring depth (Pile toe level) should be confirmed by measuring the bore hole from casing top level.
j) No additional boring should be made beyond the design depth.
k) The complete boring operation shall be recorded in a standard boring format and preserved for future reference.

c) Cleaning/Washing of Bore Hole:

a) On confirmation of the final bore hole's depth as per design, the bottom of the bore hole must be carefully cleaned of mud, sedimentation and other soft materials.
b) The washing operation shall be carried out by supplying bentonite slurry from the supply tank with required viscosity and density.
c) The supplied slurry shall go down through hollow drilling shaft and return back to the receiving tank through the annular space between shaft and hole wall and carry out the deposition from the bore hole bottom.
d) The smaller sand particles shall be floated on slurry and return to the receiving tank with the back flow of slurry.
e) The slurry at the hole's bottom shall be tested by sand content tester to confirmed its sand content.
f) Washing shall be continued until the sand content of slurry reduced to less than 4%

d) Placing of Reinforcement:

a) Reinforcement for pile shall be tested prior to fabrication to confirmed its properties as per design requirement
b) Fabrication of re-bar cage shall be done as shown in the drawing. Main reinforcement in the form of a cage shall be assemble with additional support, like spreader forks, to form a rigid cage.
c) Spiral reinforcement shall fit closely around the main longitudinal bars and welded to the main longitudinal bar at each alternate contact point.
d) Numbers and length of re-bar cage shall be made as shown in the drawing.
e) The clear cover (75mm) of the re-bar case shall be ensured by inserting circular concrete disc of 150mm diameter and 50mm thick in spiral bar at regular interval. The concrete of the covering disc shall be same quality as of pile concrete.
f) Alternately, clear cover shall be maintained by providing steel chairs welding with main reinforcement.

g) The main longitudinal re-bar in each cage must not have any splicing
h) The fabrication of re-bar cage for selected pile must be completed and approved prior to commencing of boring operation.
i) The bottom re-bar cage as shown in the drawing shall be placed first using lifting tools (winch, crane) in the bore hole maintaining the correct center line position and hold it by any means on top of casing pipe.
j) The remaining re-bar cage shall be installed and spliced with the previously placed cage successively as per drawing.
k) The lap length for splicing in successive two cages shall be as per drawing and splicing shall be done applying continuous welding (both face) in main longitudinal bar.
l) Splicing of longitudinal bar shall be staged and not more than 50% of main bar shall be spliced in a horizontal plan.
m) Alternately, splicing can be carried out by using couple, a mechanical splicing system, if permitted by the client.
n) Special care should be taken during the splicing of successive two case to prevent the falling down of lower case.
o) The complete spliced re-bar case must be con-centrically placed in the bore hole so the clear cover of re-bar is uniform around the cage.
p) The complete spliced re-bar cage must be hanged from the casing top by a both end hooked steel rod so the rebar case does not penetrate into bore hold's bottom
q) The bottom of lower re-bar cage shall be 150mm above the bore hole base or as shown in the drawing.
r) The time required for completion of splicing and placing of reinforcement cage in the bore hole should be minimum as per as possible.

Reinforcement Cage Being Assembled, Showing Threaded Couplers

e) Re-Wash of Bore Hole

iii. As it takes time for splicing and placing of re-bar cage into the bore hole some sediment floated in the slurry may deposits to the bore hole's bottom

iv. Hence, further cleaning of bore hole must be carried out to flash out the deposition from the bore hole.

v. The washing can be carried out by supplying slurry to the bore hole through the drilling pipe placing inside the re-bar

vi. The re-washing shall be continued until the sand content is further reduced to less than 4% by volume

f) Placing of Tremie Pipe

B) Tremie pipe is required for pouring concrete in the bore hole under drilling fluid

C) The tremie pipe shall be made of heavy gauge steel pipe (Min 6mm)

D) The diameter of the tremie pipe shall bbe not less than 200mm

E) The joint system of tremie segments must be sound and watertight and needs the approved of the Engineer.

F) The total length of tremie pipe shall not be less than depth of bore hole

G) The tremie shall be placed such way that the tremie bottom shall be maximum 150mm above the borehole bottom.

H) The tremie should be provided with adequately sized funnel or hopper connected at the top of tremie to facilitate transfer of sufficient concrete from the delivery device.

I) The joint between the funnel and tremie should be sound and watertight

J) The size (volume) of the hopper shall not be less than the volume of concrete required for filling up 1.5m length of pipe.

K) The full tremie pipe should be marked with paint at 0.3m interval for monitoring lifting of tremie pipe during concreting.

g) First Charging Concrete:

a) If the bottom of tremie pipe is open to drilling fluid after placing, the tremie concrete shall be directly mixed with slurry inside the tremie which makes the concrete quality very poor. Hence, concrete shall not be placed free into the water or drilling slurry.

b) The mouth of tremie at top should be temporarily plugged/closed by steel circular plate (stopper) which shall be hooked for its lifting out.

c) When the steel plate stopper shall be lift out, full volume of concrete from the hopper shall be suddenly fall down through the tremie which quickly flash out the slurry from inside the tremie and the process is termed as first charging of tremie concrete.

d) When the steel plate stopper shall be lift out, the full volume of concrete from the hopper shall be suddenly fall down through the tremie which quickly flash out the slurry from inside the tremie and the process is termed as first charging of tremie concrete.

e) The first charged concrete shall raise up to 1.5m through the bottom of tremie pipe and shall remove up any small deposition at bore hole base. In the same process second charge of concrete should be applied so the concrete level in the bore hole shall be raised up to 3.0m.

- Alternately, Cement plate with inclusions of Lathe Cutting/Nut-Bolts- Small MS rod pieces (shape: Cylindrical, Size: diameter slightly larger than the inside diameter of tremie pipe and length is about 300mm) can be used, known as plug, at the tremie mouth for separating concrete from slurry
- A steel plate closer may be used at the tremie bottom for making tremie free from any slurry tin the inside, which shall be opened when concreting.

h) Pouring of Concrete:

a) Concrete shall be then poured in the hopper until fully filled up the tremie pipe. Tremie pipe shall be slowly raised & dropped (Max. 150mm) so the concrete in the tremie fall down and concrete level is further raised up outside the pipe.

b) The lifting of tremie should be such that it always embedded in the fresh concrete a minimum of 2.0 to 3.0me

c) The embedment of tremie in the concrete should be maintained through the concreting to prevent entry of water into the pipe.

d) Rapid raising and lowering of the tremie pipe should not be allowed and all vertical movement of tremie pipe should be done slowly and carefully.

e) Concrete shall then be continuously placed without any interruption by meal breaks, change of shift, movement of placing positions and like so that a monolithic concrete shaft of full cross section id formed.

f) If blockage in the tremie occurs during placing of concert, the tremie shall be quickly raised 150 to 450mm and then lowered to dislodge the blockage.

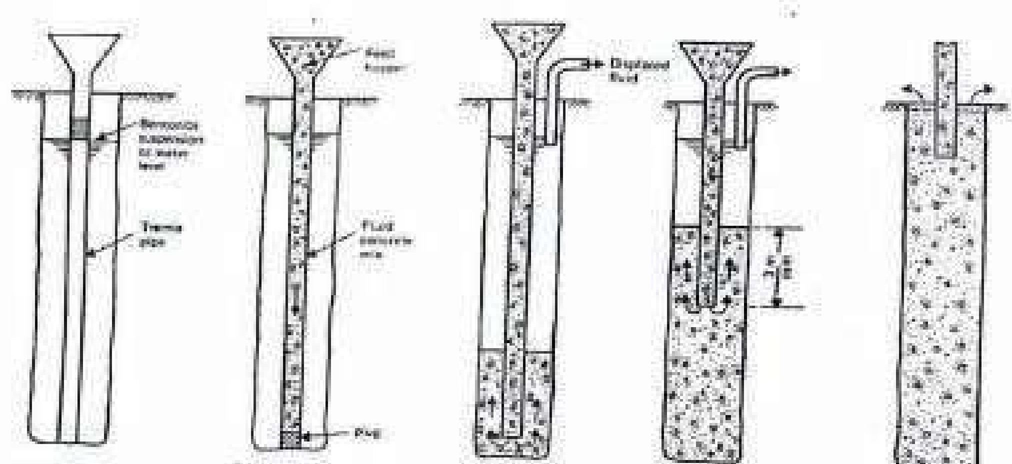
g) Alternately, tremie surface may be hammered from outside to dialoged the blockage.

h) The depth of pipe embedment (2.0 to 3.0m) must be closely monitored during all such attempts.
i) Note that the tremie bottom shall never be allowed to lift above the concrete top level within the bore hole.
j) Supplied volume of concrete, corresponding concrete level in bore hole. Lifting of tremie should be closely monitored and recorded in a format.
k) In case of temporary casing, concrete pouring shall be continued until the fresh concrete is reached at pile cut-off level.
l) As top level of concrete in the bore hole is of poor quality, hence concreting cannot be stopped until the top level of concrete is found at least 0.75 to 1.0m above the pile cut-off level.
m) In case of permanent casing, concrete pouring shall be continued until the sound/fresh concrete is reached at casing top level. It means, some portion of upper level concrete must be over flown to achieve the sound concrete.
n) The total supplied volume of concrete to the bore hole must be compared with calculated volume of full bore hole.
o) The supplied volume must be always higher than the calculated volume.
p) If possible. The concrete pouring work should be done in day light for easy monitoring.
q) The full concreting operation should be completed within shortest possible time preferably within 8 hours.
r) Necessary arrangement (double set of mixture machine, lab uretic) for quick preparation and placing of concrete should be kept at site.
s) For large diameter and higher length pf pile where concrete volume is more and concreting cannot be completed in 8 (eight) hours arrangement of batching plant, ready mix concrete, transit mixture, pump concreting should be ensured for completion of concreting as early as possible.

i) **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. 0 and hardened concrete (Cylinder strength etc.). Bentonite suspension test report (Density, Viscosity, Sand content test etc.) ID number 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 property and marked with peg and Tag (ID number) and test report 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.

Various Stages of Concreting by Tremie is given below



a)Tremie rested on the bottom of pile. Plug placed inside tremie at suspension level.

b)Concrete discharged into tremie hopper until full and plug reaches the bottom.

c)Trieme is then lifted off the bottom slightly (50-100mm)Concreting is continued pumping away the displaced fluid.

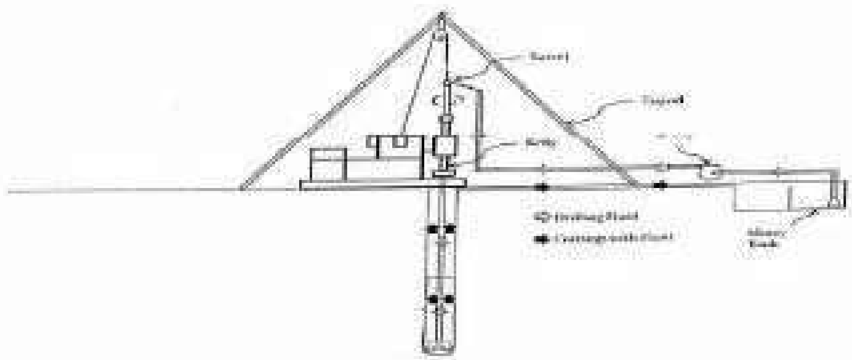
d)Maintaining & continuous embodment of tremie in the concrete, a section of tremie is removed.

e)As concrete reaches surface, pumping is stopped. Tremie is further shortened gradually and more concrete poured till sediment is displaced completely and concrete appear at the top of the pile.

j) Feature of Rotary Boring:

a) Boring advances, cutting soil by a <u>rotating drill bit</u>
b) Drill bit is attached with hollow drill string
c) Mud flows through the hollow stem of drill rod.
d) Bentonite slurry is used as drilling fluid.
e) Slurry stabilizes the borehole and remove cutting from borehole
f) Mud circulation from underground mud tank
g) Slurry/mud flows down through drill road.
h) Slurry returns through annular space between drill & borehole face.

Rotary Drilling Overview (Direct Mud Circulation-DMC)



Slurry/Wet Methods (Rotary Boring Under DMC):

Advantages:

- Less disturbance
- Equipment cost is cheaper than RCD
- Relatively cheaper than other rotary boring technique

Disadvantages:

- Slow method
- Mud management is terrible
- Torque is low
- Borehole cleaning/flashing is poor
- Huge space is required

Slurry/Wet Method: Rotary Reverse Circulation Drilling RCD:

Features:

a) All features are same as DMC only difference is mud circulation
b) Mud circulated from partially underground mud tank
c) Slurry/mud flows down through annular space between drill rod & borehole face
d) Slurry returns through drill rod
e) During return, flow velocity is very high
f) Very efficient in removing cuttings

6. Pile Construction Record Keeping

1st Ring File: For each Abutment and each pier

- Design an drawing; correction if any
- Pile construction sequence sheet
- Various Record of each pile including pile driving log.

2nd Ring File:

- Materials Lab Test Report of each lot
- Concrete Mixed design report

3rd Ring File

- Lab Test report (Fc) of each component individual casting.
- Site order book
- Measurement Book (MB)
- Duty Roster signed by employ

• LOCAL GOVERNMETN ENGINEERING DEPARTMENT

• SECOND RURAL TRANSPORT IMPROVEMENT PROJECT (RTIP-II), D&SC- R1, (IDA CREDIT NO.5107-BD)

• vi. Bridge Checklist For Boring and Casting Record of RCC Cast-in-Situ Pile, (FOR SWP/IPC No.:)

- District: Upazila: Contract Package / Sites No.: Date:
- Name of Work (Chainage):
- Name of Contractor:
- The following Bridge check list is being suggested as Boring and Pouring Record of RCC Cast-In-Situ Pile : Chisel Dia - mm
- Discription:

Boring Length - m

Name of Component & Location	Total No. of Pile & Dia of Pile	Length of Pile (Including Breaking Length) (m)	Length of Reinforcement Found (m)	Volume of each Pile (cum)	Cement Bag Required for each Pile (no.)	Date of Boring & Casting	Pile No.	Boring			Washing			Casting			Actual Number of Cement Bag Used
								Start Time	End Time	Elapsed Time	Start Time	End Time	Elapsed Time	Start Time	End Time	Elapsed Time	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Abutment Pier																	

- Remarks :

Signature of Contractor's Representative	SAE Upazila: District:	Upazila Engineer Upazila: District:	ARE, D&SC-R1, RTIP-II, LGED District:	Executive Engineer, LGED District:

TROUBLE SHOOTING-BULGING

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13.2 Trouble shooting installation of Cast-in-Situ Pile

Trouble Shooting – Bulging

Bulging may occur when borehole wall collapses within a certain depth resulting in enlarged diameter. Common cause of borehole wall collapse is drilling fluid unable to hold the integrity of the borehole wall or inadequate length of casing in sandy strata.

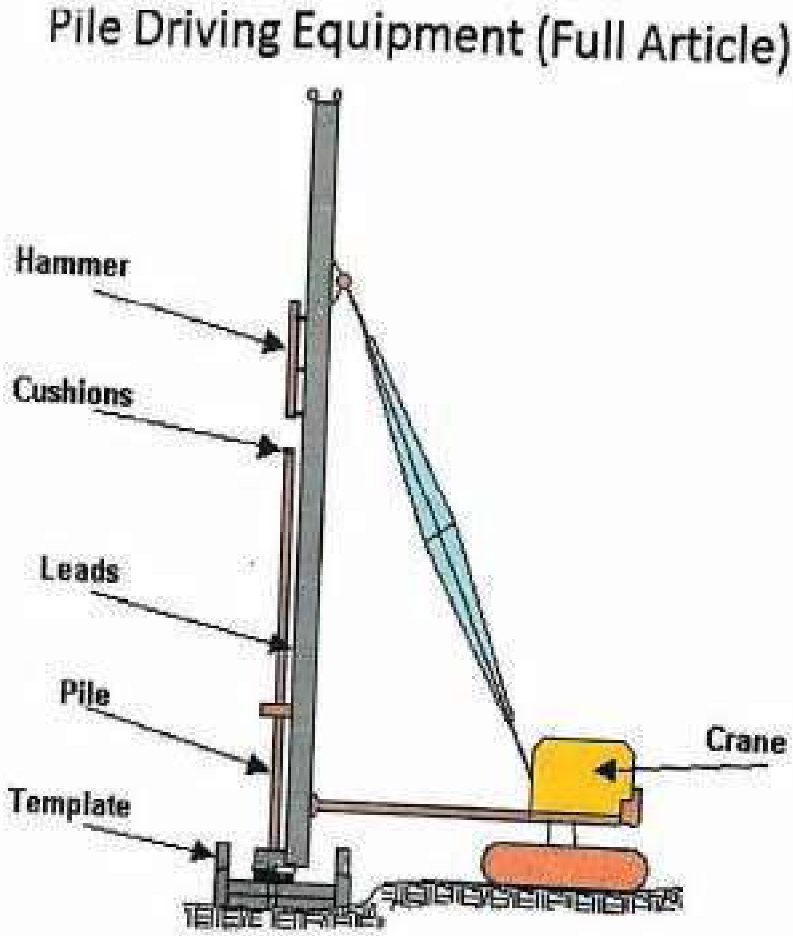
- To avoid such problem soil profile should be carefully studied and adequate density of drilling fluid and casing must be maintained.
- Necking may occur in soil when drilling fluid pressure cannot hold the open resulting in reduced diameter. Necking may occur due to lower density of drilling fluid 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 – Discontinuity

- 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 may be withdrawn after concreting if above conditions stated earlier are met.
- Casing should be withdrawn as soon a 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.



13.3 Tolerance of Construction Works

Unless it has been specified otherwise, all works shall be constructed within the tolerances shown in the Table given below:

Type of Structure	Item	Tolerance
Concrete Structure	Tolerance from specified position (Structure) Maximum departure of plan position structure or element	25mm
	Tolerances from specified dimensions (Structure) Maximum departure in thickness or cross-sectional dimensions of columns, beams, buttresses, piers, wall footing etc. like up to and including 500mm thick (except tunnel and shaft linings)	+6mm -3mm
	Ditto – 500mm to 1000mm thickness	+10mm -5mm
	Ditto – 1000mm to 4000mm thickness	+10mm -8mm
	Ditto – Over 4000mm thickness	+25mm -10mm
	Tolerance from specified position (Surface) Maximum departure of vertical, sloping or curved surfaces including joint surfaces.	25mm
	Maximum departure of horizontal or near-horizontal surfaces including joint surfaces	20mm
	Tolerance on straightness or Departure from Specified Curve (Surfaces) General Surface Maximum Deviation in horizontal or vertical direction-gradual	12mm in 2m
	Maximum Deviation in horizontal or vertical direction-abrupt	6mm
	Surface in contract with low velocity flowing water Maximum deviation in direction of flow or normal to flow-gradual	6mm in 2m
	Maximum deviation in direction of flow or normal to flow-abrupt	4mm
	Surface in Contact with High velocity flowing water Maximum deviation in direction of flow or normal to flow- gradual	3mm in 2m
	Maximum deviation in direction of flow or normal to flow-abrupt	0 (Grind to 1 in 50 level)

Formwork	Sectional dimension Plumb Levels (before any deflections has been taken place)	+5mm +1 in 1000 of height +3mm
Reinforcement	Length of splice	-25mm
	Variation of protective cover	+5mm
	Variation in indicated position or reinforcement: • Starter bars	One bar diameter
	• Slabs and Walls	0.25 times the indicated spacing
	• Beams and columns	+5mm
	Dimension of bent bars: • Stirrups and ties	+5mm
	• Other bars	+10mm
Slope protection	Stone Works Pitching and Masonry	+50mm over 3m
	Thickness of tipped rock or filter	+50mm+ -000
	Block work/ brick Work Vertically	+3mm in 1m
	Line	+5mm in 3m
	Finished level	+10mm
Piles	1. Pre-cast driven pile	
	a) Verticality for vertical pile	1 in 50
	b) Verticality for raker pile	1 in 25
	c) Deviation from position shown on the plan for vertical and raker piles after driving	1/4th of least dimension or 75mm whichever is greater
	Concrete piles casting tolerance:	
	vii. Maximum departure in thickness or cross section dimensions	+6mm -0.00
	viii. Deviation of pile face	6mm in 3m
	ix. Deviation of cross-section centroid from straight line connecting the centroid of the end faces of the pile	10mm
	2. Bored and Cast-in-situ pile:	
	a) Verticality for vertical pile	1 in 75
	b) Verticality for raker pile	1 in 25

	c) Deviation from position shown on the plan for vertical and raker piles shaft	Maximum 75mm in any direction
Elastomeric bearing	Level of the top surface	3 mm
	Point on either surface in contact with the bearing from the plane of that surface	1 mm
	Slope of each face	5mm per m
	Horizontal position of any point from the location	10mm

Pre-condition for Surface Coating: Surface preparation is must by blasting system before coating. White surface must be obtained before applying the contents of coatings. The surface preparation standard would be SA-2.5 to 3.0 (Swedish standard). Curing times is 7 to 14 days.

Table: Tolerance for Placing Reinforcement

Depth of Member, d	Tolerance for d	Tolerance for Minimum Concrete Cover
d≤200mm d> 200mm	±10mm ±13mm	-10mm -13mm

13.4 Bentonite Slurry Tank & Descending Machine

Following tests to be carried out for bentonite

- Liquid Limit (fresh bentonite)>450
- Swell Index>450
- Density
- Viscosity
- P^H^

Drilling Fluid Properties:

Parameter	Unit	Values	Test Method
Density	g/cc	1.03 to 1.10 max 1.12	Mud balance
Viscosity	Sec	30 to 60	Marsh Funnel
Gel Shear Strength	N/sqm	1.4 to 10	Shear Meter
P^H^	no	9 to 11.5	Paper strip

a) Slurry Preparation & Circulation System

a) Slurry tank is double Chamber Rectangular in shape.
b) Volume of slurry=2.5 to 4 times of Borehole Volume
c) Depth of tank= up to 1.5m
d) Bore hole to setting tank to circulation tank to supply tank
e) Normally the supplies slurry contains 4% to 6% fresh bentonite by weight to meet the required value of viscosity, density and gel strength
f) Initially 15 to 20% bentonite is mixed with potable water in a cyclone having continuous stirring system

g) The mix is then transferred to a rejuvenation tank (volume is one third of supply chamber) and kept there for 24 hours.
h) Before the starting of boring works, slurry from the rejuvenation tank is transferred to supply chamber and be diluted mixing with three times water.
i) The properties (viscosity, density etc.) of slurry from supply tank shall be tested
j) After getting satisfactory propertied, the slurry shall be supplied to the bore hole by pumping through the drilling shaft.
k) The cutting materials in the bore hole shall mixed with slurry and back to the setting tank for re-use
l) The cutting particles shall settle in the setting tank and circulation tank and the slurry shall be flowed to the supply tank
m) The deposited materials shall be removed from the setting and circulation tank at certain interval
n) The slurry from the supply tank and bore hole shall be tested at certain interval to confirmed the properties. If needed concentrated slurry from the rejuvenation shall be mixed
o) The slurry tank shall be under ground-so the mud returns to mud tank under gravity from borehole
p) Quantity of slurry shall varies 2.5 to 4 times of volume of borehole
q) Depth of tank shall be restricted up to 1.5m
r) All sides and bottom to be lined with brick wall
s) Mud to be spilled off from one chamber to another
t) To be located away from pile point-Most of the sand deposited in surface drain before reached to the circulation tank
u) Steel tank can be used if crane is available at site-manual shifting would be difficult
v) In case of RCD-Mud tank to be a bit (about 500mm) raised from EGL-Mud flows from mud tank to borehole under gravity.

b) Quantity of Bentonite:

Factors affecting quantity of bentonite:

- Size of the pile
- Soil Type Boring technique
- Quality of bentonite
- Recycling of mud
- Efficiency of mud management

c) Field Testing of Bentonite Slurry (Equipment Kit)

- Marsh Funnel & Viscosity Cup
- Mud Balance
- P^H Test Paper
- Sand Content Kit
- Fluid Sample
- Stop Watch

- Durable Carrying Case

1. Slurry Formation

- **Support for Excavation**: Bentonite is used to create a slurry that supports the walls of boreholes during piling operations. This prevents collapse and maintains stability in soft or loose soils.
- **Hydraulic Properties**: The slurry has excellent viscosity and yield strength, which helps in stabilizing the borehole and controlling fluid loss.

2. Soil Stabilization

- **Sealing Properties**: Bentonite can swell and form a gel-like mass when mixed with water, effectively sealing porous soils and preventing water ingress.
- **Reduction of Soil Erosion**: The use of bentonite helps in reducing soil erosion around the piling area, which is crucial for maintaining the integrity of the site.

3. Environmental Protection

- **Contaminant Barrier**: Bentonite is often used to encapsulate contaminants in the soil, preventing their spread during excavation or piling operations.
- **Minimizing Waste**: Its use can help minimize waste and manage byproducts during construction, promoting more sustainable practices.

4. Improved Load-Bearing Capacity

- **Enhanced Bonding**: Bentonite can improve the bonding between the pile and the surrounding soil, enhancing the overall load-bearing capacity of the structure.
- Friction Reduction: The slippery nature of bentonite helps reduce friction during pile installation, making it easier to drive piles into the ground.

TYPES OF PILE TESTING AND WHY THEY ARE NEEDED

13.5 Pile Load test (Static & Dynamic)

13.5.1 Pile Load Test:

Pile Load Teat : It is a test conducted physically on piling site to test the magnitude of the pile foundation strength against the civil engineering load factor.

Objectives of Pile Load Test:

- The pile load test involved the direct measurement of pile lead displacement ibn 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 : 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;

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

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 less than 2% of total nos. of pile or not less than 2

Compression Load test:

There are two types of compression load tests-

a. Maintained Loading (ML) test:
   - The best suited method of carried out a compression load test on pile;

- The load is applied in stages and maintained constant unit the resulting settlement of the pile ceases before appling next increment

b. Constant rate of penetration (CRP) test:
   - The load being adjusted to given a constant rate of down warded movement to the pile and continued until failure point as reached
   - The test is rapidly performed but does not show any elastic-settlement under working load

13.5.2 Methodology of Pile Load Test

Loading Procedure:

01. Kentledge Method:

- A platform is constructed on the head of the pile on which a mass of heavy material termed "Kentledge" is placed;
- A hydrologic Jack is placed on the pile head and load is applied jacking against the Kentledge load

02. Anchor Piles Method:

- Anchor piles capable of withstanding an upward force are constructed on each side of the test pile with a beam tied down to the load obtain a reaction against the underside of the beam

Test Loading Type:

b. Static Load-Continued up to failure load

III. Cyclic load- Repetitive Loading

Test Standard:

The test has been standardized as ASTM-D1143. However, some local codes may stipulated the load increments and time sequence.

Test Load:

- The test load carried to some multiple of the working load
- Test load on pilot pile may be 2 to 3 times the working load
- The test load on service pile for routine test shall be 1.5 to 2 times the working / design load

Compression Load Test of Pile: The test has been standardized as ASTM-D1143

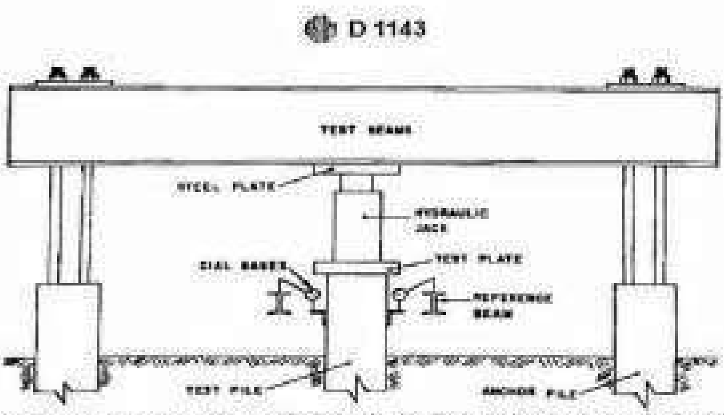


FIG. 1 Schematic Set-Up for Applying Loads to Pile Using Hydraulic Jack Acting Against Anchored Reaction Frame

Testing Equipment:

Hydraulic Jack	:	Placed on the top of pile head and loads is applied to the pile head through it.
Pressure Pump	:	Connected to the jack and pressure is served to the hydraulic jack by pipe
Pressure Gauge	:	Attached to the pump and hydraulic pressure is recorded
Deflection Gauge	:	Attached to the pile and pile head displacement is recorded

13.5.3 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;

iv. The head of the test pile shall be cut-off leveled and chapped with a steel plate to produce a level bearing surface;

v. Pile head to b e 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) Plate form 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
i) Pipes and other accessories should be in order

Cyclic Loading Procedures

The load shall be applied and removed in increments based on the anticipated working load of the pile with the following schedule:

Load as Percentage of Working Load		Minimum Time of holding Load
Bored Pile	Driven Pile	
25	50	1 hour
50	100	1 hour
75	125	1 hour
100	150	1 hour
75	125	10 minutes
50	100	10 minutes
25	50	10 minutes
0	0	1 hour
100	150	6 hour
125	200	1 hour
150	250	6 hour
175	275	1 hour
200	300	24 hours-Proof Load
175	275	10 minutes
150	250	10 minutes
125	225	10 minutes
100	200	10 minutes
75	150	10 minutes
50	100	10 minutes
25	50	10 minutes
0	0	1 hour

Record of Pile Load Test		
General Information:		
Project Name:		Contact No.
Pile Type: Pre-cast/Cast-in-site	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

13.5.4 Office Order of LGED

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

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

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

৩। Pressure Gauge এর Calibration BUET থেকে Test করে 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 efficiency 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) থাকতে হবে।

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 2wU Dial Gauge এর 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।

13.5.5 DYNAMIC LOAD TEST ON PILES

Dynamic Load Test on piles is a method that can be used to evaluate pile load-carrying capacity by applying a dynamic load. The method is valid, reliable, and helps to evaluate pile capacity quickly compared to static load tests, and one or more piles can be tested per day as per the requirement of the project. Dynamic load test for piles is conducted using Pile Driving Analyzer (PDA) to determine pile load capacity by collecting and analyzing force and velocity data under drop-weight impacts. The field data are further analyzed using Pile Wave Analysis to refine the soil parameter and assumptions.

13.5.5.1 Objectives: Dynamic Load Test on Piles

⇒ Static pile capacity at the time of load testing.
⇒ Simulated static load test curve
⇒ Bearing capacity and skin friction
⇒ Distribution pattern of skin friction along the pile shaft
⇒ Developed compressive stresses during testing
⇒ Displacement of the test pile
⇒ Pile integrity

12.5.5.2 Dynamic Load Test Preparation:

⇒ Dynamic load test on piles is carried out by fixing strain sensors and accelerometers to the sides of the pile below 1.5 times of pile diameter or higher from the pile head top and then connecting them with PDA.
⇒ Test pile should be extended to 1.6 times pile diameter after chipping top loose concrete.
⇒ In the case of the liner pile, two openings (300mm x 300mm) shall be left below 1.5 times of pile diameter from the top of the pile head for sensor fixing.
⇒ The extended pile head diameter, reinforcement and grade of concrete should be the same as the actual pile. A higher grade of concrete mix can be used for pile head built up if required after special approval from the authority.
⇒ Vertical and helical reinforcement shall also be extended to avoid cracking of concrete under hammer impact.

⇒ A reinforcement mesh must be provided at the top of the pile reinforcement, as shown on the test pile drawing.

⇒ Concrete at the sensor level shall be smooth, hard and uniform.

⇒ It is necessary to ensure that the pile top has sound concrete, and it should be even and flat at the top. The pile sides also shall be reasonably uniform in diameter.

⇒ After grinding, a flat surface is prepared to fix the sensors.

⇒ Sometimes a pile top cushion consisting of sheets of plywood with a total thickness between 25mm to 50mm or as directed by the Test Engineer shall be placed on the pile top.

12.5.5.3 Pile Monitoring and Analysis:

a) After 15 days of pile installation, a dynamic load test on piles may be carried out, providing the cube compressive strength of pile concrete and built-up portion concrete has achieved the required strength.

b) High Strain dynamic load test for piles is conducted by fixing strain transducers and accelerometers to the sides of the pile shaft. The sensors, as mentioned above, are connected to the PDA through the main cable.

c) First of all, sensors record strain and acceleration measurements and convert them from analogue to digital from display them on PDA screens.

d) Dynamic load test for piles is started by impacting the pile head with a hammer blow, starting with a smaller drop height (typically 0.5m). This is to ensure the correctness of the data and setup arrangements.

e) Each hammer blow, the strain transducers measures strains, whereas accelerations are measured by accelerometers connected on the other sides of the test pile.

f) By integration, these signals are converted to digital from by thr equipment and then converted to force and velocity.

g) PDA displays immediate field results in the form of the mobilized capacity, pile top compression, integrity, stresses etc., are shown after each hammer blow.

h) The force and velocity curve shall be as per ASTM D4945.

i) Dynamic load test on piles is continued by increasing the hammer height by around 0.5m increments until either the pile set or the pile capacity reaches the required or limiting values.

j) The limiting value for the pile capacity would be the test load at which settlement would be 3-4mm per blow. In other words, a test can be terminated when settlement is more than 3-4mm per blow.

k) Generally, the pile capacity shall be considered fully mobilized if the energy levels due to hammer impact are enough to cause a measurable net displacement of at least 3-4mm per blow for minimum of three successive impacts.

l) Suppose the pile settlement is less than 3-4mm per blow and the pile achieves the required capacity. In that case, it implies that not all the static pile resistance has been mobilized and that the pile still has some capacity that could not be measured or was not required to be measured at the time of testing.

m) After combining measured field data with the pile wave equation, an analytical method can predict the static bearing capacity of the test pile and distribution of soil resistance.
n) Recorded force and velocity data is straight input as obtained from field measurements.
o) Depending on the measured velocity, the program computes the force required to cause the imposed velocity.
p) Both measured and computed forces are plotted as a function of time.
q) The interactive analysis is continued until a good match quality between both the curves is received.
r) If the match quality is not satisfactory, the soil resistances at the pile point and along the pile shaft are adjusted until a good match is found.
s) This provides a better judgment of the actual static pile capacity measured during the field dynamic load test on piles and the friction and end-bearing components.
t) A good match is obtained when match quality is less than five tor bored piles. However, there may be exceptions that shall be acceptable when justifiable.
u) A graphical printout can be obtained on-site, which shall include input and output quantities, the force/velocity response graph, the upward and downward wave time response graph, the static and dynamic resistance-time graph, the energy time and displacement time graph shall be presented along with the following key input and output results.

13.5.5.4 Input Parameters for Dynamic Load Test on Piles:

⇒ Pile No.
⇒ Date and time of test
⇒ The pile length below gauges (LE)
⇒ The adopted pile wave speed at the pile head and the overall wave speed
⇒ The wave return time (2L/c)
⇒ The pile modulus at the transducer location
⇒ The pile specific weight
⇒ The pile area at the transducer location (AR)
⇒ The pile impedance
⇒ The Case Method damping factor (Jc)

13.5.5.5 Output Parameters for Dynamic Load Test on Piles:

⇒ The maximum force applied (FMX)
⇒ The maximum energy imparted to the pile (EMX)
⇒ The maximum displacement of the pile head (DMX)
⇒ The pile capacity estimate (RMX, RSU)
⇒ Force velocity Proportionality (FVP)
⇒ The maximum compressive stress in a pile (CSX)
⇒ The maximum tensile stress in a pile (TSX)
⇒ Estimated finalize set (DEN)

The final report contains all aspects of pile monitoring. The report will incorporate the results of CAPWAP analysis and a plot of simulated static load test curve with all the output mentioned in the introduction that satisfies all the requirements of a standard dynamic load test on piles.

13.5.5.6 Limitation of Dynamic Load Test on Piles:

⇒ Although the method can be used to predict skin friction and end bearing along the length of the pile, these values should be used with caution as the CAPWAP is an iterative procedure.

⇒ Further, this separation also depends on pile geometry; reliability of soil bore log, and movement of the pile under repetitive impacts.

Unlike static testing, the evaluation of dynamic pile test results requires an experienced engineer trained in interpreting the results.

13.6 Pile Integrity Test

A Pile Integrity test (PIT) is done to assess the quality and structural integrity of concrete piles used in deep foundation, by detecting potential defects like crack, voids, or inconsistencies along the pile shaft, ensuring the safety and load-bearing capacity of the foundation system without the need for extensive excavation or destructive testing: essentially acting as a quality control measure to identify major issues that could compromise the pile's stability and performance.

13.6.1 Key points about pile integrity testing:

a) **Non-destructive method:**
   - It is a low-strain, non-destructive test, meaning it doesn't damage the pile while evaluation its condition.

b) **Low-cost and efficient:**
   - Compared to other pile testing methods, PIT is relatively cost-effective and can be performed quickly on a large number of pile on a project site.

c) **Early defect detection:**
   - By identifying potential issues early on, it allows for corrective actions to be taken before further construction, improving overall foundation stability.

d) **Detects major defects:**
   - The test can identify significant anomalies like crack, necking, soil inclusion, or voids within the pile shaft.

e) **Quality assurance:**
   - By performing PIT, engineers can verify that the piles meet design specifications and standards, contributing to overall project quality

How it Works:

- Impact and data collection: A small hammer is used to strike the pile head, generating stress wave that travel down the pile. An accelerometer attached to the pile head records the reflected wave data, which is then analyzed to identify irregularities.

Applications:

- Quality control during pile installation
- Assessing the condition of existing piles in older structure
- Verifying pile length
- Identifying potential issues before further construction

13.6.2 Key steps in a pile integrity test:

a) Preparation:

- Clean the top surface of the pile to ensure good contact with the accelerometer
- Attach the accelerometer (motion transducer) firmly to the pile head
- Connect the accelerometer to the data acquisition system

c) Impacting the pile:

- Use a light hand-held hammer to strike the pile head with a controlled impact
- Record the impact force and time of impact

d) Data acquisition:

- The accelerometer records the velocity or accelerometer response of the pile as the stress wave travels through it and reflects back from the pile toe or other anomalies.
- The data acquisition system stored the recorded signal.

e) Data analysis:

- Analyze the recorded wave pattern to identify any significant changes in impedance (related to concrete quality, cross-section variations, or defects) within the pile
- Interpret the wave reflections to determine the pile length, identify potential defects like cracks or voids, and assess overall pile integrity

13.6.3 Important Considerations:

- **Calibration:** Ensure the accelerometer is properly calibrated before testing
- **Multiple Impacts:** Perform multiple impacts on different locations on the pile head to get a more comprehensive picture.
- **Soil conditions:** Consider the soil conditions surrounding the pile as they can affect the wave propagation and interpretation of results.
- **Data filtering:** Apply appropriate filtering to remove noise from the recorded signal

13.6.4 Key elements typically included in a pile integrity test Report:

a) Project details:

- Project name, Location, Pile type, design parameters

b) **Testing equipment and procedures:**

- Specific pile integrity testing method used (e.g. sonic echo, transient response), equipment details, calibration information, test procedures followed.

c) **Test results:**

- Waveform graphs showing reflections at different depths along the pile
- Interpretation of wave patterns to identify potential defects) e.g. voids, cross-sectional changes)
- Numerical values like "impedance" or "beta" depending on the analysis method used

d) **Data analysis and interpretation:**

- Assessment of pile quality based on the test results
- Identification of any critical defects and their location
- Comparison of test results against acceptance criteria

13.7 Pile Load Test & Integrity Report Analysis

a) Pile Integrity Test Results, Load test Results & Photo already mentioned in Chapter 7.0 Quality Control tests Requirement

13.8 Precast Driven Pile (Concreting, Driving methods, driving Equipment, Problems & Trouble Shooting etc.)

13.8.1. Pre-cast Concrete Piles Casting & Driving Features

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 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 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 Drawing Design and Specifications.

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 for each pile and shall be compacted by vibrating or by other means satisfactory to the Engineer. The forms shall be slightly overfilled, the surplus concrete screened off, and the top surface finished to a uniform, even texture similar to that produced by the forms.

Curing and Removal of Formwork: Curing of the concrete shall be commenced prior to the formation of surface shrinkage cracks but only after the concrete has hardened sufficiently to prevent damage. Curing shall conform to the requirements of section 3.1.13. Under good weather curing conditions, side forms may be removed at any time not less than 24 hours after placing the concrete but the 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.

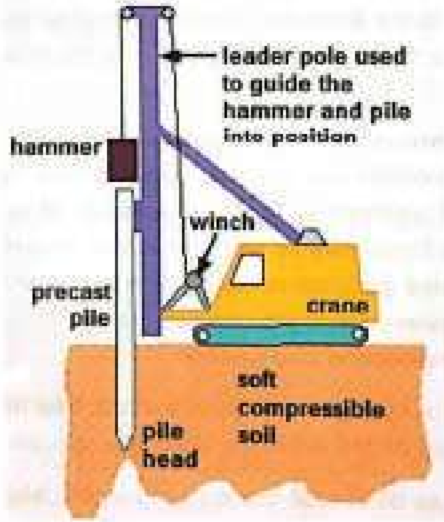
Handling and storage of piles: The method and sequence of letting handling, transporting and sorting piles shall be proposed by the contractor with supporting calculations for approval of the Engineer which verifies, the piles shall not be damaged during lifting, handing transportation and storing. During 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. (Fig. Pre-cast Pile Driving)

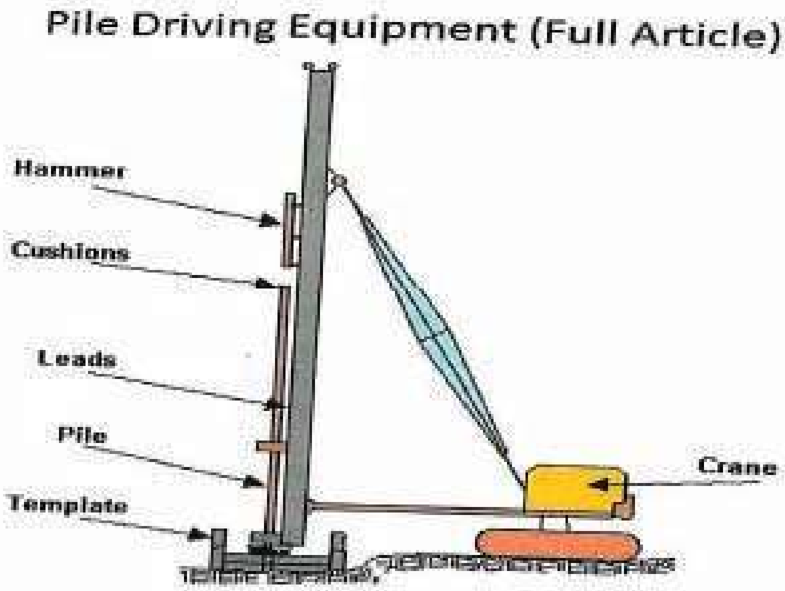


Piles shall be driven with steam hammers diesel hammer. When diesel hammers are used, they shall be calibrated by load test if necessary. The driven equipment shall be of type, which assures that the energy needed to penetrate the pile to the required depth is transmitted to be the pile head without damaging the pile. When gravity hammers are used for driven concrete piles, the drop of the hammers shall not exceed 1.0 m and the hammer shall have a weight if not less than 80% of the weight of the pile and 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: Piles shall be driven in an approved sequence to improve 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 concreting 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 avoid 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 shall 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 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 be removed by wire brushing, followed by washing

with water. If pile is to be subjected to further driving, the head shall be replaced with concrete of the pile is below the cut-off level, the pile shall be made good to the cut-off level with concrete of 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.

Summary:

- Set up formwork for pile construction.
- Construct the reinforcement case according to the design specifications, placing it within the formwork.
- Mix the concrete to the specified grade outlined in the design.
- Pour the concrete into formwork and ensure through compaction using vibrators.
- Transfer the completed piles to curing tank.
- After the curing process, the precast concrete piles are ready for use

13.8. 2. Spun Pile Features

"**Spun Pile**" is the concrete products by using the advantage of pre-stressed concrete.

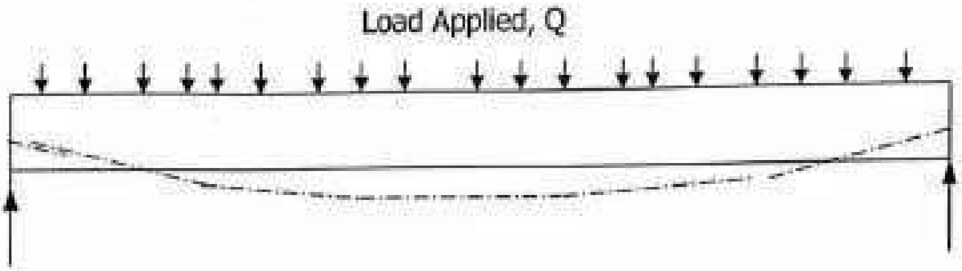
- Spun pile is produced by a centrifugal force.
- Less permeability which works to protect the pile from marine or high chloride soil.
- Spun pile is a **prestressed concrete pile with circular hollow section.**

14. BASICS OF PSC GIRDER BRIDGE CONSTRUCTION

14.1 Basics of Pre-stressed Concrete

14.1.1 Simply Supported Beam

A. Simply Supported Concrete Beam (Applied Load Q):

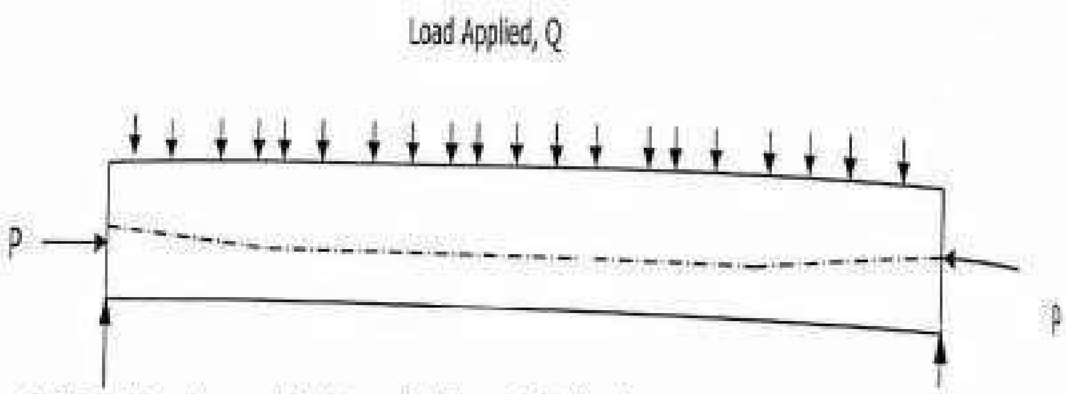


a) Tensile stress developed at bottom
b) Compressive stress developed at top
c) Deflection/sagging shall develop along the beam alignment
d) Reinforcement is required when tensile stresses exceed allowable limit and section shall be designed as cracked section

B: Simply Supported Concrete Beam (Applied Load P):

I. External Compressive force, P applied from both end of beam
II. Tensile stress shall develop at Top
III. Compressive stress develop at Bottom
IV. Upward hogging shall develop along the beam alignment

A+B: Simply Supported Concrete Beam (Simultaneous loading of P & Q)
Pic



1) Tensile stress at bottom shall be minimized

2) Compressive stress at top shall be minimized
3) Deflection along the beam alignment shall be reduced
4) No reinforcement is required at bottom

14.1.2 Pre-stressed Concrete

Pre-stressed concrete can be defined as concrete in which there have been introduced internal stresses of such magnitude and distribution that the stresses resulting from given external loadings are counteracted a desire degree of acceptable limit.

Pre-stressing is artificially inducing compressive stresses in a structure before it is loaded so that any tensile stress which might be caused by external dead and live loads are automatically cancelled and the cracks are fully eliminated.

14.1.3 Source of Pre-stress:

- Pre-stress force can be induced to a concrete members by elongating high tensile steel, known as pre-stressing steel, embedded in concrete which in turns creates internal stresses to the concrete section up to desired level & distribution and known as pre-stress force.
- The elongation of pre-stressing steel can be done by pulling the steel using mechanical device (Jack), heating the steel with electricity, expanding concrete member by chemical reaction etc.
- Pre-stressing force can also be induced without elongation steel, by externally jacking at proper places or cast concrete on pre-deformed shape.

14.1.4 Methods of Pre-stressing:

The methods of pre-stressing can be classified under four groups:

- Mechanical Pre-stressing: The tensioning operation is done by pulling the tendons by means jack. Mostly used method in the pre-stressed concrete industry.
- Electrical Pre-stressing: Pre-stressing is done with application heat with electricity. Thermoplastic coated tendons are placed in the concrete with protruding threaded ends. After concrete has hardened, electric current is passed through the tendons. When the bars are cooled pre-stressed is developed.
- Chemical Pre-stressing: Using expanding cement in concrete, embedded steel is elongated by the expansion of concrete. Thus, the steel is pre-stressed in tensions which in turns produce compressive force in concrete. This often termed as self-stressing or can be called chemical pre-stressing.
- Miscellaneous
- Miscellaneous: Other than the above, a new method known as "Pre-flex" method is developed in Belgium. This is a composite section of high tensile steel beam and concrete.

14.1.5 Advantages & Disadvantages of Pre-stressing

Advantages of Pre-stressed Concrete:

a) Reduces or eliminates undesirable tensile stresses in the concrete member
b) Cracking under service loads can be minimize or even avoided entirely
c) Deflections may be limited to an acceptable limit or fully eliminated

d) Reduces self-weight of the members: hence reduces the load foundation
e) Reduces the depth of the member's section; hence longer span can be achieved.

Disadvantages of Pre-stressed Concrete:

1) Involves high cost on formwork and shuttering/scaffolding materials.
2) Pre-stressing steel (high tensile strength) and tensioning equipment are not locally manufactured and needs to be improved.
3) Needs qualified and skilled technical persons to maintain the quality of Pre-stressed concrete construction and pre-stressing operation.
4) Needs high care for installation/erection of pre-cast PC members to its final position on bearing.

14.1.6 Pre-stressed vs. Reinforced Concrete:

a) Entire section becomes effective in pre-stressed concrete; section above neutral axis become effective in RC concrete.

b) Due to pre-compression and curved tendon, concrete shear strength is higher in PC member than that of RC member. Hence, smaller amount of shear reinforcement is needed in PC member than RC member.

c) In elastic design lever arm (jd) between tension and compression force in member section is constant for RC member whereas it is variable in PC member design.

High strength material (steel & concrete) can be economically utilized in pre-stressed concrete than in RC.

f) For longer span, pre-stressed concrete is more suitable and economic than reinforced concrete section.

14.1.7 Application of Pre-stressed Concrete

i) **Bridge Industry:**

a) Longitudinal pre-stressing in concrete bridge girder ('I', 'T' section, Box section, voided slab etc.)

b) Transverse pre-stressing in deck slab (pre-cast/in-situ)

c) Cable-stayed concrete box Girder Bridge (segmental)

ii) Other Areas:

Rail-road sleepers, Concrete Poles, Pre-cast concrete piles, Concrete pavements, Water tank, marine structures (floating docks, off-shore platforms) etc.

14.1.8 Classification of Pre-stressed Concrete:

Pre-stressed concrete structures can classified in a number of ways depending upon their features of design and construction:

a. Based on Design Philosophy

01. Fully Pre-stressed concrete: The whole external load effects is counteract pre stressing and hence no cracks developed.
02. Partial Pre-stressed Concrete: Major portion of the external load effect is counteract by pre-stressing and remaining effect is counteract by providing reinforcing steel.
03. Extra-dodged Pre-stressed: Pre-stressing force amount for external load effect is reduced by providing cable-stayed.

b. Based on Construction Method

01. Pre-cast Pre-stressed concrete: The member is cast and pre-stressed in a separate place other than the final position and installed on bearing by many ways (pre-cast 'I', 'T' girder, segmental box girder etc.)
02. In-situ Pre-stressed concrete: The Member is cast and pre-stressed on its final position and does not require transportation, lifting, shifting etc. (Box girder, progressive cantilever etc.)
03. Composite Concrete Section: Part of the total section is pre-cast pre-stressed. After erecting on final position, the remaining portion is cast in place. (Composite bridge deck slab)

c. Based on Member's Shape

01. Linear Pre-stressing: Member should be straight or slightly curved and Pre-stressing force is imparted to member at single/both ends (girders, slab, piles, poles etc.)
02. Circular Pre-stressing: Generally used for circular structures like cylindrical tanks, silos, pressure pipes etc. Tendons are provided in the form of rings.

d. Based on Tendon Exposition:

01. Bonded: The pre-stressing steels are bonded throughout their length to the surrounding concrete. Pre-tensioned tendons are necessarily bonded ones. Post-tension tendons may be either bonded or un-bonded to the concrete.
02. Un-bonded: The pre-stressing steels are not bonded throughout their length to the surrounding concrete. For un-bonded tendons, protection of the tendons from corrosion must be provided by galvanizing, greasing or some other means.

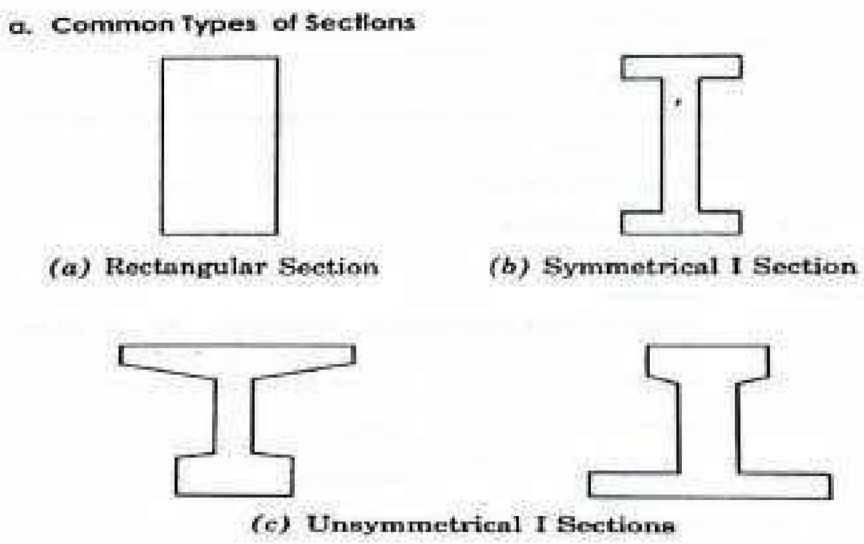
e. Base on Pre-stressing Time:

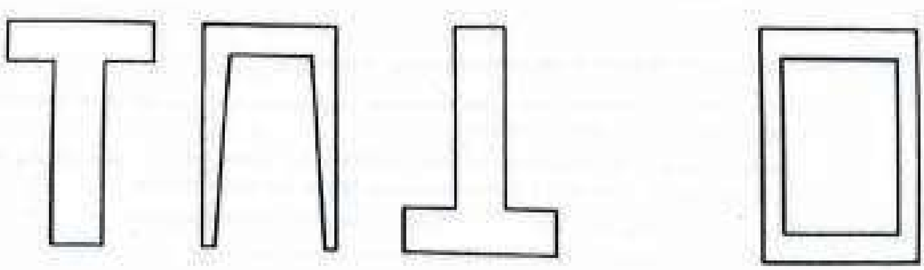
01. Pre-tensioning: The pre-stressing steels are stressed before concrete is placed. After concrete has attained desired strength, the stress is transferred to the concrete. The pre-stressed is transferred by bonding of steel with concrete. Tendons are stressed by temporarily anchored them with buttress/abutment.
02. Post-tensioning: Post-tensioning is a method in which tendons are tensioned after the concrete has hardened. Tensioning is done against the concrete member itself and stress is transferred to the concrete by anchoring the tendons with concrete member.

Pre-tensioning of Girders

14.1.9 PC Bridge Girder Section

a. Common Types of Sections



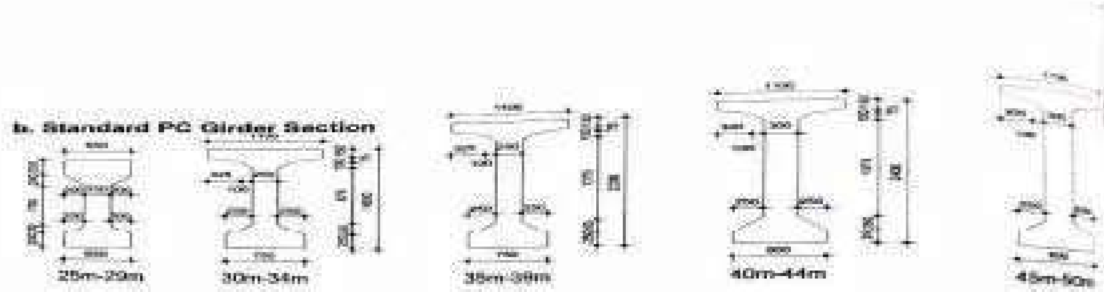


(a) Rectangular Section

(b) Symmetrical I Section

(b)

b. Standard PC Girder Section



14.1.10 Pre-stressing System and Post-tensioning System

- To maintain the quality of pre-stressing and to ensure the effectiveness of pre stressing force, the pre-stressing systems developed by many authorities were patented at early stage.
- Most of the patents on pre-stressed concrete are based on either or both of the following two operational details:
  - ✓ The method of applying pre-stress
  - ✓ The details of end anchorage.

Some Post-tensioning System:

Common types of post tensioning systems based on anchorage methods are as follows:

01	Freyssinet System	-	France: Mostly use in Bangladesh
02	Mangle System	-	Belgium
03	B.B.R.V System	-	Switzerland
04	Prescon System	-	USA
05	Stress-steel	-	USA

Comparison of Pre and Post-tensioning System:

1. The members of pre-tensioning shall be pre-cast; for post-tensioning the member may be pre-cast or cast-in-place
2. Pre-stress force is transferred to the concrete by bond in pre tensioning; whereas end anchorage is needed for transferring force for post-tensioning.
3. Transportation cost can be saved from post-tensioning system
4. Long and heavy members are the best for post-tensioning system
5. Curving of tendons are not feasible in pre-tensioning system; hence advantage of reducing shear reinforcement due to curving is achieved in post-tensioning system.

14.2 Materials & Equipment for Pre-stressed Concrete

14.2.1 Pre-stressed Concrete Materials

Concrete:

a) Normally, concrete of substantially higher compressive strength is used for pre-stressed concrete due to following reasons.

b) Use of high strength concrete reduces the loss of pre-stress force as the creep strain and elastic strain is less.

c) High strength concrete increases the bearing strength of concrete at the anchorage of post tensioned pre-stress.

d) In case of pre-tensioned concrete, the use of high strength concrete permits the development of higher bond stresses.

Specified Concrete Strength, f'c

- The specified compressive strength for pre-stressed concrete shall not be less than 28 Mpa at 28 days of casting (Cylinder).
- Normally, specified compressive strength for pre-stressed concrete as used in Bangladesh is 35 Mpa.

Concrete Strength at Transfer, f'ci

a) The compressive strength at transfer shall be adequate for the requirement of anchorage or for transfer through bond as well as for camber and deflection requirements.

b) Normally, the concrete strength shall not be less than 65 percent of the ultimate strength

High Strength Concrete

i. Special attention/care should be taken for manufacturing.

ii. Mix design or trial mix must be made at laboratories considering all parameters affecting the strength prior to actual concreting.

Factors affecting High Strength Concrete:

Among others, following are the factors need more attention for high strength concrete:

a) Cement Content including type and brand

b) Water cement ratio; Slump etc.

c) Proportion of Aggregates

d) Properties of Coarse aggregates. i.e. LA, AIV of coarse and FM of fine aggregates etc.

e) Gradation of aggregates

f) Use proper admixture; use vibrator, Curing time

Stress Limit of Concrete

Concrete stress limit is considered in two stages of pre-stressing force losses.

1. Temporary stresses before loss: Concrete stress at transfer of pre-stress shall be as follows:

   a) Compressive stress:

      The compressive stress limit for pre-tensioned and post-tensioned concrete components shall be 0.6f'ci Mpa.

   b) Tensile Stress:

- For without bonded tendons: 0.25√f'ci Mpa
- For with bonded tendons: 0.63√f'ci Mpa

2. Final stresses after loss: Concrete stress at service limit state after all losses of pre-stress force shall be follows:

a) Compression stress: The compressive stress limit for pre-tensioned and post-tensioned concrete components shall be:
   - Due to sum of effective pre-stress and permanent loads: 0.45 f,c Mpa
   - Due to live load one half the sum of effective pre-stress and permanent loads: 0.40 f'c Mpa
   - Due to the sum of effective pre-stress, permanent loads and transient Loads: 0.60Φw f'c **Mpa; (Φw= stress reduction factor based on slenderness ratio)**

14.2.2 Pre-stressing steel

⇒ High-tensile steel is almost the universal material for producing pre-stress and supplying the force in pre-stressed concrete.

⇒ High tensile steel for pre-stressing usually takes three forms:

1. Steel wires- designated by **Φ**
2. **Steel strand- designated by** T
3. **Steel bar- designated by** B
   - ✓ Steel Wires: Conforms to ASTM specification A-421.

⇒ "Uncoated Stress-relieved Wire for Pre-stressed Concrete"

- ✓ The wires are round bar of high tensile having diameter varies from 4.5mm to 11mm.

⇒ Most usable size in Bangladesh= 7mm dia.

- ✓ Minimum tensile strength: = 1655 and 1725 Mpa
- ✓ Typical modulus of elasticity, E = 200x10^3 Mpa
- ✓ Typical elongation at rupture = 5 to 6%

Pre-stressing Steel Wire – Steel Strand:

- ✓ Conforms to ASTM specification A-416 or AASHTO- M- 203 "Uncoated Seven-wire stress-relieved Strand for pPre-stressed Concrete".
- ✓ The Strands are consists of 7 rounded wires of small diameter.
- ✓ These seven wire strands all have a center wire slightly larger than the outer six wires which enclose it tightly in helix.
- ✓ Normal Size of strands are varies 6.35 mm to 15.24 mm
- ✓ Most usable size in Bangladesh = 12.7mm dia.
- ✓ Minimum tensile strength : 1724 and 1861 Mpa
- ✓ Modulus of elasticity = 197000 Mpa
- ✓ Minimum elongation at rupture : 4%

- ✓ Two types strands are available based on relaxation:
    - Normal Relaxation: 5%, fy= 0.85 fpu
    - Low Relaxation : 3%, fy = 0.90fpu

Pre-stressing Steel Strand – Steel Bars:
Conforms to ASTM specification A-322 and A-29
The bars are deformed round size of high tensile having diameter varies from 25.4mm to 34.9mm

- ✓ Minimum tensile strength : 1000 and 1100 Mpa
- ✓ Typical modulus of elasticity, E = 172 to 193x10^3 Mpa
- ✓ Typical elongation at rupture =

Stress limit of Pre-stressing Steel bar

The tendon stress limit due to pre-stress or at the service limit state for post tensioning shall be as follows:

Condition	Tendon Type		
	Stress Relieved Strand	Low Relaxation	High Strength Bar
Prior to Seating	090fpy	0.90fpy	0.90fpy
At anchorage after transfer	0.70fpy	0.70fpy	0.70fpy
Elsewhere along the length after transfer	0.70fpy	0.74fpy	0.70fpy
At service limit state after all losses	0.80fpy	0.80fpy	0.80fpy

14.2.3 Pre-Stressing Cables

1) For post tensioned pre-stressing system cables are made up of wires or strands depending on the design.

2) The cables are either placed inside their ducts before concreting or threaded through the empty ducts after concreting

3) The standard cables are made out of 12 elements, a number of which may be changed 4 to 19 elements

4) Pre-stressing may be carried out using single bar or single strand know as mono-strand or mono bar.

Pre-stressing Cables Notation:

a) The notation for any cable consist of three parts
   - ✓ The number of elements in the cable
   - ✓ The type of steel
   - ✓ Diameter in mm

b) Example-1 : 12 Φ 7 designates a cable of 12 wires of 7 mm

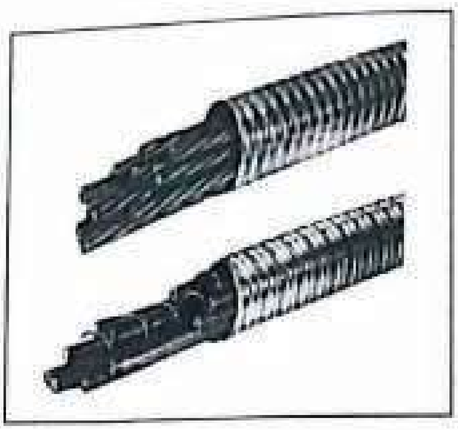
c) Example-2 : 12 T 13 denotes a cable of 12 strand of 13mm

d) Example-3 : B 26 designates single bar of 26 mm

Cables Ducts:

1) Ducts for tendons shall be rigid or semi rigid either galvanized ferrous metal or polyethylene.
2) Polyethylene ducts shall not be used when the radius of curvature of the tendon is less than 9.00m.
3) The connection between duct sections is made by threaded sleeves or by slip connections.
4) The water tightness of the joint should be completed by adhesive tape.
5) The inside diameter of ducts shall be at least 6mm larger than the nominal diameter of single bar or strand for mono-strand
6) For multi-strands tendons the inside cross-sectional area of the duct shall be at least 2.5 times the net area of the tendons
7) The size of duct shall not exceed 0.4 times the least gross concrete thickness at the duct.
8) The strand inside diameter of duct for 12T13 cables is 75mm
9) The external diameter of the ducts is 6mm larger than internal diameter.

Cable Ducts:



14.2.4 Post tensioning Anchorage:

e) Pre-stressing cables are anchored in devices, called anchorage, to transfer pre-stress force to the concrete member.

f) Anchorage systems are based on various type of cable system i.e. 12Φ7, **6T13, 12T13 etc.**

g) Anchorages are depends on various types of patented post-tensioning system.

h) Freyssinet branded or equivalent type anchorage systems are generally used in Bangladesh

Some Freyssinet Anchorages:

Pic: Multi-strand wedge type anchorage (Post-tensioning Institute)

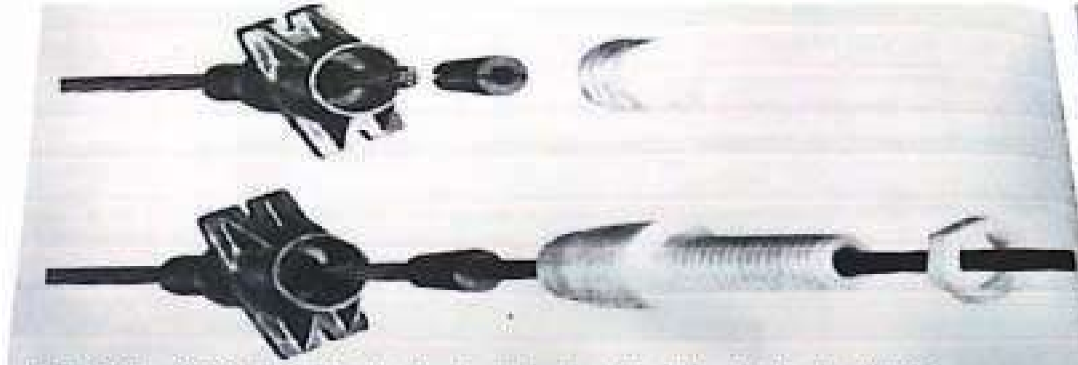
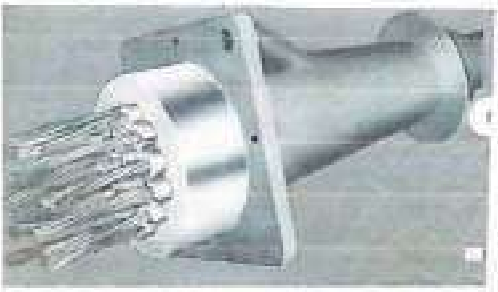


Fig. 3-7. Anchorage for single-strand tendon (Post-Tensioning Institute).

Anchorage for single-strand tendon (Post – Tensioning Institute)



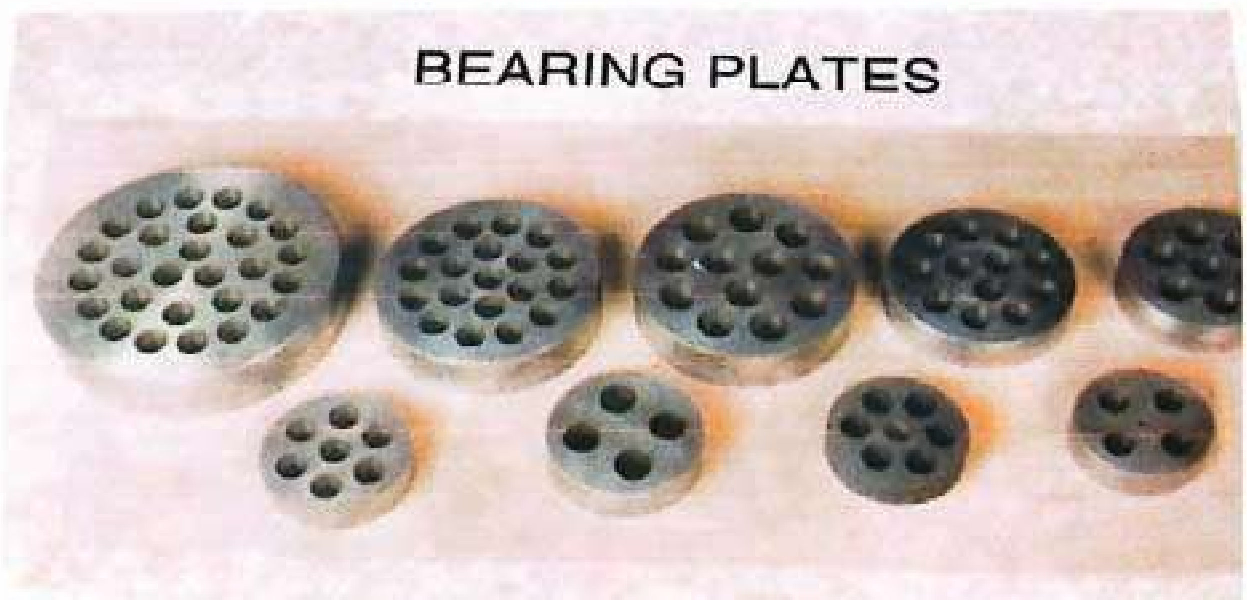
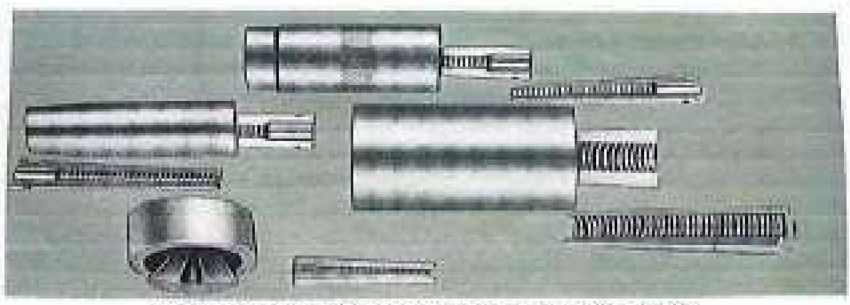


Fig. 3.7. Anchorage for single-strand tendon (Post-Tensioning institute).
Anchorage for single-strand tendon (post – Tensioning Institute)

A- Freyssinet Type "B1" Internal Anchor

B- Freyssinet Types "BA" External Anchor

Fig.3-8. Freyssinet "T" system anchorage cones (Prescon/Freyssinet)



End anchorage (Prescon. Western Concrete. BBRV).

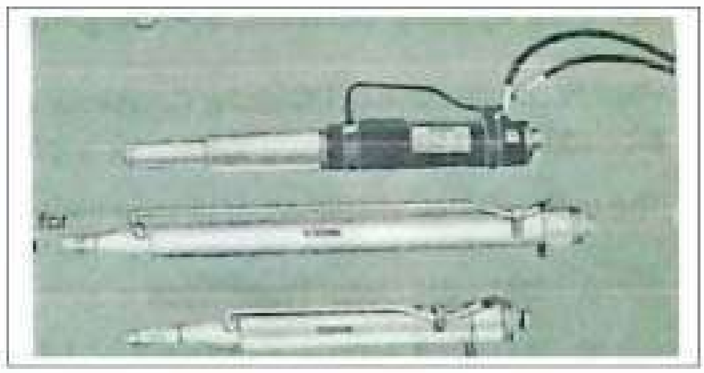
End anchorage (Prescon. Western Concrete. BBRV)

Fig. 3-11. End _ (Prescon, Western Concrete, BBRV)

14.2.5 Pre-stressing Jack :

- ⇒ In both pre-tensioning and post-tensioning, the most method of stressing the tendons is jacking
- ⇒ In post-tensioning, jacks are used to pull the steel against the hardened concrete
- ⇒ In pre-tensioning jacks are used to pull the steel against the end bulkhead
- ⇒ Hydraulic jacks are normally used because of their high capacity
- ⇒ Hydraulic jacks are operated using hand or electric pump

Pic: WEDGES



14.3 Testing of Equipment (Anchorage System Test, Calibration of Jacking Equipment and analysis of Test Report)

Bangladesh University of Engineering and Technology (BUET)

Department of Civil Engineering

Mobile: 01819 557 904; PABX: 966 5650-80 Ext. 7226; www.buet.ac.bd/ce/

BRTC
Bureau of Research, Testing & Consultation

Strength of Materials Laboratory

Calibration of Pressure Gauge

Page: 1 of 2

BRTC No.: 1103-02028/CE/23-24 Date: 02.10.2023

Reference: Letter. Date: 02.10.2023

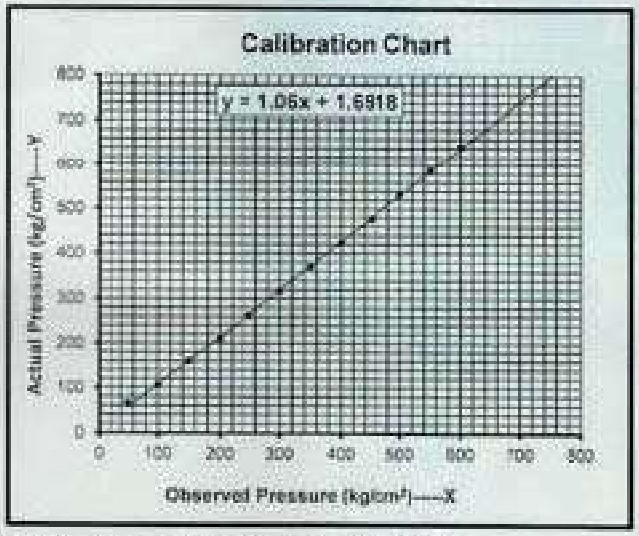
Client: [illegible]

Project:

Equipment: Pressure Gauge: MICRO; Gauge ID: MPC-193860M (Side)

Capacity: 0-700 kg/cm2

Date of Calibration: 02.10.2023



Observed Pressure (kg/cm²)	Actual Pressure (kg/cm²)
50	55.3
100	107.1
150	160.1
200	210.1
250	262.1
300	317.1
350	370.2
400	422.7
450	476.7
500	531.3
550	588.4
600	643.4

Note: Pressure Gauge was received in unsealed condition.

1 kg/cm² = 14.223 psi

PPNJKdQ43

Countersigned by:

Prof. Dr. Hasib Mohammed Ahsan
Test-in-Charge
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Calibrated by

11/10/2023

Dr. Md. Shafiul Bari
Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

BRTC - BUET

BUETCE 0438178

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)

DEPARTMENT OF CIVIL ENGINEERING

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BRTC
Bureau of Research, Testing & Consultation

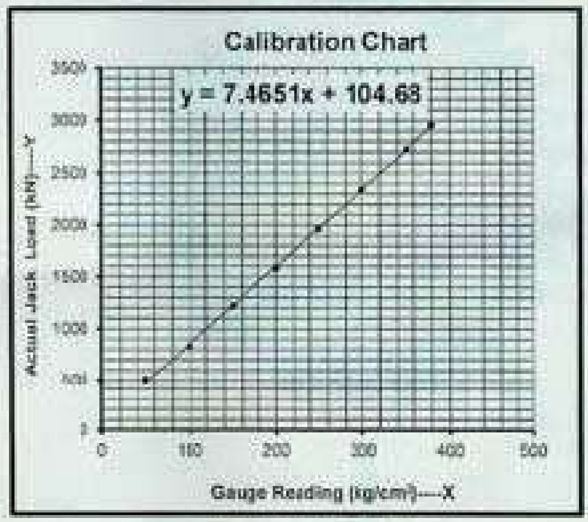
STRENGTH OF MATERIALS LABORATORY

Calibration of Hydraulic Jack

Page: 2 of 2

BRTC No.: 1103-02028/CE23-24 — Date: 02.10.2023
Reference : Letter — Date: 02.10.2023
Client: [illegible]
Project: -

Machine: 400 Ton Capacity Hydraulic Jack; Jack ID:88 — **Pump:** Motorized
Jack Information: Piston Dia: 280mm; Body Dia: 435mm; Body Height: 335mm. — **Pump ID:** 88
Pressure Gauge: Range:0-700 kg/cm2; Gauge ID: MFC-211462D (MICRO)
Calibration Device: E.L.E 1062-10-6696 (3000 kN)
Date of Calibration: 10.10.2023



Gauge Reading (kg/cm²)	Actual Jack Load (kN)	Uncorrected Jack Load (kN)
50.0	505.4	200.77
100.0	830.1	527.55
150.0	1221.3	794.34
200.0	1581.5	1061.12
250.0	1966.5	1327.91
300.0	2338.0	1594.68
350.0	2723.0	1861.48
380.0	2954.3	2021.55

Note: 1 Metric-Ton = 9.806 kN

Warning: Calibration is valid only when the above mentioned **Jack and Pressure Gauge** pair are used together as they are calibrated. Re-calibration shall be needed if any of the above Jack or Pressure Gauge is changed/replaced or repaired.

2

gfj64ejKX

Countersigned by :

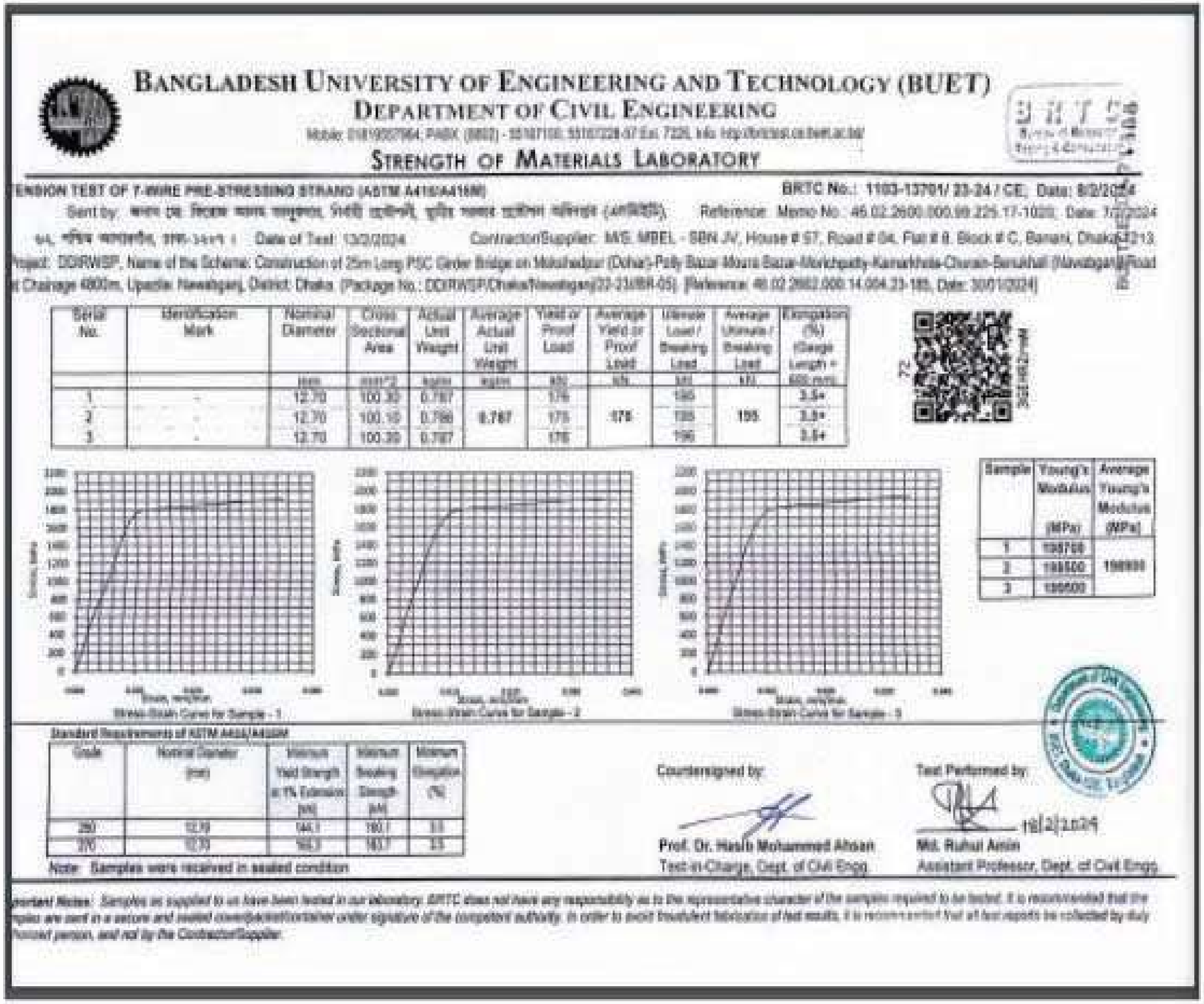
Prof. Dr. Hasib Mohammed Ahsan
Teacher-in-Charge
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Calibrated by :

14/10/2023

Dr. Md. Shafiul Bari
Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

BUETCE 0418447



BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)
DEPARTMENT OF CIVIL ENGINEERING

Mobile: [illegible], PABX: [illegible], Info: [illegible]

STRENGTH OF MATERIALS LABORATORY

TENSION TEST OF 7-WIRE PRE-STRESSING STRAND (ASTM A416/A416M) — BRTC No.: 1103-13701/ 23-24 / CE; Date: 8/2/2024

Sent by: [illegible] Reference: Memo No.: 46.02.2600.000.99.225.17-1020, Date: 7/2/2024

[illegible] Date of Test: 13/2/2024 — Contractor/Supplier: M/S. MBEL - SBN JV, House # 57, Road # 04, Flat # 8, Block # C, Banani, Dhaka-1213.

Project: DDRWSP, Name of the Scheme: Construction of 25m Long PSC Girder Bridge on Mokshedpur (Dohar)-Polly Bazar-Moura Bazar-Morichpatty-Kamarkhola-Churain-Benukhali (Nawabganj) Road at Chainage 4800m, Upazila: Nawabganj, District: Dhaka. (Package No.: DDRWSP/Dhaka/Nawabganj/22-23/BR-05). (Reference: 46.02.2602.000.14.004.23-185, Date: 30/01/2024)

Serial No.	Identification Mark	Nominal Diameter	Cross Sectional Area	Actual Unit Weight	Average Actual Unit Weight	Yield or Proof Load	Average Yield or Proof Load	Ultimate Load / Breaking Load	Average Ultimate / Breaking Load	Elongation (%) (Gauge Length = 600 mm)
		mm	mm^2	kg/m	kg/m	kN	kN	kN	kN	
1	-	12.70	100.30	0.787	0.787	176	176	195	195	3.5+
2	-	12.70	100.10	0.786		175		195		3.5+
3	-	12.70	100.30	0.787		176		196		3.5+

72

Sample	Young's Modulus (MPa)	Average Young's Modulus (MPa)
1	[illegible]	[illegible]
2	[illegible]	
3	[illegible]	

Standard Requirements of ASTM A416/A416M

Grade	Nominal Diameter (mm)	Minimum Yield Strength at 1% Extension (kN)	Minimum Breaking Strength (kN)	Minimum Elongation (%)
250	12.70	144.1	160.1	3.5
270	12.70	165.3	183.7	3.5

Note: Samples were received in sealed condition

Countersigned by:

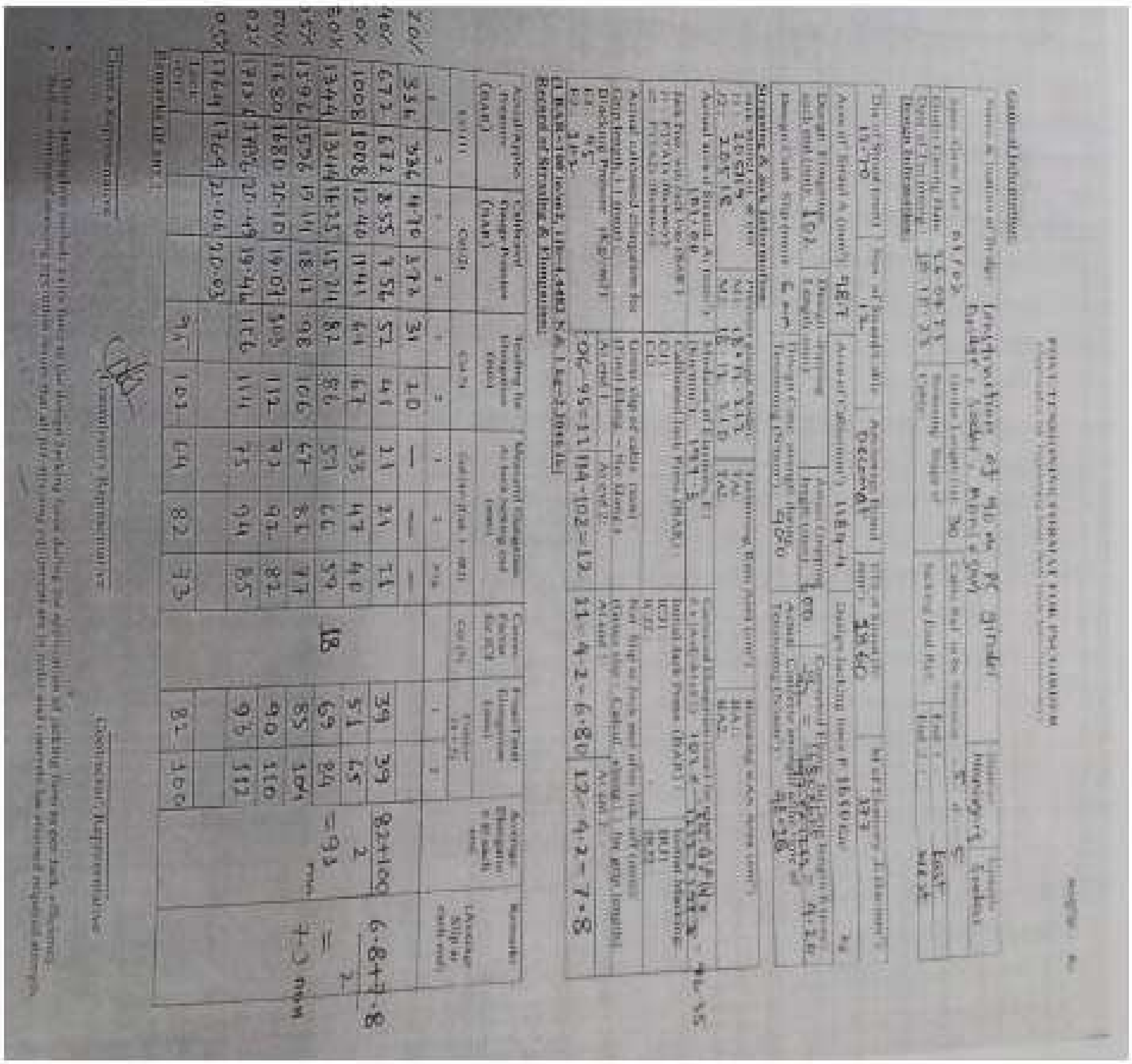
Prof. Dr. Hasib Mohammed Ahsan
Test-in-Charge, Dept. of Civil Engg.

Test Performed by:

18/2/2024

Md. Ruhul Amin
Assistant Professor, Dept. of Civil Engg.

Important Notes: Samples as supplied to us have been tested in our laboratory. BRTC does not have any responsibility as to the representative character of the samples required to be tested. It is recommended that the samples are sent in a secure and sealed cover/packet/container under signature of the competent authority. In order to avoid fraudulent fabrication of test results, it is recommended that all test reports be collected by duly authorized person, and not by the Contractor/Supplier.



15. PSC GIRDER BRIDGE CONSTRUCTION SEQUENCE

15.1 Step by Step Construction Sequence of PC Girder Bridge

Prior to construction of PC girder contractor should submit detail methodology of construction procedure and pre-stressing system for approved of the authority.

The methodology should cover at least the following:

A. Materials Detail preparation
B. Formwork & Shuttering materials details & shop drawing
C. Equipment Detail
D. Design drawing of staging/casting yard
E. Fabrication bending binding & shuttering
F. Concerting
G. Stress operation
H. Grouting operation
I. Lifting & shifting operation

A. Materials Detail Preparation

a) Concrete:

i) Necessary tests of Sand, stone aggregate, water.
ii) Type of admixture to be used and its proportion
iii) Mix design/Trail mix for specified concrete class of PSC girder
iv) Cement content, water cement ratio etc.
v) Methodology & Sequence of concrete casting in PSC girder,
vi) Curing system

b) Pre-stressing steel (HT wire/strand)

- Manufacture's certificate for guaranteed of materials specifications
- Manufacture's Test results of pre-stressing steel
- Lab test results of steel (actual strand area, Unit weight, Ultimate tensile strength, Elongation, Modulus of elasticity, Yield strength, Stress-strain curve)
- Storage of Materials at site

c) Anchorage:

- Type and brand of Anchorage: gripping details
- Manufacture's certificate for guaranteed of anchorage brand & type
- Test report for Anchorage capacity, slip limit etc.
- Anchorage literature/brochure supplied by the Manufacture
- Field test of anchorage to confirm its capacity

d. Sheathing Duct

- Sheathing material type
- Sheathing size (inner & outer diameter), thickness

- ➢ Sheathing splicing system

e. Grouting of Duct

- ➢ Mix composition and their proportion
- ➢ Compressive strength of grout
- ➢ Admixture type and its proportion

B. Formwork and Shuttering

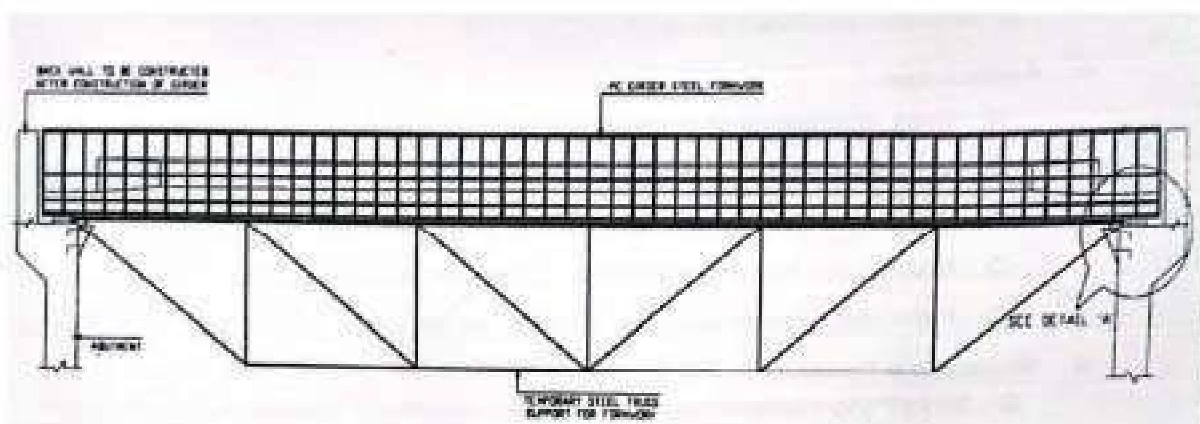
Formwork materials (must be steel of required thickness)

- ✓ Formwork materials (must be steel of required thickness)
- ✓ Formwork section and framing system
- ✓ End shuttering geometry must satisfy the design section
- ✓ Bottom shutter
- ✓ Joint of various segments should be water tight

Casting Yard/staging System

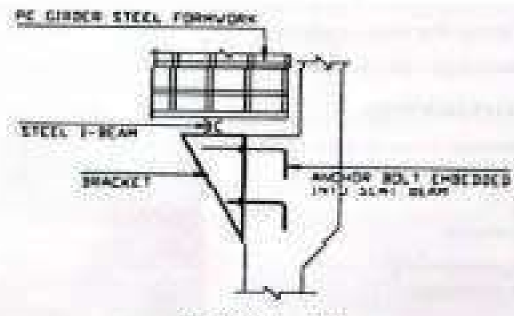
- ➢ Casting of PC girder may be done either on a separate casting bed on bank or over a staging system on bridge alignments
- ➢ Details of casting bed withdrawing (if propose)
- ➢ Detail of staging system; Framing system of stage (drawings)
- ➢ Size and materials of post to be used in stage
- ➢ Nos. of post in row and columns: bracing system
- ➢ Load carrying capacity of each post: depth of driving post
- ➢ Calculation of load carrying capacity (Engineering news formulae

Steel Staging system: Mostly used in Bangladesh



ELEVATION SHOWING STEEL TRUSS SUPPORT FOR FORMWORK

(Typical)



DETAIL 'A'

C. Equipment Details:

Pre-stressing Jack:

- Jack type (should be multi-pulling system)
- Jack model and brand for specified stressing system;
- Maximum tensioning and blocking capacity of Jack
- Tensioning and blocking ram area size; maximum stroke length;
- Jack efficiency/calibration should be ensure;
- Jack operation manual (brochure/literature)
- Type of Jacking pump (must be electric)

Pressure Gauge for tensioning & blocking

- Identification No. for tensioning & blocking gauge
- Latest calibration charts for pressure gauges

Grout pump

- Type, brand and capacity of grout pump

Concrete Casting Equipment

- Form vibrator type & Nos.
- Mixture machine's capacity & Nos.

D. Pre-Stressing Operation:

- Details of tensioning system (single/both end stressing)
- Standard stressing Format be used
- Elongation correction due to grip length
- Elongation correction for modified strand properties
- Elongation controlling system
- Elongation measuring system
- **Hogging recording system**

E. Erection or Installation of Pre-cast PC Girder to the Final Position:

Lifting and Shifting System:

- When PC girder are concreted adjacent to their actual location, these may be lifted by hydraulic jacks, shifted by sliding and placed in positions by lowering as required.
- This system is very common practice in Bangladesh, Needs hydraulic
- Jacks
- Any risky as labour based

Jin Pole System

- When the PC girder are concreted adjacent to the spans immediately below, either at dry bed level or by erecting low height scaffolding, these may be lifted by and placed in positions by using Jin pole

- This system Needs two poles at either end of the girder; rarely used in Bangladesh; Initial cost is high but low risk.

Crane System:

-PC girders are concreted in the pre-cast yard either away from or nearer to the location of the bridge. These are then transported by trailers and then lifted & placed in position using crane.

F. Grouting of Post-tensioning Duct:

Filling of space between pre-stressing steel and the sheath/duct by cement mortar is known as grouting

Objectives of Grouting:

- *To protect the steel against correction*
- *To effect bond between the pre-stressing steel and the concrete*

Conditions of Good Grouting Operation:

- The mortar must completely fill the duct, without air pockets;
- The mortar must not contain any components which could attack the steel
- The mortar must have a strength of about 25 Mpa;
- The duct must in to way have obstacles to the flow of mortar;
- The duct must be uniform as possible; without changes in section;
- The area free space inside the duct must be more than steel area;
- The gout equipment must be powerful to ensure passage mortar

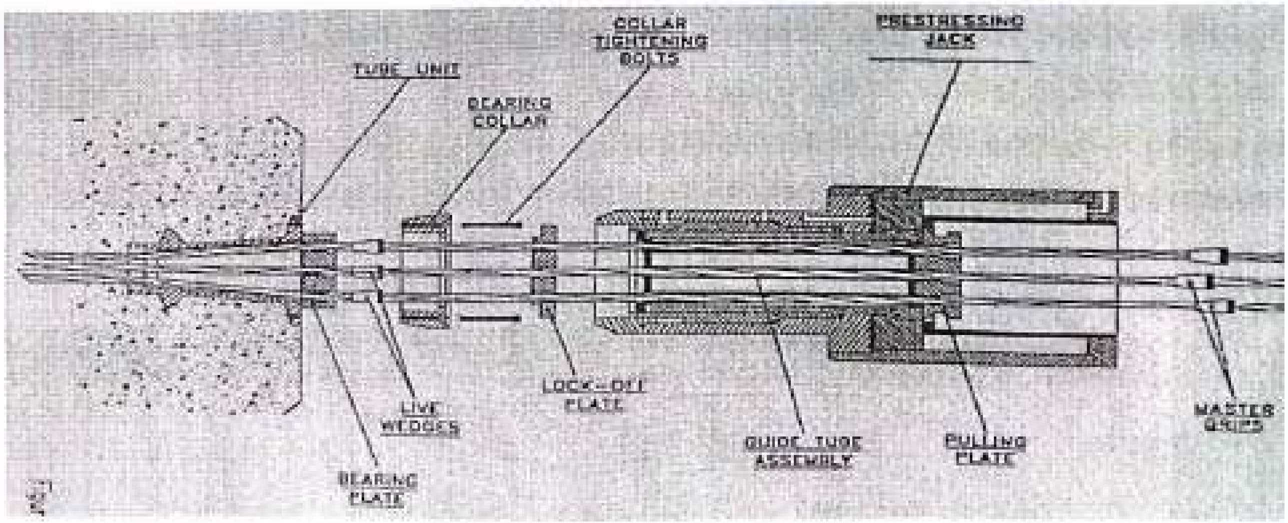
Composition of the Mortar:

a. Normally a mixture of water and OPC is used as grout mortar;
b. W/C ratio varies between 0.4 to 0.45
c. Admixture may be used to reduce the W/C ratio and also act as expansive agent;
d. Salt water must not be used for making grout

Functioning of Multi-pull Jack

Post tensioning Operation is performed in three Steps:

- Tensioning/Stressing Operation
- LOCK-Off Operation
- RAM Retraction



15.2 Post Tensioning Operation of PC Girder

Jack Threading Sequence for pre-stressing Operation

Technical Specification

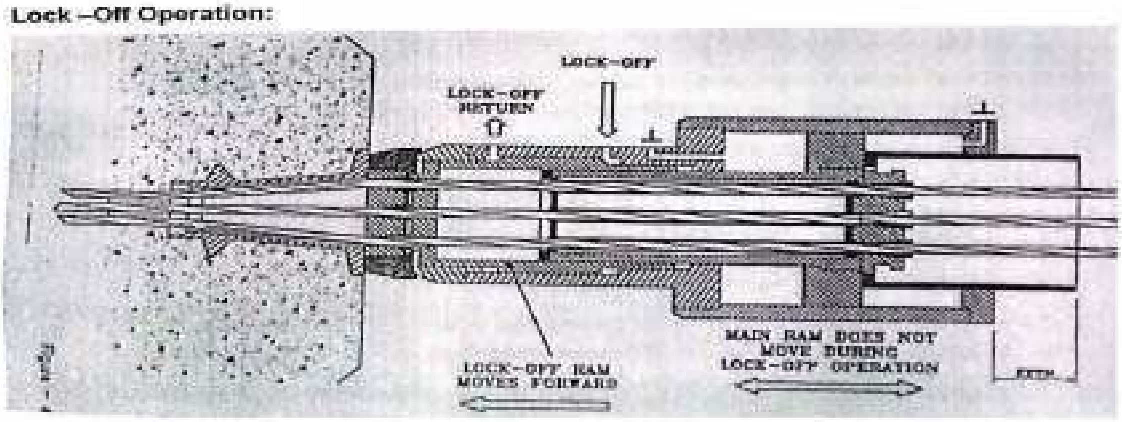
Local Capacity	:	2000KN (200 tons)	Stroke Length of Lock Off Ram	:	25mm (Max)
Main Ram Area	:	628.50 cm			
Working Pressure	:	325kg. f/cm2	Strand Gripping Length	:	750 mm (Min)
Stroke Length of Main Ram	:	220 mm (Max)	Total Closed Length	:	711 mm
Lock off Ram Area	:	91.90 cm2	Total Extended Length	:	931 mm

Stressing Operation:

1. Oil flows into the stressing chamber of the jack through the stress port, thus exerts pressure on the main ram, in turn main ram extension moves out from back side.
2. The oil of return chamber flows out of the jack through the return port goes back to the oil tank of power pack.
3. The pulling plate placed on the rear side of the ram holds the strand with the help of required number of conical master grips placed in the female conical holes
4. As the ram moves out, the strands locked in the pulling plate gets elongated and induces stresses in the tendon.

Lock-Off Operation

Lock –Off Operation:



1. When the desired elongation & stress is achieved, wedges are required to be positioned in the taper female hole of the bearing plate before transferring the stressing force from master grips to the live grips.
2. This operation is carried out with the help of the locking cylinder of the jack, when the lever of the lock-off D.C valve is actuated, oil flows from pump to the lock-off chamber of the jack and pushes forward the lock-off ram and thus the lock-off plate provided at the front side.
3. The face of the lock-off plate comes completely in contact with all the wedges and thus pushed forward up to its maximum possible seating position.
4. Locking force should not exceed the prescribed recommended level.

Jack Retraction

1. After lock-off operation the transfer of load from master grip to live grip is achieved during the process of retraction
2. During retraction, the stressing force of the strand/cable gets slackened and thus tries to move inside along with the live grips due to friction between them.
3. The threaded serrations provided in the grips penetrate to the strand and thus hold the load of the strand/cable. Any jerk or sudden retraction may cause the failure of live grips.
4. Master grips leave its seat and remain rapped around the strand and can be removed after completed retraction of the main ram.
5. Lock-off ram also retracts simultaneously during this operation.

Design information of PC Girder:

Following are the minimum design information that should be mentioned in the working drawing of PC girder:

1. Dimensional details of PC girder including plan, elevation, section, end-block & recess end details.
2. Minimum girder concrete strength at the time of tensioning and at final stage (Cylinder or Cube strength)
3. Details of cable system, nos. of cables, cables profile (horizontal ND VERTICAL) **INCLUDING CABLES ORDINATION AT MINIMUM INTERVAL, CABLE ELONGATION AT RECESS END.**
4. Type and grade od pre-stressing steel, properties including normal area, ultimate tensile strength, yield strength, modulus of elasticity.
5. Anchorage system, brand and set back details od anchorage setting, jack system, design grip length, limit of design slip.
6. Sheath/ducting type, size, and materials thickness.
7. Tensioning schedule including minimum age & strength of concrete at the time of tensioning, stage & sequence of cable tensioning.
8. Jacking force of cable prior to transfer including requirement of jacking force modification due to jack loss.

➢ Single end or both end tensioning must be mentioned

9. Elongation of each cables, requirement of elongation modification due to grip length, due to change of material properties, influence length of elongation
10. Elongation controlling guides, maximum limit of elongation, jack force etc.
11. Hogging details at various stage of tensioning
12. Details of non-pre-stress reinforcement, spiral & mesh re-bar etc.

Check List Prior to Stressing Operation:

Girder concrete surface should be checked for cracks, distress etc.; Tendons should be checked for free movement;

a) Test result of concrete sample should be satisfactory;
b) Test result of pre-stressing steel should be available at site;
c) Calibration of stressing Jack, pressure gauge etc. should available;
d) Tensioning equipment jack, pump, generator etc. should be in order;
e) Tension recording format; graph paper, tape, stationary etc.
f) Communication equipment like mobile phone, intercom, walky-talky
g) Design and drawing of PC member

Tensioning Operation

i. Correction of Jacking Force:

a) Required for Jack efficiency or Jack loss as per calibration or efficiency report of Jack

➢ Required Jacking Force= Design Jacking Force/Jack efficiency

b) Jacking force to be converted to pressure based on Tensioning RAM area of Jack

- Jacking Pressure=Jacking force/RAM Area
    c) Jacking Pressure to be calibrated as calibration of pressure gauge Y (Actual pressure)=A+BX(observed pressure) Where A & B = Constant From gauge calibration

ii. Correction of Elongation

Reason for Elongation correction:

1. Change of Cable Gripping length
2. Change of Pre-stressing steel properties
3. Slacking of cable in the Duck (Zero Correction)

iii. Correction of Elongation for Grip Length:

New Extension = EX +P (AG-DG)/AE

Where

EX = Design Elongation
P = Design Jacking Force
AG = Actual Grip Length
DG = Design Grip Length
A = Area of Tendon
E = Modulus of Elasticity

iv. Correction of Elongation for Change of Steel Properties:

Revised Extension = EX.A.E/A1.E1

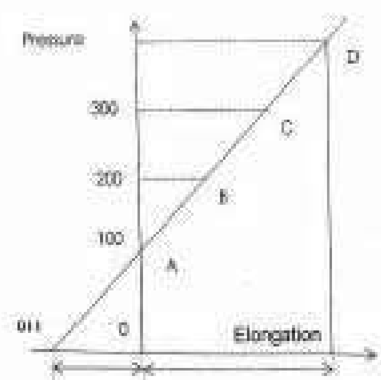
Where

EX = Design Elongation
A = Design Area of Tendon
E = Design Modulus of Elasticity of Tendon
A1 = Actual Tendon Area
E1 = Actual Modulus of Elasticity of Tendon

v. Correction of Elongation for Slack of Tendon:

a) At the beginning of stressing, the cable is lying freely in its sheath and the jack is not tightly attached. To removed slack, a small jacking force must be applied to the cable which makes it difficult to define exactly the beginning of stressing, i.e. the moment where the tension in the cable is equal to zero and where, in theory, the marks must be placed to measure the elongation.

b)The fixed zero point is determine in the following manner:



- The pressure is raised to an arbitrary value, 100 kg/cm2 foe example, and the marks are place on the wires or strands.
- This is point A of the diagram. The stressing is then carried out in steps, 200 then 300 kg/cm2 until the final pressure P, and at each pressure the corresponding elongation is measured, thus giving B, C and D points of the diagram
  a) For the systems 12Φ8-12 T 13 and 12 T 15 the marks are placed at 200 kg/cm2 and points recorded at 400 kg/cm2 and 500 kg/cm2 or at the final pressure P.
  b) Because the elongations are proportional to the load in the elastic zone of the diagram the line CBA can be prolonged until it meets the base line ar the origin 01. The total elongation is thus d+e, e being the elongation from the arbitrary starting point 0

Vi) Irregularities in the Elongation Results:

1. If after reaching the calculated final pressure P in the jack a discrepancy of more than 5% exists between the calculated and measured elongations, a special investigation must be made.
2. Firstly the pressure-elongation diagram must be drawn. Miss reading of marks or gauge are possible and these errors can be detected by misalignment of the points on the diagram. The diagram will also permit the correct location of the point of origin. A bend in the diagram at high pressures is due to plastic flow of the steel as it passes the yield point, resulting in extra-elongation.
3. If the calculated elongation Ao is reached before the calculated gauge pressure Po, continue tensioning until Po provided the elongation does not exceed 1.05 Ao. In case this elongation 1.05Ao is reached before Po, stop stressing and inform the engineer.
4. If at the pressure Po the elongation Ao has not been reached, continue tensioning by interval of 5 kg/cm2 until the elongation Ao has been reached or a pressure no greater than 1.05 Po.
5. If the elongation at 1.05 Po is less than 0.95 Ao the following measure must be taken, in succession, to define the cause if this lack of elongation.
6. Recalibration the pressure gauge.
   I. Checked the correct functioning of the jack, pump and leads;
   II. Detention the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Retention the cable if free.
7. If the required elongation is not obtained, no finishing operation such as cutting or sealing, may take place without approval of the engineer.

Vii) Record of Jacking force & Elongation in Stressing Book:

- Tensioning from Both END
- Tension from single END

15.3 Grouting Operation of Cable Duct

The following guidelines recommended by LGED should be followed in Grouting Operation of a Cable Duct:

- Tensioning প্রক্রিয়া সুষ্ঠুভাবে সম্পন্ন হওয়ার ২৪ (চব্বিশ) ঘণ্টা পর Cable এর উভয় প্রান্তে Strand এর অতিরিক্ত অংশ Live Grip এর মাথা থেকে অন্তত ২৫ মিঃ মিঃ রেখে Electric Grinder এর মাধ্যমে কাটিতে হবে তবে **কোন ভাবেই GAS Welder দিয়ে কাটা যাবে না।**

- PC Girder এর Cable এর Tensioning Operation সম্পন্ন করার পর Duct-এর Grouting প্রক্রিয়া শুরু করতে হবে।

- Cable এর Duct সমূহ Grout করার জন্য Electric Operated Pump, Agiater এবং Air Compresser সাইটে থাকতে হবে।

- Grout Mix তৈরীর জন্য অবশ্যই Ordinary Portland Cement, Drinkable Water এবং Non-Shrinkage Admixture ব্যবহার করতে হবে।

- Grouting এ Water/Cement Ratio 0.45 হবে এবং Admixture এর পরিমাণ Manufacturer এর Recommendation অনুযায়ী নিশ্চিত করতে হবে।

- Grouting শুরুর পূর্বে Cable Duct এর ময়লা পানি Pump দ্বারা পরিষ্কার করতে হবে তারপর Air Compressure এর মাধ্যমে Duct এর ভেতর শুকিয়ে নিতে হবে।

- দক্ষ প্রকৌশলীর উপস্থিতিতে Cable duct এর Grouting প্রক্রিয়া সম্পন্ন করতে হবে।

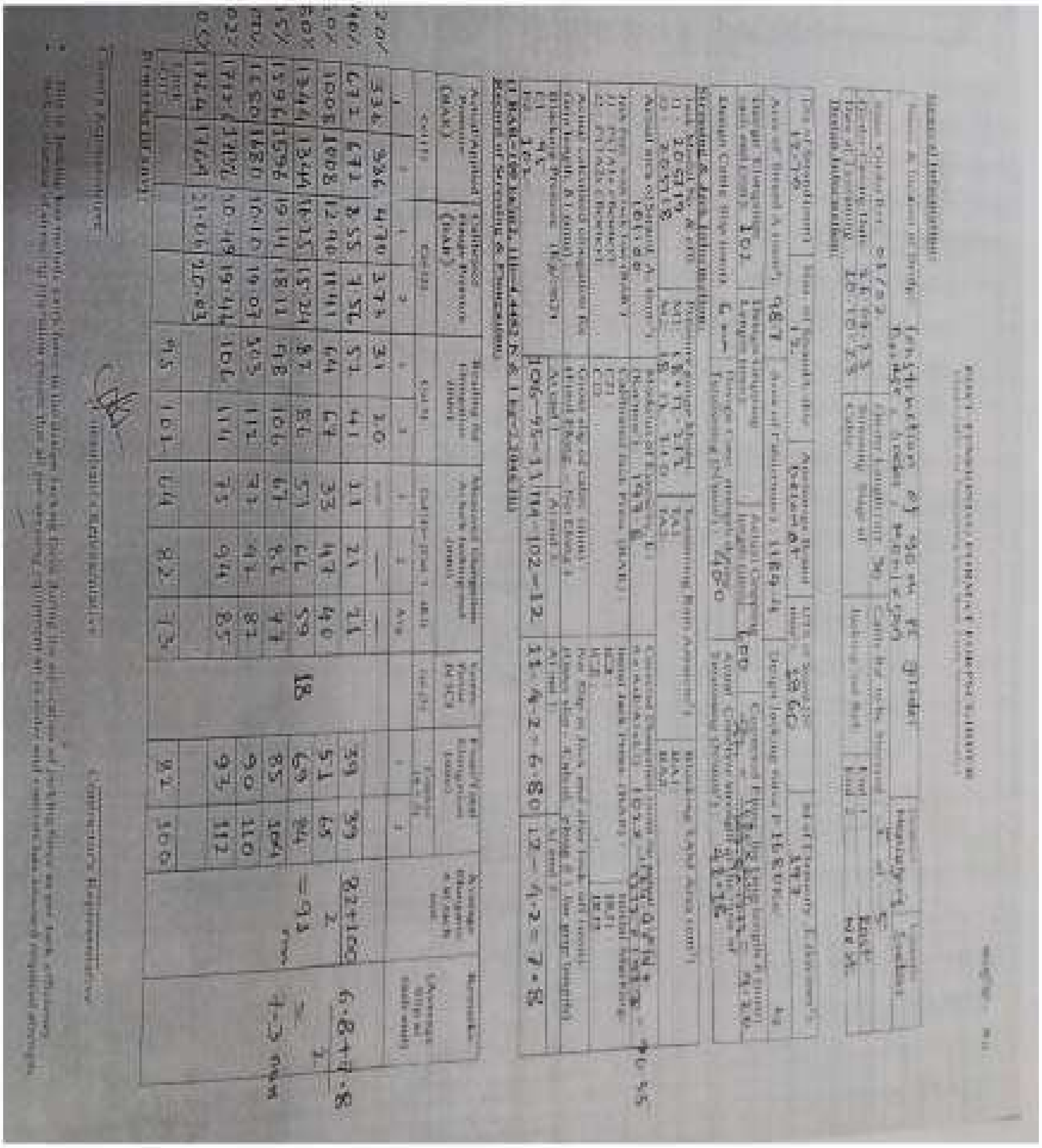
- PC Girder এর Cable সমূহের Grouting সম্পন্ন করার পর Girder এর Final Position এ Bearing এর উপর না বসানো পর্যন্ত গার্ডারের উভয় পার্শ্বে Support (বালির বস্তা, Re-bar Tie-up etc.) দিয়ে PC Girder কে Stable অবস্থায় রাখতে হবে।

15.4 Lifting & Shifting Operation of Girder

- গার্ডারের সকল Cable এর Tensioning ও Grouting প্রক্রিয়া সুষ্ঠুভাবে সম্পন্ন করার পর গার্ডারকে Lifting & Side Shifting প্রক্রিয়ার মাধ্যমে Bearing এর উপর বসাতে হবে।
- গার্ডার Bearing এর উপর বসানোর পূর্বেই Bearing এর জন্য নিম্নে বর্ণিত নির্ধারিত সকল Test সমূহ সন্তোষজনক ভাবে সম্পন্ন করতে হবে।

- PC Girder এর Casting অবস্থা থেকে অত্যন্ত সতর্কতার সাথে দক্ষ জনবল ও সঠিক Equipment (Lifting & Shifting Jack, Chennel etc.) ব্যবহার করে Bearing এর উপর বসাতে হবে।
- কোন অবস্থাতেই Girder কে শুধুমাত্র Lifting Jack এর উপর বসিয়ে ফেলে রাখা যাবে না।
- PC Girder Bearing এর উপর বসানোর পর যত দ্রুত সম্ভব Cross Girder Casting করতে হবে।
- Cross Girder Casting না হওয়া পর্যন্ত PC Girder এর উভয় পার্শ্বে যে কোন উপায়ে Lateral Support দিয়ে Girder কে Stable Condition এ রাখতে হবে।

15.5 Calculation of Jack pressure and Cable force



BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY (BUET)

DEPARTMENT OF CIVIL ENGINEERING

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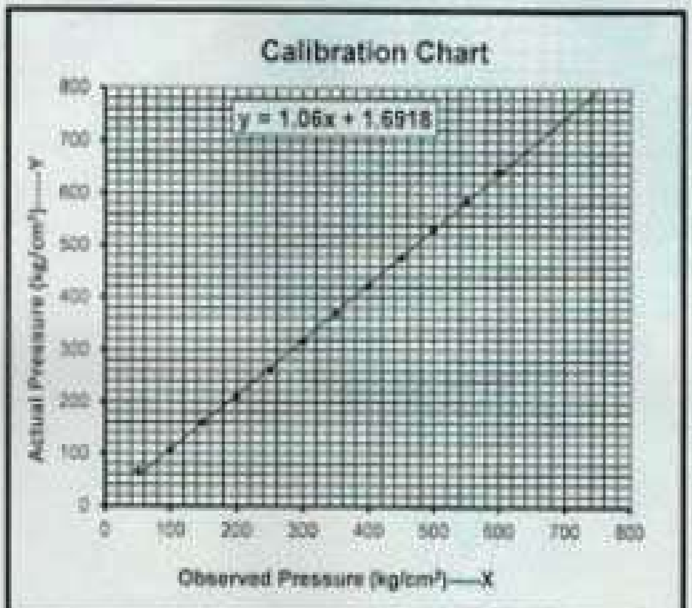
BRTC Bureau of Research, Testing & Consultation

STRENGTH OF MATERIALS LABORATORY

Calibration of Pressure Gauge

BRTC No.:	1103-02028/CE/23-24	Date: 02.10.2023
Reference :	Letter.	Date: 02.10.2023
Client:	[illegible]	
Project:	-	
Equipment:	Pressure Gauge: MICRO; Gauge ID: MPC-193950M (Side)	
Capacity:	0-700 kg/cm2	
Date of Calibration:	02.10.2023	



Observed Pressure (kg/cm²)	Actual Pressure (kg/cm²)
50	55.3
100	107.1
150	160.1
200	210.1
250	262.1
300	317.1
350	370.2
400	422.7
450	476.7
500	531.3
550	588.4
600	643.4

Note: Pressure Gauge was received in unsealed condition.

1 kg/cm² = 14.223 psi

PP#3KdQ43

Countersigned by :

Prof. Dr. Hasib Mohammed Ahsan
Test-in-Charge
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Calibrated by :

11/10/2023

Dr. Md. Shafiul Bari
Professor
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BUET, Dhaka-1000, Bangladesh

Bangladesh University of Engineering and Technology (BUET)

Department of Civil Engineering

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BRTC
Bureau of Research Testing & Consultation

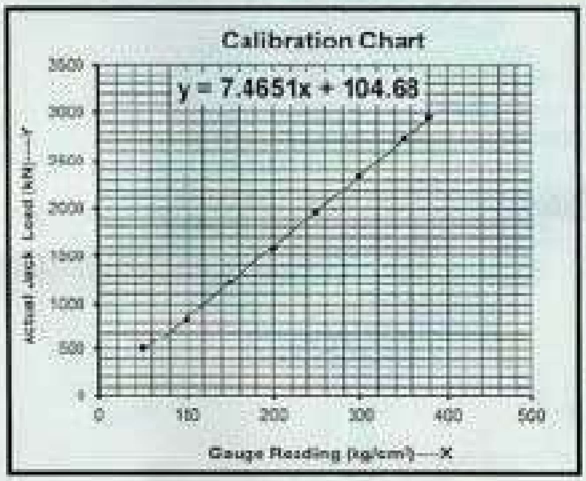
Strength of Materials Laboratory

Calibration of Hydraulic Jack

Page: 2 of 2

BRTC No.:	1103-02026/CE23-24	Date: 05.10.2023
Reference :	Letter	Date: 05.10.2023
Client:	[illegible]	
Project:	-	

Machine: 400 Ton Capacity Hydraulic Jack; **Jack ID:** 88 **Pump:** Motorized
Jack Information: Piston Dia: 280mm; Body Dia: 435mm; Body Height: 355mm. **Pump ID:** 88
Pressure Gauge: Range: 0-700 kg/cm2; **Gauge ID:** MPC-211462D (NICRO)
Calibration Device: ELE 1062-10-6696 (3000 kN)
Date of Calibration: 10.10.2023



Gauge Reading (kg/cm²)	Actual Jack Load (kN)	Calibrated Jack Load (kN)
50.0	505.4	260.77
100.0	831.1	527.55
150.0	1221.3	794.34
200.0	1581.6	1061.12
250.0	1960.8	1327.91
300.0	2338.0	1594.68
350.0	2723.0	1861.48
380.0	2954.5	2021.56

Note: 1 Metric Ton = 9.806 kN

Warning: Calibration is valid only when the above mentioned **Jack and Pressure Gauge** pair are used together as they are calibrated. Re-calibration shall be needed if any of the above Jack or Pressure Gauge is changed/replaced or repaired.

gf j54ejKH

Countersigned by :

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14/10/2023

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STRENGTH OF MATERIALS LABORATORY

ENSION TEST OF 7-WIRE PRE-STRESSING STRAND (ASTM A416/A416M)

BRTC No.: 1103-13701/ 23-24 / CE; Date: 8/2/2024

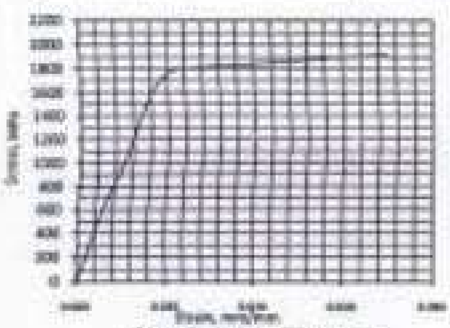
Sent by: [illegible] Reference: Memo No.: 46.02.2600.000.99.225.17-1020, Date: 7/2/2024

[illegible] Date of Test: 13/2/2024 Contractor/Supplier: M/S. MBEL - SBN JV, House # 57, Road # 04, Flat # 8, Block # C, Banani, Dhaka-1213

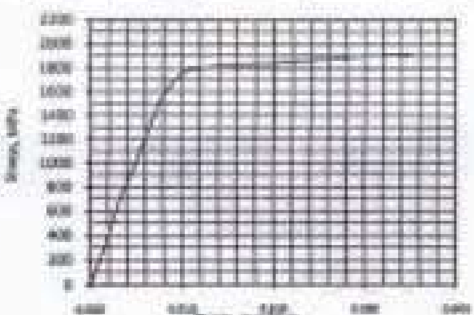
Project: DDRWSP, Name of the Scheme: Construction of 25m Long PSC Girder Bridge on Molohadpur (Dohar)-Polly Bazar-Moura Bazar-Morichpatty-Kamarkhola-Churain-Benukhali (Nawabganj) Road at Chainage 4800m, Upazila: Nawabganj, District: Dhaka. (Package No.: DDRWSP/Dhaka/Nawabganj/22-23/BR-05). [Reference: 46.02.2602.000.14.004.23-185, Date: 30/01/2024]

Serial No.	Identification Mark	Nominal Diameter	Cross Sectional Area	Actual Unit Weight	Average Actual Unit Weight	Yield or Proof Load	Average Yield or Proof Load	Ultimate Load / Breaking Load	Average Ultimate / Breaking Load	Elongation (%) (Gauge Length = 600 mm)
		mm	mm^2	kg/m	kg/m	kN	kN	kN	kN	
1	-	12.70	100.30	0.787	0.787	175	175	195	195	3.5+
2	-	12.70	100.10	0.786		175		195		3.5+
3	-	12.70	100.30	0.787		176		196		3.5+

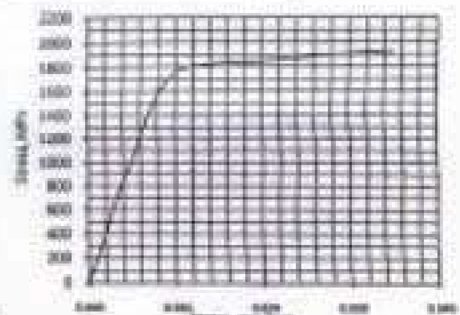
Sample	Young's Modulus (MPa)	Average Young's Modulus (MPa)
1	198700	198900
2	198500	
3	199500	



Stress-Strain Curve for Sample - 1



Stress-Strain Curve for Sample - 2



Stress-Strain Curve for Sample - 3

Standard Requirements of ASTM A416/A416M

Grade	Nominal Diameter (mm)	Minimum Yield Strength at 1% Extension (kN)	Minimum Breaking Strength (kN)	Minimum Elongation (%)
250	12.70	144.1	160.1	3.5
270	12.70	165.3	183.7	3.5

Note: Samples were received in sealed condition

Countersigned by:

Prof. Dr. Hasib Mohammed Ahsan
Test-in-Charge, Dept. of Civil Engg.

Test Performed by:

18/2/2024

Md. Ruhul Amin
Assistant Professor, Dept. of Civil Engg.

Important Notes: Samples as supplied to us have been tested in our laboratory. BRTC does not have any responsibility as to the representative character of the samples required to be tested. It is recommended that the samples are sent in a secure and sealed cover/packet/container under signature of the competent authority. In order to avoid fraudulent fabrication of test results, it is recommended that all test reports be collected by duly authorized person, and not by the Contractor/Supplier.

15.6 Post Tensioning FORMAT for PC Girder

POST-TENSIONING FORMAT FOR PSCGIRDER
(Applicable for Tensioning from Both Ends Simultaneously)

General Information:

Name & location of Bridge:			District:	Upazila :
Span /Girder Ref.:	Girder Length (m):	Cable Ref. to be Stressed : ------ of --------		
Girder Casting Date:	Sequence Stage of Cable:	Jacking End Ref:	End 1 :	
Date of Tensioning :			End 2 :	

Design Information:

Dia of Strand (mm):	Nos. of Strand/Cable:	Anchorage Brand	UTS of Strand (N/ mm²):	M of Elasticity ,E (kn/mm²):
Area of Strand A (mm²):	Area of Cable(mm²) :	Design Jacking force P: Kn/ kg		
Design Elongation each end (mm):	Design Gripping Length (mm):	Actual Gripping length (mm):	Corrected Elong. for Grip length δ (mm):	
Design Cable Slip (mm):	Design Conc. strength during Tensioning (N/mm²) :	Actual Concrete strength at the time of Tensioning (N/mm²) :		

Stressing & Jack Information:

Jack Model No. & effi. J1 : J2 :	Pressure gauge Model: M1: M2:	Tensioning Ram Area (cm²) TA1: TA2:	Blocking RAM Area (cm²) BA1: BA2:	
Actual area of Strand, A_1 (mm²):	Modulus of Elasticity, E1 (Kn/mm²):	Corrected Elongation (mm) for actual A1&E1 δ x (AxE/A1xE1):		
Jack Pres. with Jack loss (BAR) J1 : P/(TA1x efficiency): J2 : P/(TA2x efficiency):	Calibrated Jack Press. (BAR) : CJ1 : CJ2 :	Initial Jack Press. (BAR) : ICJ1 : ICJ2 :	Initial Marking: IRJ1 : IRJ2 :	
Actual calculated elongation for Grip length, δ l (mm):	Gross slip of cable. (mm) : (Final Elong. – Net Elong.)		Net Slip at Jack end after lock-off (mm): (Gross slip - Calcul. elong δ l for grip length)	
Blocking Pressure (Kg/cm2): E1 : E2 :	At end 1:	At end 2:	At end 1:	At end 2:

(1 BAR=100 kn/m2, 1lb=4.4482 N & 1 kg=2.2046 lb)

Record of Stressing & Elongation:

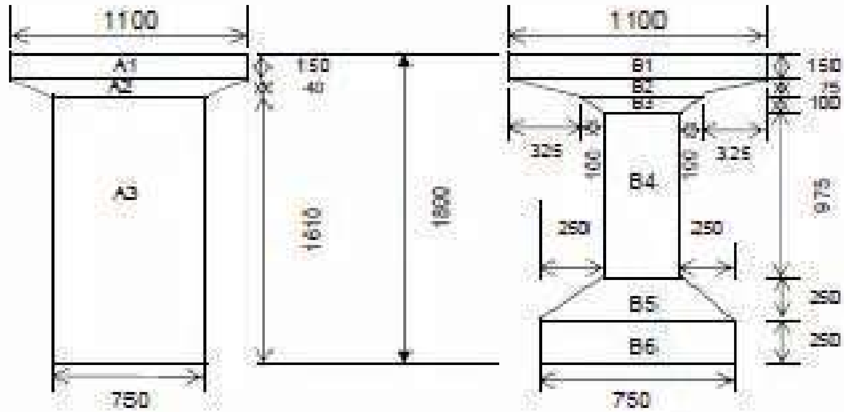
Actual/Applied Pressure (BAR)		Calibrated Gauge Pressure (BAR)		Reading for Elongation (mm)		Measured Elongation At both Jacking end (mm)			Correc. Factor for ICJ	Final/Total Elongation (mm)		Average Elongation at each end	Remarks
Col (1)		Col (2)		Col 3)		Col (4)= (Col. 3 - IRJ)			Col (5)	Col(6)= (4 + 5)			(Average Slip at each end)
1	2	1	2	1	2	1	2	Avg.		1	2		
Lock -Off													

Remarks (If any) :

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

- Due to Jacking loss include extra force to the design Jacking force during the application of jacking force as per Jack efficiency.
- Before starting of stressing operation ensure that all pre-stressing equipment are in order and concrete has attained required strength.

Procedure for Girder weight Calculation



End section Mid section

Area for End Section

A1= 1100X150 = 0.165 m2

A2= $\frac{1100+750}{2}$ X 40 = 0.037 m2

A3= 750X1610 = 1.208 m2

Area for End Section, A = A1 + A2 + A3 = 1.410 m2

Area for Mid Section

B1= 1100X150 = 0.165 m2

B2= $\frac{1100+450}{2}$ X 75 = 0.058 m2

B3= $\frac{450+250}{2}$ X 100 = 0.035 m2

B4= 975X250 = 0.244 m2

B5= $\frac{250+750}{2}$ X 250 = 0.125 m2

B6= 750X250 = 0.188 m2

Area for Mid Section, B = B1 + B2 + B3 + B4 + B5 + B6 = 0.814 m2

Total Lengrt of Girder	=	30.00	X	1	=	30.00	L
Lengrt of Mid Section	=	22.80	X	1	=	22.80	Lb
Lengrt of End Section	=	2.00	X	2	=	4.00	La
Lengrt of Tapper portion	=	1.60	X	2	=	3.20	Lp

Volume of Girder $= A X La + B X Lb + \frac{A+B}{2} X\ Lp$

= **27.764 m3**

Unit weight of Concrete = 2300 kg/m3

Weight of Girder = 63.86 Ton = 2.13 Ton/m

25m Dohar Bridge

Pressure Calculation

S.F=1600 KN

E=197

A=1184.4

$\delta = \frac{PL}{AE} = \frac{1600 \times [illegible]}{1184.4 \times 197}$

$= 3.08$

		Jack=97	Jack=99
20%	320	$X1(20\%) = \frac{320-72.168}{7.3759} = 33.60\ kg/cm^2$	$X1(20\%) = \frac{Y-104.60}{[illegible]} = 28.85\ kg/cm^2$
40%	640	$40\% = 76.99 \approx 77\ kg/cm^2$	$40\% = 71.77\ kg/cm^2$
60%	960	$60\% = 120.37\ kg/cm^2$	$60\% = 114.58\ kg/cm^2$
80%	1280	$80\% = 163.76\ kg/cm^2$	$80\% = 157.45\ kg/cm^2$
95%	1520	$95\% = 196.30\ kg/cm^2$	$95\% = 189.59\ kg/cm^2$
100%	1600	$100\% = 207\ kg/cm^2$	$100\% = 200\ kg/cm^2$

$C.F = \frac{AE}{A1E1} = \frac{1184.4 \times 197}{1202.4 \times 198.9}$

$= 0.976$

A1=100.2×12 = 1202.4

E1 = 198.90

	Cable	With Group Length	$\delta = \frac{AE}{A1E1} \times \delta\ Target$	Allowable Line	
				95%	105%
1	78.61	(78.61+3.08)=81.69	79.93	75	83
2	79.97	83.05	81.06	77	85
3	83.40	86.48	84.40	80	88
4	83.26	86.34	84.27	80	88

16. PSC GIRDER BRIDGE CONSTRUCTION GUIDELINE

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার

স্থানীয় সরকার প্রকৌশল অধিদপ্তর
আগারগাঁও, শের-ই-বাংলা নগর
ঢাকা-১২০৭।

স্মারক নং-এলজিইডি/সিই/ডিঃইউঃ/ডি-৭৫/২০০৯/৫২৬ তারিখঃ ২৫-০৭-২০১৩ ইং।

অফিস আদেশ

বিষয়ঃ **Pre-Stressed Concrete ব্রীজের গার্ডার কাস্টিং ও Tensioning প্রসঙ্গে।**

এলজিইডি'র অধীনে বিভিন্ন উপজেলা ও ইউনিয়ন সড়কের উপর সম্প্রতি ব্যাপকভাবে প্রিস্ট্রেস্ড কনক্রিট গার্ডার ব্রীজ নির্মিত হচ্ছে। প্রিস্ট্রেস্ড কনক্রিট মূলতঃ কনক্রিট এর একটি Advanced Technology বিধায় এর গুনগত মান সঠিক রাখার জন্য PC গার্ডারের নির্মাণ কৌশল সম্পর্কে উপযুক্ত জ্ঞান সম্পন্ন দক্ষ জনবলের মাধ্যমে নিবিড় তদারকি প্রয়োজন। কিন্তু মাঠ পর্যায়ে বাস্তবায়নাধীন পিসি গার্ডার ব্রীজের সার্বিক অবস্থা পর্যালোচনা করে দেখা যায় যে, অধিকাংশ ক্ষেত্রে Pre-stressed Concrete Technology'র যথাযথ জ্ঞান ও এর নির্মাণ পদ্ধতি সম্পর্কে সঠিক ধারণা না থাকার কারণে সুষ্ঠুভাবে তদারকি হচ্ছে না, ফলে প্রিস্ট্রেস্ড কনক্রিট গার্ডারের গুনগত মানের ব্যত্যয় ঘটছে যা ব্রীজের কার্যকারীতা ও স্থায়ীত্বের জন্য অত্যন্ত ক্ষতিকর। এর প্রেক্ষিতে সংশ্লিষ্ট সকলকে প্রিস্ট্রেস্ড কনক্রিট গার্ডার নির্মাণকালে প্রতিটি স্তরে যথাযথ পদ্ধতি অনুসরণ পূর্বক গুনগত মান রক্ষার জন্য উপযুক্ত পদক্ষেপ গ্রহণের নির্দেশ দেয়া হলো। সেই সঙ্গে প্রিস্ট্রেস্ড কনক্রিট গার্ডার কাস্টিং ও Tensioning Operation সুষ্ঠুভাবে সম্পন্ন করার জন্য সংযুক্ত নির্দেশনাবলী (সংযুক্তি-১-ছয় পৃষ্ঠা) যথাযথভাবে অনুসরণ করে চেকলিষ্ট (সংযুক্তি-২,৩-৪ পৃষ্ঠা) ও Post Tensioning Format (সংযুক্তি-৪-২ পৃষ্ঠা) সন্তোষজনকভাবে পুরণ করার জন্য নির্দেশ প্রদান করা হলো।

Concrete Mix Design/Trial Mix, Concrete Casting এবং Pre-stressing Steel Tensioning এর পূর্বে এলজিইডি'র ডিজাইন/মান নিয়ন্ত্রণ ইউনিটের কর্মকর্তা/পরামর্শকদের পরামর্শ গ্রহণ/সাইট পরিদর্শনের ব্যবস্থা নিতে হবে।

20/9/2013

(মোঃ ওয়াহিদুর রহমান)
প্রধান প্রকৌশলী

অনুলিপিঃ

জ্ঞাতার্থে ঃ

১। অতিরিক্ত প্রধান প্রকৌশলী (সমন্বিত পানি ব্যবস্থাপনা/বাস্তবায়ন/রক্ষণাবেক্ষণ/পরিকল্পনা ও ডিজাইন),

এলজিইডি এর অধীনে নির্মাণাধীন/নির্মিতব্য ব্রিজ সমূহের Pre-stressed Concrete Girder Casting ও Tensioning এর জন্য প্রয়োজনীয় নির্দেশনাবলী

১। Scaffolding & Formwork :

- Scaffolding এর জন্য কমপক্ষে ৬" (ছয়) ইঞ্চি diameter ও ১/৪" Thickness এর MS Pipe ব্যবহার করতে হবে।
- একটি Girder Casting এর জন্য MS Pipe সমূহ সর্বোচ্চ ৫' (পাঁচ) ফুট অন্তর Long Direction বরাবর Drive করতে হবে এবং Transverse Direction বরাবর কমপক্ষে ৫(পাঁচ) টি Pipe সর্বোচ্চ ১.০মিটার অন্তর Drive করতে হবে।
- Engineering News Formula (P=WH/6(S+C)) ব্যবহার করে Pipe সমূহের Bearing Capacity নিশ্চিত হওয়ার জন্য driving record সঠিকভাবে সাইটে সংরক্ষণ করতে হবে।
- Driving এর জন্য কমপক্ষে 120 Kg ওজনের Hammer ব্যবহার করতে হবে এবং Height of fall অন্তত ৫' (পাঁচ) ফুট রাখতে হবে।
- Driving এর সময় Pipe সমূহের Settlement পরপর সর্বোচ্চ প্রতি Blowতে ১মিঃ মিঃ এর নীচে না আসা পর্যন্ত Driving Continue করতে হবে।
- Scaffolding এর X-bracing এর জন্য 2"x 2"x ¼" Size এর MS Angle Welding করে লাগাতে হবে।
- Bracing সমূহ Horizontal এবং Vertical বরাবর সর্বোচ্চ ১.০মিটার অন্তর দিতে হবে।
- উল্লেখিত নির্দেশনা অনুযায়ী Scaffolding এর Calculation সহ ড্রইং প্রস্তুত করে সংশ্লিষ্ট নির্বাহী প্রকৌশলী/ডিজাইন ইউনিটের অনুমোদন নিতে হবে।
- PC Girder এর Formwork এর জন্য MS Sheet এর Thickness Girder Depth ২.০ (দুই) মিটার পর্যন্ত 12 BWG এবং ২.০ দুই মিটারের অধিক Depth এর জন্য 10 BWG হতে হবে।
- Formwork এর বাহির সাইডে আনুভূমিক ও লম্বভাবে 1½"x1½"x ¼" MS Angle এর Bracing ১' (এক) ফুট অন্তর Welding করে বসাতে হবে।
- Formwork এর Size ও Shape design/drawing অনুযায়ী সম্পন্ন করতে হবে।
- PC Girder এর End Shutter ডিজাইন/ড্রইং এ প্রদত্ত Immergence Angle অনুযায়ী বসাতে হবে।

২। Casting of Pre-stressed Concrete :

- PC Girder এর Concreting এর জন্য অবশ্যই সর্বোচ্চ মানের Ordinary Portland Cement (OPC)-BDS EN-197-1(CEM-I) ব্যবহার করতে হবে। কোনভাবেই Fly Ash/Slag মিশ্রিত Composite Cement ব্যবহার করা যাবে না।
- Pre-stressed Concrete এ ব্যবহৃত পাথরের LA Value অবশ্যই ৩০ (ত্রিশ) এর কম থাকতে হবে এবং Well graded (20mm down) হতে হবে। কোন প্রকার মরা পাথর, Oversize পাথর, Flaky পাথর থাকতে পারবে না।
- Casting এর সময় পাথর SSD Condition এ থাকতে হবে। কোন অবস্থায়ই Casting চলাকালীন সময়ে পাথরে পানি দেয়া যাবে না। Casting এর-২৪ (চব্বিশ) ঘন্টা পূর্বেই পাথর পানি দিয়ে wash করতে হবে।

- বালির F.M ডিজাইন অনুযায়ী ২.৮ এর উপরে হতে হবে এবং Casting এর বালিতে কোন প্রকার মাটি বা অর্গানিক পদার্থ থাকতে পারবে না। Casting এর ২৪ (চব্বিশ) ঘন্টা পূর্বে বালিতে পানি দিয়ে ভালোভাবে wash করতে হবে।
- Concrete Mix. Design/Trial Mix এর জন্য Target Strength Concrete এর Specified Strength এর ১.৩৩ গুণ হতে হবে।
- Casting এ ব্যবহৃত পানি অবশ্যই Drinkable হতে হবে। পানিতে কোন প্রকার Salinity থাকতে পারবে না।
- Casting এর সময় Mix design অনুযায়ী সিমেন্ট বালি পাথরের অনুপাত, w/c ratio (Max. 0.4), Water Reducing Admixture এর Type ও পরিমান নিশ্চিত রাখতে হবে।
- Casting এর পূর্বেই Pre-stressing Steel এবং Anchorage এর সন্তোষজনক Test Result সম্পন্ন করতে হবে। উল্লেখ্য যে, Pre-stressing Steel এর Yeild Strength অবশ্যই Ultimate Strength এর ৯০% এর বেশী হতে হবে।
- Drawing অনুযায়ী Cable Profile Maintain করে Duct সমূহ ১(এক) মিটার অন্তর Welding করে শক্তভাবে বাঁধতে হবে।
- End Shutter এ Anchorage সমূহ ড্রইং-এ প্রদত্ত Immergence Angle অনুযায়ী শক্তভাবে বসাতে হবে।
- Formwork এর Joint সমূহ Foam/Rubber Sheet ব্যবহার করে সম্পূর্ণভাবে Leak Proof করতে হবে।
- Casting আরম্ভ পূর্বে প্রয়োজনীয় পরিমাণের Material (সিমেন্ট, বালি, পাথর, পানি, admixture) এর ব্যবস্থা সাইটে নিশ্চিত রাখতে হবে।
- Casting এ ব্যবহৃত Equipment (Mixture Machine, Nozzle Vibrator, Form Vibrator, Generator, Cylinder) ভালো অবস্থায় সাইটে থাকতে হবে এবং প্রয়োজনে অতিরিক্ত Equipment Stand by অবস্থায় রাখতে হবে।
- কোন গার্ডারের Casting আরম্ভ পর কোন প্রকার Gap না দিয়ে সম্পূর্ণ Casting সর্বোচ্চ ৬ (ছয়) ঘন্টার মধ্যে শেষ করতে হবে। তার জন্য অন্তত দুই সেট Mixture Machine এবং দুই Group Labour রাখতে হবে।
- Casting এর পরিমাণ ৪০ (চল্লিশ) CUM এর বেশি হলে Batching Plant অথবা Ready Mix Concrete ব্যবহার করে সম্পূর্ণ Casting ৬ (ছয়) ঘন্টার মধ্যে সম্পন্ন করতে হবে।
- Casting চলাকালীন সময়ে Random ভিত্তিক প্রতি গার্ডারের জন্য কমপক্ষে ৩ (তিন) সেট সিলি-ডার (তিনটিতে এক সেট) Sample সংগ্রহ করতে হবে।
- Casting সম্পন্ন হওয়ার কমপক্ষে ৪৮ ঘন্টা পর গার্ডারের সাইড সাটার Remove করা যাবে এবং গার্ডারের Surface নিরবিচ্ছিন্ন ভাবে পানি দিয়ে কমপক্ষে ২১দিন Curing করতে হবে।

৩। <u>Pre-stressing Steel এর Test</u> :

Pre-stressing Steel এর গুণগত মান নিশ্চিত হওয়ার জন্য নিম্নবর্ণিত Test সমূহ Girder Casting এর পূর্বেই সম্পাদন করতে হবে।

- Ultimate Tensile Strength
- Yeild Strength
- X-Sectional Area/Unit Weight

- Modulus of Elasticity
- Elongation at Rupture

৪। Pre-stressing Anchorage এর Test :

- Post Tensioning Anchorage সমূহ ড্রইং ও ডিজাইন অনুযায়ী আন্তর্জাতিক মানের (Freyssinate, Dynamic Poston, Usha Martin ইত্যাদি) হতে হবে।
- Anchorage সমূহের Manufacturer কর্তৃক সম্পাদিত সন্তোষজনক Capacity Test Certificate থাকতে হবে।
- Pre-stressing Anchorage এর গুনগত মান যাচাইয়ের জন্য কোন অনুমোদিত সংস্থা (BUET) থেকে Anchorage এর Capacity/Efficiency Test সম্পাদন করতে হবে।

৫। Sheathing Duct এর Joint :

সঠিকভাবে Tensioning এর জন্য Cable/Sheathing duct এর joint নিম্নোক্তভাবে সম্পন্ন করতে হবে।

- Sheathing Duct এর joint সমূহ Socket এর মাধ্যমে সম্পন্ন করতে হবে।
- Socket এর দৈর্ঘ্য ৮-১০ ইঞ্চি হতে হবে।
- Socket এর ব্যাস Sheathing Duct এর চেয়ে একটু বেশী হতে হবে।
- Socket ও Sheathing duct এর Material একই হতে হবে।
- Socket এর দুই প্রান্ত দিয়ে Sheathing duct ঢুকাতে হবে।
- Socket ও Sheathing duct এর Joint সমূহ এডিসিভ মাসকিন টেপ দিয়ে মুড়িয়ে দিতে হবে।

৬। Tensioning Operation :

- Tension এর সময় দুর্ঘটনা এড়াতে Girder এর দুই প্রান্তে (Jacking End) নিরাপত্তা মূলক ব্যবস্থা রাখতে হবে।
- Tensioning শুরুর পূর্বে Girder এর Cable সমূহ যথেষ্ট Free আছে কিনা তা Push & Pull এর মাধ্যমে নিশ্চিত করতে হবে।
- Tensioning এর পূর্বে Hydraulic Jack, Pressure Gauge, Pump এর Updated Calibration (সর্বোচ্চ ছয় মাস) নিশ্চিত করে Report সাইটে রাখতে হবে।
- Tensioning এর পূর্বে Concrete এর Strength এবং Age, Design এর নির্দেশনা অনুযায়ী সন্তোষজনক হতে হবে।
- Tensioning এর সময় Pre-stressing Steel এবং Anchorage এর Test Result সমূহ সাইটে থাকতে হবে।
- Tensioning Jack ও Pump Operation এর জন্য ঠিকাদারের প্রশিক্ষণপ্রাপ্ত এবং দক্ষ কারিগরী লোকবল থাকতে হবে।
- Tensioning প্রক্রিয়া সুষ্ঠুভাবে সম্পন্নের জন্য প্রয়োজনীয় Intercom/Mobile, Stationary, Graph Paper ইত্যাদির ব্যবস্থা রাখতে হবে।

- Tensioning প্রক্রিয়া নির্বিঘ্নে সম্পন্ন করার জন্য Tensioning Jack, Pump ও Generator এর সঠিক Functioning সম্পর্কে নিশ্চিত হতে হবে। প্রয়োজনে অতিরিক্ত Generator এর ব্যবস্থা রাখতে হবে।
- Cable সমূহের Tensioning এর তথ্য সংরক্ষণের জন্য অত্রসাথে সংযুক্ত Tensioning Format (সংযুক্তি-৪) ব্যবহার করতে হবে।
- Tensioning শুরুর পূর্বে Pre-stressing Steel এর Properties এর সম্পন্নকৃত Test Report অনুযায়ী প্রত্যেক Cable এর Elongation সংশোধন করতে হবে। তাছাড়া Tensioning এর জন্য ব্যবহৃত Hydraulic Jack এর Actual Grip Length অনুযায়ী Cable সমূহের elongation সংশোধন করতে হবে।
- Hydraulic Jack এবং Pressure Gauge এর Updated Calibration অনুযায়ী ধাপে ধাপে (50 Kg/cm^2 অন্তর) প্রয়োজনীয় Design Jacking Force Apply করতে হবে।
- PC Girder এ অবস্থিত Cable সমূহের Slack remove করার জন্য Initial Jacking Force (100 kg/cm^2) Apply করে Zero Correction এর মাধ্যমে প্রতি ধাপে Jacking Force এর জন্য সঠিক Elongation নির্ণয় করতে হবে। Tensioning Operation এর যাবতীয় তথ্যাদি Standard Tensioning Format (সংযুক্ত-৪) এ লিপিবদ্ধ করতে হবে।
- Both End Tensioning এর ক্ষেত্রে Jacking Force Cable এর উভয় প্রান্তে সমানভাবে সমান সময়ে একই সাথে Apply করতে হবে যেন উভয় প্রান্তের Elongation সমান হয়। এজন্য দুই প্রান্তের Hydraulic Jack এবং Pump Operator দ্বয়ের মধ্যে সমন্বয় করে Jacking Force Apply করতে হবে।
- Single End Tensioning এর ক্ষেত্রে Hydraulic Jack এর সম্প্রসারণযোগ্য Ram/Piston এর দৈর্ঘ্য অবশ্যই Cable এর Corrected elongation এর চেয়ে কমপক্ষে ২৫ মিঃমিঃ বেশী হতে হবে।
- যদি Cable এর সংশোধিত Calculated elongation প্রয়োজনীয় Jacking Force প্রয়োগের পূর্বেই পাওয়া যায় তবে অবশিষ্ট Jacking Force এর মাত্রা ধীরে ধীরে এমনভাবে বাড়াতে হবে যেন প্রাপ্ত elongation প্রয়োজনীয় Elongation এর ৫% এর অধিক না হয়। যদি প্রয়োজনীয় Jacking Force এর ৯৫% Force প্রয়োগের পূর্বেই অতিরিক্ত Elongation ৫% পর্যন্ত হয়ে যায় **তখন Tensioning প্রক্রিয়া বন্ধ রেখে সংশ্লিষ্ট ডিজাইন প্রকৌশলীকে অবহিত করতে হবে।**
- যদি প্রয়োজনীয় Jacking Force প্রয়োগের পরও Cable এর সংশোধিত Calculated Elongation না পাওয়া যায় তবে Calculated Elongation পর্যন্ত Jacking Force এর প্রয়োগ ধীরে ধীরে বাড়াতে হবে কিন্তু কোন অবস্থাতেই Jacking Force এর পরিমাণ প্রয়োজনীয় Jacking Force এর ৫% এর অধিক হবে না।
- Jacking Force এর প্রয়োগ ডিজাইন Jacking Force এর অধিক ৫% বৃদ্ধির পরও যদি Cable এর প্রাপ্ত Elongation Calculated Elongation এর ৯৫% এর কম থাকে **তবে Tensioning প্রক্রিয়া বন্ধ রেখে সংশ্লিষ্ট ডিজাইন প্রকৌশলীকে অবহিত করতে হবে।**
- কোন Cable এর Tensioning Operation সুষ্ঠুভাবে সম্পন্ন হওয়ার পর Hydraulic Jack এর Manufacturer's Recommendation অনুযায়ী Blocking Pressure Apply করতে হবে। তবে কোন ভাবেই Recommended Pressure এর অতিরিক্ত Blocking Pressure দেয়া যাবে না।
- Blocking প্রক্রিয়া সম্পন্ন হওয়ার পর Cable এর Tensioning Force ধীরে ধীরে (কমপক্ষে ৩০ মিনিট পর্যন্ত) Release করতে হবে যেন Cable এর Net Slip ড্রইং এ প্রদত্ত Design Slip এর মধ্যেই সীমাবদ্ধ থাকে। যদি Net Slip Design Slip এর থেকে বেশী হয় **তবে পরবর্তী নির্দেশনার জন্য সাথে সাথে ডিজাইন প্রকৌশলীকে অবহিত করতে হবে।**
- Tensioning এর ফলে Girder এর Upward Hogging পরিমাপের জন্য Tensioning শুরুর পূর্বেই গার্ডারের Top Surface এ তিনটি Point এ (দুই প্রান্ত এবং মধ্য স্থানে) Level Machine এর মাধ্যমে

R.L. সংরক্ষণ করতে হবে। Tensioning প্রক্রিয়া সুষ্ঠুভাবে সম্পন্ন হওয়ার পর আবারও Girder Top Surface এ পূর্বের তিনটি Point এর R.L. সংরক্ষণ করতে হবে। তিনটি স্থানের দুইবারের R.L. এর পার্থক্য থেকে গার্ডারে Upward Hogging পরিমাপ করতে হবে।

- Tensioning প্রক্রিয়া সম্পন্ন করার পর Jack Cable থেকে সরিয়ে ফেলতে হবে এবং নিশ্চিত হতে হবে যেন Strand ও Live Grip সমূহ অক্ষত অবস্থায় আছে। তাছাড়া Live Grip সমূহ Anchorage এর Bearing Plate থেকে অন্তত ১৫ মিঃ মিঃ Exposed থাকে।
- Cable থেকে Jack অপসারণের পর যদি দেখা যায় যে Stand এর কোন Ply কেটে গিয়েছে বা Grip ভেঙ্গে গিয়েছে তবে তা তত্ত্বাবধায়ক প্রকৌশলীকে জানাতে হবে। প্রয়োজনে Cable কে Detensioning করে পুনরায় Tensioning করতে হবে।
- Tensioning এর পর Cable এর উভয় প্রান্তে Bearing Plate থেকে কোন নির্দিষ্ট দূরত্বে Strand সমূহের উপর Marking করে তা ২৪ ঘন্টা Observe করতে হবে এবং এই সময়ে কোন Slip হয়ে থাকলে তা পূর্বের Net Slip সাথে যোগ করতে হবে।
- উপরে উল্লেখিত পদ্ধতিতে ড্রইং এ প্রদত্ত Tensioning Sequence এবং Stage অনুসরণ করে PC Girder এর প্রতিটি Cable এর Tensioning Operation সুষ্ঠুভাবে সম্পন্ন করতে হবে।

৭। **<u>Grouting of Cable Duct</u>** :

- Tensioning প্রক্রিয়া সুষ্ঠুভাবে সম্পন্ন হওয়ার ২৪ (চব্বিশ) ঘন্টা পর Cable এর উভয় প্রান্তে Strand এর অতিরিক্ত অংশ Live Grip এর মাথা থেকে অন্তত ২৫ মিঃ মিঃ রেখে Electric Grinder এর মাধ্যমে কাটতে হবে তবে **কোন ভাবেই GAS Welder দিয়ে কাটা যাবে না।**
- PC Girder এর Cable এর Tensioning Operation সম্পন্ন করার পর Duct-এর Grouting প্রক্রিয়া শুরু করতে হবে।
- Cable এর Duct সমূহ Grout করার জন্য Electric Operated Pump, Agiter এবং Air Compresser সাইটে থাকতে হবে।
- Grout Mix তৈরীর জন্য অবশ্যই Ordinary Portland Cement, Drinkable Water এবং Non-Shrinkage Admixture ব্যবহার করতে হবে।
- Grouting এ Water/Cement Ratio 0.45 হবে এবং Admixture এর পরিমাণ Manufacturer এর Recommendation অনুযায়ী নিশ্চিত করতে হবে।
- Grouting করার পূর্বে Cable Duct এর ময়লা পানি Pump করে পরিষ্কার করতে হবে তারপর Air Compressure এর মাধ্যমে Duct এর ভেতর শুকিয়ে নিতে হবে।
- দক্ষ প্রকৌশলীর উপস্থিতিতে Cable duct এর Grouting প্রক্রিয়া সম্পন্ন করতে হবে।
- PC Girder এর Cable সমূহের Grouting সম্পন্ন করার পর Girder এর Final Position এ Bearing এর উপর না বসানো পর্যন্ত গার্ডারের উভয় পার্শ্বে Support (বালির বস্তা, Re-bar Tie-up etc.) দিয়ে PC Girder কে Stable অবস্থায় রাখতে হবে।

৮। **<u>Erection of PC Girder</u>** :

- গার্ডারের সকল Cable এর Tensioning ও Grouting প্রক্রিয়া সুষ্ঠুভাবে সম্পন্ন করার পর গার্ডারকে Lifting & Side Shifting প্রক্রিয়ার মাধ্যমে Bearing এর উপর বসাতে হবে।
- গার্ডার Bearing এর উপর বসানোর পূর্বেই Bearing এর জন্য নিম্নে বর্ণিত নির্ধারিত সকল Test সমূহ সন্তোষজনক ভাবে সম্পন্ন করতে হবে।

- PC Girder এর Casting অবস্থা থেকে অত্যন্ত সতর্কতার সাথে দক্ষ জনবল ও সঠিক Equipment (Lifting & Shifting Jack, Chennel etc.) ব্যবহার করে Bearing এর উপর বসাতে হবে।
- কোন অবস্থাতেই Girder কে শুধুমাত্র Lifting Jack এর উপর বসিয়ে ফেলে রাখা যাবে না।
- PC Girder Bearing এর উপর বসানোর পর যত দ্রুত সম্ভব Cross Girder Casting করতে হবে।
- Cross Girder Casting না হওয়া পর্যন্ত PC Girder এর উভয় পার্শ্বে যে কোন উপায়ে Lateral Support দিয়ে Girder কে Stable Condition এ রাখতে হবে।

৯। <u>Elastomeric Bearing এর Test</u> :

Bearing Pad এর গুণগতমান নিশ্চিত হওয়ার জন্য নিম্নলিখিত Test সমূহ সম্পন্ন করতে হবে ঃ

- Hardness Test (60 ± 5, duro)
- Compression Set (Max. 35%)
- Neoprene Content (Min. 60%)
- Ash Content (Max. 5%)
- Shear Modulus (0.8 to 1.10 MPa)
- Peel Strength

এলজিইডি'র আওতায় প্রিস্ট্রেসড কনক্রিট ব্রীজের গার্ডারের কনক্রিট কাস্টিং এর চেক লিস্টঃ

১। কর্মসূচী/ প্রকল্পের নাম ঃ ____________________

২। ব্রিজের নাম ঃ ____________________ ; ব্রিজের দৈর্ঘ্যঃ __________

৩। গার্ডার নম্বর __________ ; চেইনেজ ঃ __________ ; উপজেলা ঃ __________ ; জেলা ঃ __________

প্রিস্ট্রেসড কনক্রিট কাস্টিং এর চেকলিস্ট ঃ

কনক্রিট কাস্টিং এর পূর্বে নিম্নবর্ণিত চেকলিস্ট সমূহ পালন করতে হবে।

SL	Item Name	Issues on the Quality of Work Performed	Opinion
01	Scaffolding & Shuttering System	ক) Staging/Scaffolding/ Formwork System এর ড্রইং নির্দেশনা অনুযায়ী (সংযুক্ত-৩) Calculation সহ ঠিকাদার কর্তৃক প্রণয়ন পূর্বক ডিজাইন ইউনিট/নির্বাহী প্রকৌশলী এর অনুমোদন নেয়া হয়েছে কিনা।	হাঁ ☐ না ☐ ▪ MS Pipe dia : ▪ Spacing- Long dir: Short dir:
		খ) Staging/Scaffolding/Formwork System বাস্তবে অনুমোদিত ড্রইং মোতাবেক তৈরি করা হয়েছে কিনা?	হাঁ ☐ না ☐
		গ) PC গার্ডারের Bottom Shutter এর লেভেল ও Alignment ড্রইং অনুযায়ী সঠিক আছে কিনা ?	হাঁ ☐ না ☐
		ঘ) গার্ডারের Form work এর Shape, Size ও Thickness ডিজাইন মোতাবেক তৈরী করা হয়েছে কিনা ?	হাঁ ☐ না ☐ ▪ Thickness : BWG
		ঙ) গার্ডারের End Shuttering Drawing-এ প্রদত্ত Immergence Angle অনুযায়ী তৈরী হয়েছে কিনা ?	হাঁ ☐ না ☐
02	Materials for Concrete	ক) কনক্রিটের জন্য পাথর ও বালির পরীক্ষা (Gradation, LA, FM) সমূহ করা হয়েছে এবং মান সঠিক আছে কিনা ?	হাঁ ☐ না ☐
		খ) OPC সিমেন্টের গুনগত মান (Brand, Setting Time, Cube Strength) নিশ্চিত করা হয়েছে কিনা?	হাঁ ☐ না ☐ ▪ Brand : ▪ Type :
		গ) Mix Design/Trial Mix করে কনক্রিটের প্রয়োজনীয় Target Strength (1.33 x Specified strength) এর জন্য সিমেন্ট, বালি ও পাথরের অনুপাত ঠিক করা হয়েছে কিনা ?	হাঁ ☐ না ☐ ▪ Mix. Ratio :
		ঘ) কনক্রিটের জন্য W/C ratio এবং admixture এর type ও পরিমান নিশ্চিত করা হয়েছে কিনা ?	হাঁ ☐ না ☐ ▪ W/C Ratio : ▪ Admixture Type : ▪ Brand : ▪ Dodge :

SL	Item Name	Issues on the Quality of Work Performed	Opinion
		ঙ) Concrete Casting এর জন্য ব্যবহৃত পানির গুনগত মান (Drinkable Water) নিশ্চিত করা হয়েছে কিনা ?	হাঁ ☐ না ☐
03	Pre-stressing Material [সকল টেষ্ট অনুমোদিত সংস্থা হতে সম্পাদন করতে হবে। টেষ্ট রিপোর্ট সাইটে সংরক্ষণ করতে হবে।]	ক) Pre-stressing Steel এর টেষ্ট সমূহের (সংযুক্তি-১) রিপোর্ট সন্তোষ জনক কিনা ?	হাঁ ☐ না ☐
		খ) Pre-stressing Steel এর Manufacturer কর্তৃক সন্তোষ জনক Test Report আছে কিনা ?	হাঁ ☐ না ☐
		গ) Anchorage System এর Brand Freyssinate এ টেষ্ট (সংযুক্তি-১) রিপোর্ট সন্তোষ জনক কিনা ?	হাঁ ☐ না ☐
		ঘ) Anchorage এর Manufacturer Test Report জমা দেয়া হয়েছে কিনা ?	হাঁ ☐ না ☐
		ঙ) Sheathing Duct এর Size, Thickness ডিজাইন অনুযায়ী সঠিক আছে কিনা ?	হাঁ ☐ না ☐ • Size (dia) :
04	Cable Profiling	ক) Cable Profile (Vertical এবং Horizontal Ordinate) ড্রইং মোতাবেক বসানো হয়েছে কিনা ?	হাঁ ☐ না ☐
		খ) Sheathing Duct Tack Welding করে ১.০মিঃ অন্তর শক্তভাবে বাধা হয়েছে কিনা ?	হাঁ ☐ না ☐
		গ) Sheathing Duct এর Joint ভালো Socket (সংযুক্তি-১) এর মাধ্যমে সম্পন্ন করা হয়েছে কিনা ?	হাঁ ☐ না ☐
05	Others	ক) Anchorage ড্রইং মোতাবেক (Imargence Angle) বসানো হয়েছে কিনা ?	হাঁ ☐ না ☐
		খ) Stirrups এর Size ও Spacing ড্রইং মোতাবেক বসানো হয়েছে কিনা ?	হাঁ ☐ না ☐
		গ) কনক্রিটিং এর Equipment (Mixture Machine, Form vibrator, generator) এর সংখ্যা ও মান সঠিক আছে কিনা ?	হাঁ ☐ না ☐ • Mixture Machine(Nos.) : • Form Vibrator(Nos.) :

বিঃ দ্রঃ উল্লেখিত চেক লিষ্ট সমূহ সন্তোষজনকভাবে নিশ্চিত হওয়ার পরই গার্ডারের Concrete Casting সংযুক্তি-১ এর নির্দেশনা অনুযায়ী সম্পন্ন করা যেতে পারে। প্রতিটি PC Girder এর Casting এর পূর্বে উপরোক্ত Check List অবশ্যই সন্তোষজনকভাবে পূরণ করে সংরক্ষণ করতে হবে।

এলজিইডি'র আওতায় প্রিস্টেসড কনক্রিট ব্রীজের গার্ডারের Tensioning Operation এর চেক লিষ্টঃ

১।   কর্মসূচী/ প্রকল্পের নাম ঃ ________________________________

২।   ব্রিজের নাম ঃ ________________________________; ব্রিজের দৈর্ঘ্যঃ __________

৩।   গার্ডার নং ঃ ________; চেইনেজ ঃ ________; উপজেলা ঃ __________; জেলা ঃ __________

Pre-stressing Steel Tensioning এর পূর্বে নিম্নবর্ণিত চেকলিষ্ট সমূহ পালন করতে হবে।

SL	Item Name	Issues on the Quality of Work Performed	Opinion
01	Basic Check	ক) Tensioning এর জন্য গার্ডারের দুই প্রান্তে নিরাপত্তামূলক ব্যবস্থা রাখা আছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) গার্ডারের Surface এ কোন Crack অথবা Honey Comb আছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) Cable এবং Steel সমূহ Freely move করে কিনা ?	হ্যাঁ ☐ না ☐
		ঘ) Scaffolding এর কোন Pipe লেগে গিয়েছে কিনা ?	হ্যাঁ ☐ না ☐
02	Test Results	ক) Girder এর Cylinder কনক্রিট Strength ডিজাইন মোতাবেক সন্তোষজনক আছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) Pre-stressing Steel এর Test Result সমূহ সাইটে আছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) ডিজাইনের নির্দেশনা অনুযায়ী Tensioning এর জন্য Girder Concrete এর Age পূর্ণ হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
03	Equipments Check [সকল টেষ্ট অনুমোদিত সংস্থা হতে সম্পাদন করতে হবে। টেষ্ট রিপোর্ট সাইটে সংরক্ষণ করতে হবে।]	ক) Hydraulic Tensioning Jack এর Updated Calibration/Efficiency Test করা আছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) Pressure gauge এর Updated/Calibration Test করা আছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) Jack ও Pump এর Calibration Capacity Test সঠিক আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঘ) Hydraulic Jack এর Manufacturer's Brochure/ Catalog Supply দেয়া হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		ঙ) Tensioning format (সংযুক্ত), graph paper, tape, Cell Phone, Intercom, Stationary ইত্যাদি আছে কিনা ?	হ্যাঁ ☐ না ☐
		[illegible] Generator Site [illegible]	[illegible]

SL	Item Name	Issues on the Quality of Work Performed	Opinion
	Design Information	গ) Cable সমূহের Elongation এর জন্য Influence Length ড্রইং বলা হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		ঘ) Pre-stressing Steel এর Design modules of Elasticity (E), X-Section Area (A) ড্রইং এ দেয়া আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঙ) Drawing এ Design grip length দেয়া আছে কিনা ?	হ্যাঁ ☐ না ☐
		চ) ড্রইং এ Cable সমূহের Tensioning Schedule এবং Sequence দেয়া আছে কিনা ?	হ্যাঁ ☐ না ☐
		ছ) ব্রীজের পূর্ণাঙ্গ ড্রইং সাইটে আছে কিনা ?	হ্যাঁ ☐ না ☐
		জ) Tensioning এর পর Cable সমূহের অতিরিক্ত অংশ কাটার জন্য Electric Grinder সাইটে আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঝ) Grouting শুরুর পূর্বে Cable এর Duct Pipe পরিষ্কার করার জন্য Air Compressure আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঞ) Grouting করার জন্য Non shrinkage admixture সাইটে আছে কিনা ?	হ্যাঁ ☐ না ☐ • Brand :
		ট) Grouting করার জন্য Electric Operated Grout Pump আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঠ) PC Girder এর Scaffolding design, Cable Laying, Concreting, Tensioning, Grouting ও Erection এর জন্য ঠিকাদারের প্রশিক্ষণপ্রাপ্ত দক্ষ জনবল আছে কিনা ?	হ্যাঁ ☐ না ☐

বিঃ দ্রঃ উল্লেখিত চেক লিস্টের আইটেম সমূহ সন্তোষজনকভাবে নিশ্চিত না হওয়া পর্যন্ত Girder এর Cable সমূহ Tensioning করা যাবে না। প্রতিটি PC Girder এর Tensioning এর পূর্বে উপরোক্ত Check List অবশ্যই সন্তোষজনকভাবে পূরণ করে সংরক্ষণ করতে হবে।

17. UNDERSTANDING OF PSC GIRDER BRIDGE DETAIL DRAWING

Learning Objects:

Overall, this session will help participants to improve their skilled in conducting effective field supervision for construction of PSC Girder Bridge. More specifically, by the end of this session the participant will be able to:

- Answer any query regarding detail drawing of PSC Girder Bridge.
- Explain to other the drawing details shown on any sheet of PC Girder Bridge drawing detail
- Get the work from the contractor according to the drawing design
- Direct the site staff/ workers to carry out centering, shuttering and reinforcement work according to the drawing design
- Instructed the site staff/ workers to correct any defects or mistakes found in centering, shuttering and reinforcement work on site
- Correct misconceptions of the participants (if any) about drawing details.

17.1 About Drawing

Drawing are a part of the information prepared by the design team in order to provide important instructions regarding the proposed bridge and how it is to be constructed. These drawings usually consist of a set that includes plan, Section. Elevation and Structural details etc.

They are included in the construction contract and tender documents, which makes them a vitally important part of the agreement between the construction company/ contractor and the client

For ease of understanding, we can divide these drawings into the following categories:

Architectural Drawing: Site plan Bridge Top plans, Sections and Elevations.

Structural Drawings: Structural plans, detail drawings of specific parts (Bridge Deck details, Girder details, Bridge Railing details. foundation details etc.).

Mechanical Drawings: Include information on mechanical work i.e. Expansion joints, Bearing, Seismic Device, electrical installations etc.

Site Plan: "Plan" refers to the top view of an object, and so a Site plan is essentially a map that shows the extent of the proposed site. This is created after a careful and thorough analysis of the proposed Ares for construction and the new construction is marked on it, this provided the contractor with the exact dimensions, access points, greenery, existing physical features, and other details of the site. The neighboring context is also included in the site plan as it might impact the functionality of the neighboring structure.

Bridge Top Plan

Bridge top plan is a fully details @D map of the top view of the bridge. This plan also provides position of Expansions joints, Bridge railings, Foot path, Wheel guard, Bridge approach etc.

Elevations

Sections are essentially an overview of the exterior faces of the proposed structure. They are drawn as an vertical illustration if one view to look directly from the outside. Elevations are useful because not only they specify the height details for the structure but also provide an inside into what the structure might look like from the outside, once it is constructed.

Sections

Sections are extremely useful drawings especially when you are dealing with multiple layers in a structure. They are similar to elevations in that they both present a vertical illustration of the structure but as the name might suggest, sections only show a specific part instead the entire view. A section provides us with the hidden details that can be seen if the building were to be cut vertically. These details are incredibly important as they provide us with the detailing of the structure (position of foundation, abutment/ pier, girder, etc.).

Detail Drawings

Since mostly the scale of the drawing is so small that it is impossible to see the minute detailing in various components. For this purpose, Blown-up drawings of just those specific components are provided to the contractor and builders.

The scale is much bigger than that of regular drawing (for example it might be around 1"=4' or 1"=6' while normal drawings are around 1"=20' or 1"=40')

The standard bridge detail drawing shall contain following;

1. General Notes for RCC Components
2. General Notes for Pre-stressed Concrete
3. Guide line for Cast-in-situ bored piles
4. Sub-Soil Bore log
5. Topographical Survey and Bridge Lay-out Plan
6. General Plan and Elevation
7. Bridge Deck Profile
8. Pile Lay-out Plan
9. Details of Bridge Deck
10. Details of RC Girders (Long & Cross sections)
11. Details of Pre-stressed Concrete Girders
12. Details of Abutments
13. Details of Abutment Piles
14. Details of Pier
15. Details of Pier Pile
16. Details of Railing
17. Details of Bearing on abutment and Pier
18. Expansion Joint
19. Protective Works around Abutment & Approach road
20. Details of Guard Post
21. Approach road cross-section & Alignment plan
22. Electrical installation & circuit diagram
23. Long & cross drain of Approach road
24. Details of underpass (in needed)
25. Drawing for assumed construction sequence
26. Camber drawing

17.2 Check List for Detail Drawing of a PSC Girder Bridge

Sl.No.	Subject		Yes	No
1.	Check point of Bridge Layout?			
2.	PWD R.L of TBM?			
3.	Northing and Easting of TBM?			
4.	Total Length of Retaining wall?			
5.	Length of each PSC Girder and Arch Rib?			
6.	Width of Expansion Gap of end span?			
7.	Deck Top R.L at center of the Bridge?			
8.	Number, Length, and Dia of the piles below Abutment?			
9.	R.L of Pile top cut-off level below Abutment?			
10.	Level difference between Bridge Top and Bridge end?			
11.	c/c distance of pier?			
12.	Type of slope of Bridge Arch Portion and PSC portion?			
13.	Coordinate of Pile (P01)?			
14.	Coordinate of Pier?			
15.	C/C spacing of PSC girder?			
16.	Width of support diaphragm?			
17.	Width of intermediate diaphragm?			
18.	C/C distance between middle two diagrams?			
19.	Thickness of deck slab?			
20.	Thickness of wearing surface of deck slab?			
21.	Thickness of bearing seat of intermediate girder and end girder?			
22.	Width of bridge carriageway?			
23.	Total width of the bridge?			
24.	Size and thickness of pre-cast slab of bridge footpath?			
25.	Dia, and spacing of deck slab main rod at top and bottom?			
26.	Dia, and spacing of deck slab binder rod at top and bottom?			
27.	Strength of concrete of deck slab?			
28.	Yield Strength of re-bar of deck slab?			
29.				

18. FORMWORK, SCAFFOLDING AND DESIGN OF PSC CASTING BED

18.1 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 defection 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.

Strength: The form should be designed so that they will safety support all loads without collapse or danger to the workmen or the structure.

Rigidity: Forms must be sufficiently rigid under construction loads to maintain the required shape and alignment. Formwork tolerance are generally tighter than the tolerances specified for the finished concrete.

Loading on Formwork: Dead loads (weight of fresh concrete, Formwork materials, reinforcement etc.)Superimposed loads (Weight of workmen, equipment, runways, allowances foe impact etc.) lateral pressure of concrete which increases with the height of concrete, Vibration of concrete also increases lateral pressure, Wind loads etc,)

For design of Formwork unit weight of RCC work should be taken as 2700Kg/m3

Lateral Pressure of Fresh Concrete: Vertical forms are loaded by the lateral pressure of the wet concrete. The freshly placed concrete behaves temporary like a fluid producing a hydrostatic pressure which acts laterally on the vertical forms. This lateral pressure is comparable to a full liquid head when concrete is placed to the full height within the period required for its initial set.

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

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 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 surface 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 surface 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

Tolerance for concrete construction

Allowable deviation 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 tolerance 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 tolerance specified. Concrete work that exceeds the tolerance limit specified in this clause shall be remedied or removed and replaced by and at the expense of the contractor

Unless otherwise stated on the drawings, wrought formwork shall be used for all permanently visible concrete surfaces. Wrought formwork shall be such as to produce a smooth and even surface free from perceptible irregularities. Tongues and grovel paneled boards, plywood or steel forms shall have their joints flushed with the surface. The formwork shall be formed with approved standard size panels. The panels shall be arranged in a uniform approved pattern, free from defects likely to be detected in the resulting concrete surface.

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

The repetitive usage of the same formwork to cast from-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, and 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 required touch up. Slight touch up for a small spot if necessary shall be carried out skillfully so as to be synonymous with the entire surface.

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

Formwork for non-exposed concrete surface

Unless otherwise stated on the Drawing, 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.

Vertical Formworks:

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 exposes 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.

18.2 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, drawing 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 o the Drawing. The supports shall be designed to withstand the worst combination of self-weight, formwork weight, formwork forces, reinforcement weight and 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 required the contractor to employ screw jacks or hardwood wedges to take up any settlement in the formwork either before or during the place 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 ids 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 bracing 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 instruction from the manufacture/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 required. The Engineer shall consider the loading and submit in writing.

Scaffolding shall be set to give the finished structure the camber shown on the Drawing 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 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 required. Test loading of the scaffoldings may be requested for the determination of the flexibility and the strength. All expensed of the tests and examinations of scaffoldings shall be borne by the contractor on non-reimbursable basis.

Scaffolding 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 bamboo shall be free from any defects, firmly ties to each other and joints made smooth. Joining members only with nails shall be prohibited. Bamboos for vertical support shall not be less than 75mm in diameter and shall be straight as far as possible. Bamboos may be used as vertical support for up to a height of 4m, if horizontal bracings are provided at the 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 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 scaffolding are used, it shall be painted in a manner that no mark of corrosion shall appear on the permanent concrete structure.

The Engineer shall only select the type of scaffolding. Bamboo scaffolding will only be used if agreed and allowed by the Engineer. All scaffolding shall remain in place for a period, which shall be determined by the Engineer.

Scaffolding shall be dismantled after use piece by piece. Holes in the wall shall be filed 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 materials or liquids, loose material lying on the gangways and proper access to the platform.

The scaffolding shall be secured to the building at enough places; no ties shall be removed warning sign, prohibiting the use of any defective or incomplete scaffolding and working in bad weather and high wind, shall be posted in prominent place. Inspections shall be made for the observance of those 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 baseplate 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 ledges connecting the vertical tubes are spaces 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 post fixed to common sole place at its base and to a head piece at the top. The entire frame is thoroughly braced dogged.

Inspection Checklist of Scaffolding:

A checklist for final inspection of scaffolding is as follows:

(a) Check to see that there is a sound base (footing) under every leg of every frame on the job and that the base area is adequately drained.

(b) Check that all base plates or adjustment screws are in firm contact with the base. All adjustment screws should be tidy against the legs of the frame.

(c) Make sure that the scaffolding has been constructed as shown in the approved drawing. If variation, consult with the engineer who prepared the drawing for the approval of the amended.

(d) Frames should be checked for alignment in both directions. The maximum tolerance is 1 in 300. If the frame exceed this tolerance, the base should be adjusted.

(e) All frames must be connected with at least one cross bracing.

(f) While checking the cross braces, also check the locking devices to ensure that they are in their correct position and they are all tight.

18.3 Load Calculation of Steel Prop for Staging & Sample drawing of staging for single and double PC Girder casting

SAMPLE LOAD CALCULATION OF STEEL PROP FOR SRAGING

1. Load Calculation:

Length of PC girder = 30m

Volume of girder concrete = 22 cum (Say)

1. Weight of PC Girder, say = 22x24 = 528 KN (unit wt of concrete= 24 kn/m3)
2. Wt shutter and form work, joist etc. 10% of the girder = 52.8 KN
3. Wt. of labour, equipment etc. on stage during casting/ tensioning: Say 5% of the girder wt. = 26.4 KN
4. Total load as stated (1+2+3) = 607.20 KN
5. Say, the total load on stage = 610 KN

2. Stage Geometry:

a. Nos. of MS pipe's line (parallel to the girder) = 4 (spacing = 1.0m c/c)
b. Nos. of pipes in each line = 19)c/c spacing 1.5m)
c. Total nos. of pipes = 19x4 = 76 nos.
d. Size of MS pipe = 5" to 6" dia
e. As the framing system is not 100% rigid, hence the mid line post will carry the maximum load from girder. Considering 30% of total load shall be taken by each of the mid line props
f. Nos. of support including pier at both ends = 19+2 = 21 (See drawing in the following page)
g. The load on mid line individual propos = 0.30x610/ (19+2) = 8.714 KN = 888 Kg

3. Driving Capacity: Using drop Hammer

Capacity of post, P = WH/6(S+C) (Engineering News Formulae)

W = Wt. hammer in kg, say 100 kg

H = Ht of fall of ram, in mm, say 5' = 1500mm

S = Avg. Penetrations in last few blows, mm/blow

C = Penetration constant, 25 (for SI unit)

Factor of safety = 6

Hence, P = WH/6(S+C)

888 = 100x1500/6(S+25)

S = 3.15mm

Thus, to attain the driving capacity of each post 888kg, the post shall be driven to a depth until the average penetration shall be less than 3.15 mm per blow.

OFFICE ORDER IN REGARDS TO SCAFFOLDING & FORMWORK CONSTRUCTION

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
স্থানীয় সরকার প্রকৌশল অধিদপ্তর
আগারগাঁও, শেরেবাংলা নগর
ঢাকা ১২০৭।
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০৫ জুন ২০২২ খ্রিস্টাব্দ

অফিস আদেশ নম্বর-৪৬.০২.০০০০.৩০১.১৮.০২৭.১৯-৮৬৮

অফিস আদেশ

এতদ্বারা সংশিষ্ট সকলের অবগতির জন্য জানানো যাচ্ছে যে, এলজিইডি'র আওতায় সেতু নির্মাণের জন্য Scaffolding & formwork নির্মাণ একটি অত্যন্ত গুরুত্বপূর্ণ Temporary Work। উক্ত কাজ যথাযথভাবে না করার দরুন নানাবিধ সমস্যা দেখা দিচ্ছে বিশেষ করে Girder/Slab এর Soffit Level সঠিক রাখা সম্ভব হচ্ছে না, কোন ক্ষেত্রে অত্যধিক deflection/sag হলে Girder/Slab ভেঙ্গে ফেলা এমনকি ক্ষেত্র বিশেষে নির্মাণ কাজ চলাকালীন সময়ে Scaffolding collapse এর মতো দূর্ঘটনার সম্মুখীন হতে হচ্ছে।

এমতাবস্থায় সঠিকভাবে Scaffolding & formwork নির্মাণের জন্য নিম্নলিখিত পদক্ষেপ গ্রহণের জন্য নির্দেশনা প্রদান করা হলোঃ

১। সংশ্লিষ্ট ঠিকাদার স্মারক নং-এলজিইডি/সিই/ডিইউডি-৭৫/২০০৯/৫২৯, তারিখঃ ২৫/০৭/২০১৩ ইং অনুসরণ পূর্বক Scaffolding & formwork Design সম্পন্ন করে Drawing এবং ইহার Calculation সংশ্লিষ্ট উপজেলা প্রকৌশলীর দপ্তরে জমা দিবেন। উপজেলা প্রকৌশলী তা নিরীক্ষান্তে জেলা নির্বাহী প্রকৌশলীর দপ্তরে জমা দিবেন।

২। সেতুর Span/Length ৫০ মিটারের কম হলে সংশ্লিষ্ট জেলা নির্বাহী প্রকৌশলী Scaffolding & formwork Design পরীক্ষা করে ইহার অনুমোদন দিবেন।

৩। সেতুর Span/Length ৫০ মিটারের বেশী হলে সংশ্লিষ্ট অঞ্চলের তত্ত্বাবধায়ক প্রকৌশলী Scaffolding & formwork Design পরীক্ষা করে ইহার অনুমোদন দিবেন।

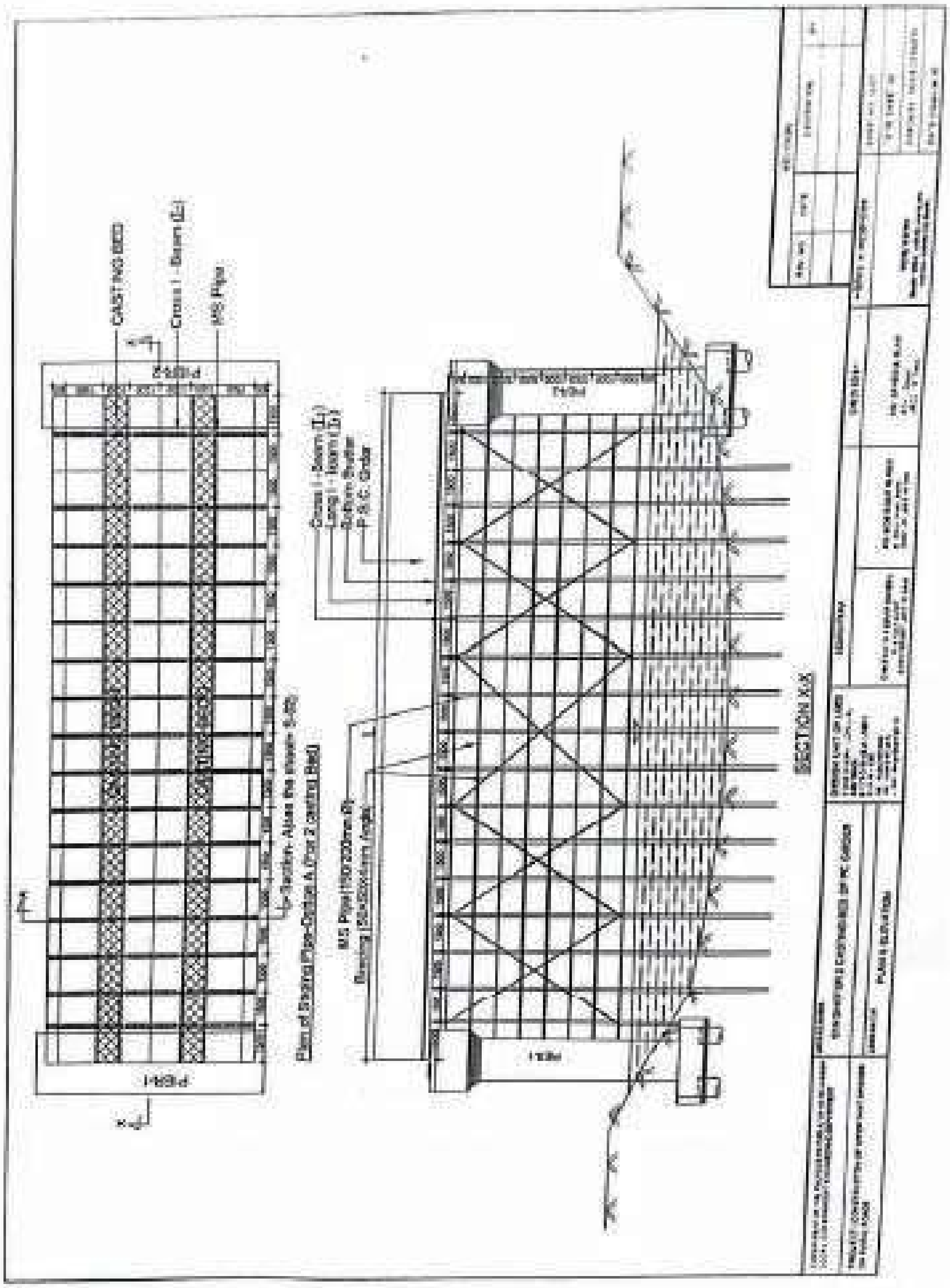
৪। অনুমোদনকৃত Scaffolding & formwork Design মাঠ পর্যায়ে সঠিকভাবে বাস্তবায়ন হচ্ছে কিনা, তা প্রতিনিয়ত সংশ্লিষ্ট সকল কারিগরি কর্মকর্তাকে মনিটরিং এবং রেকর্ড সংরক্ষণ করতে হবে।

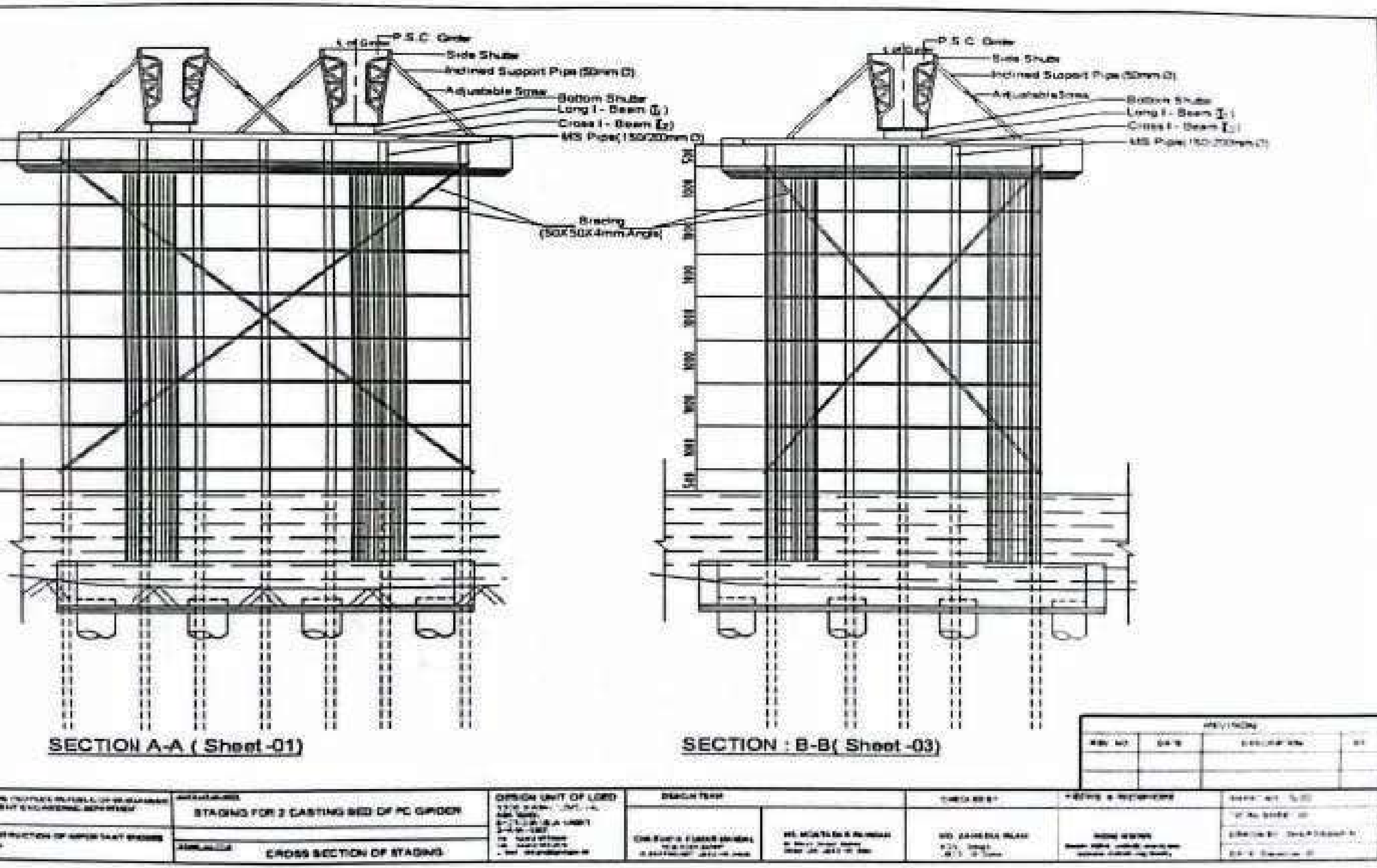
উল্লেখিত সকল ক্ষেত্রেই Scaffolding & formwork Design পরীক্ষা, অনুমোদন ও বাস্তবায়ন পর্যায়ে প্রয়োজনে সংশ্লিষ্ট প্রকল্পের পরামর্শক এবং সেতু ডিজাইন শাখা, ডিজাইন ইউনিটের পরামর্শ গ্রহণ করার নির্দেশনা প্রদান করা হলো।

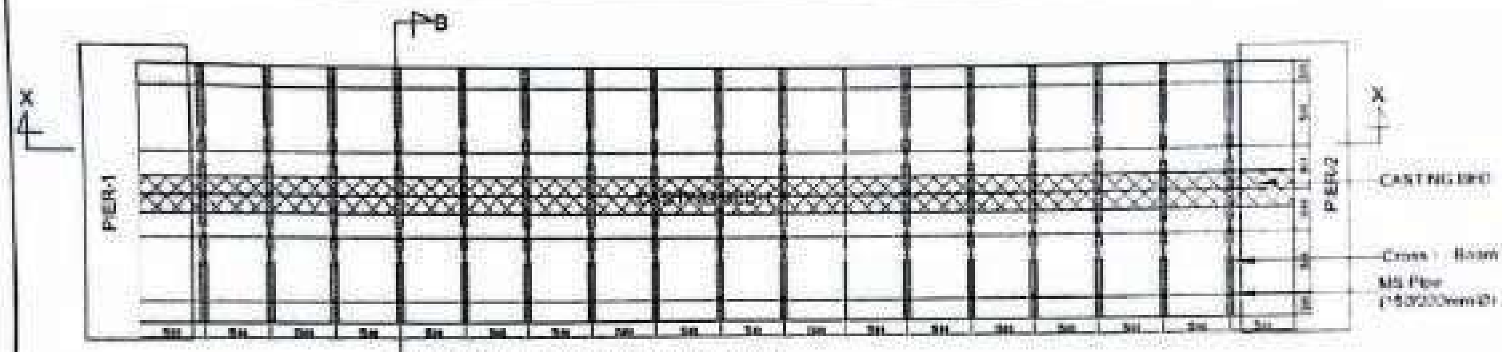
এই আদেশ জনস্বার্থে জারী করা হলো এবং ইহা অনতিবিলম্বে কার্যকর হবে।

(শেখ মোহাম্মদ মহসিন)
প্রধান প্রকৌশলী
ফোনঃ +৮৮০ ২ ৫৮১৫২৮০২

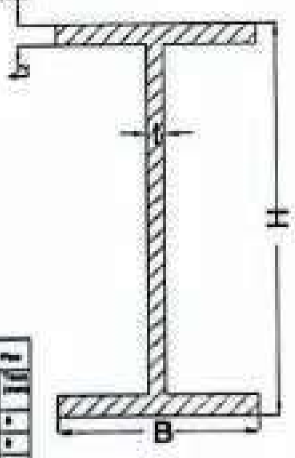
9.3 Load Calculation of Steel Prop for Staging & Sample drawing of Staging for single and


CASTING BED
MS Pipe
SECTION X-X


P.S.C. Girder
Side Shutter
Inclined Support Pipe (50mm Ø)
Adjustable Screw
Bottom Shutter
Long I - Beam
Cross I - Beam
MS Pipe (150/200mm Ø)
Bracing
(50X50X4mm Angle)
SECTION A-A (Sheet -01)
SECTION : B-B(Sheet -03)
STAGING FOR 2 CASTING BED OF PC GIRDER
CROSS SECTION OF STAGING
DESIGN UNIT OF LGED
DESIGN TEAM
CHECKED BY
REVISION



Plan of Staging Pipe-Option B (For single casting Bed)



Cross section of I-Beam

SCHEDULE OF I-BEAM

Depth of Girder (mm)	I_1 (mm)				I_2 (mm)			
	H	B	t_1	t_2	H	B	t_1	t_2
1300	200	100	6	8	150	75	5	7
1500	200	100	6	8	150	75	5	7
1800	200	100	6	8	150	75	5	7
2000	250	125	6	9	150	75	5	7
2400	250	125	6	9	150	75	5	7

Note: The above data is considering fresh or new I - Beam.

SCHEDULE OF MS PIPE & PENETRATION DATA

Depth of Girder (mm)	[illegible]	[illegible]	Set value (mm) [illegible]	Unsupported Length(m) [illegible]	Pipe Pile	
					[illegible]	[illegible]
1300	180	1500	15	10	150	8
1500	180	1500	15	10	150	8
1800	220	1500	2	10	200	8
2000	270	1500	2	10	200	8
2400	270	1500	2	10	200	8

Note: If unsupported length is more than 10m, prop pipe dia & thickness shall be calculated

Note :

1. All Materials used for staging, i.e. steel prop (MS pipe), Cross - beam, long I-beam, etc. Shall be checked properly by responsible LGED Engineer & consultant and shall be certified that all materials are as per drawing

2. Thickness of steel plate for Vertical and Bottom shutter shall be minimum 3mm Angle and flat bar shall be placed as per calculation which shall be submitted by contractor for approval

3. Prop driving shall be carried out in presence of responsible LGED Engineer & consultant

4. Drawing should be strictly followed

5. Prop driving record should be certified using following language by responsible LGED Engineer & consultant
([illegible]
[illegible])

6. [illegible]

7. Prop should be true vertical. Bracing showing in the drawing is minimum if required use more bracing

STAGING FOR 2 CASTING BED OF PC GIRDER

SCHEDULE OF I-BEAM & MS PIPE

19. GUIDELINES AND INTRODUCTION TO ARCH BRIDGE CONSTRUCTION

19.1 Principles of an Arch Bridges

The basic principle of an arch bridge is its **curved design**, which conveys load forces along the curve of the arch to the supports at each end rather than straight down. These supports (known as abutments) bear the entire bridge's weight and are responsible for keeping the arch in precise, unmoving position.

Arch Bridge, bridge in which the supporting elements are arches. Arch bridges can be made of stone, concrete, iron, or steel and typically require less material than beam bridge of the same span.

An arch bridge carries loads primarily by compression, which exerts on the foundation both vertical and horizontal forces. Arch foundations must therefore prevent both vertical setting and horizontal sliding.

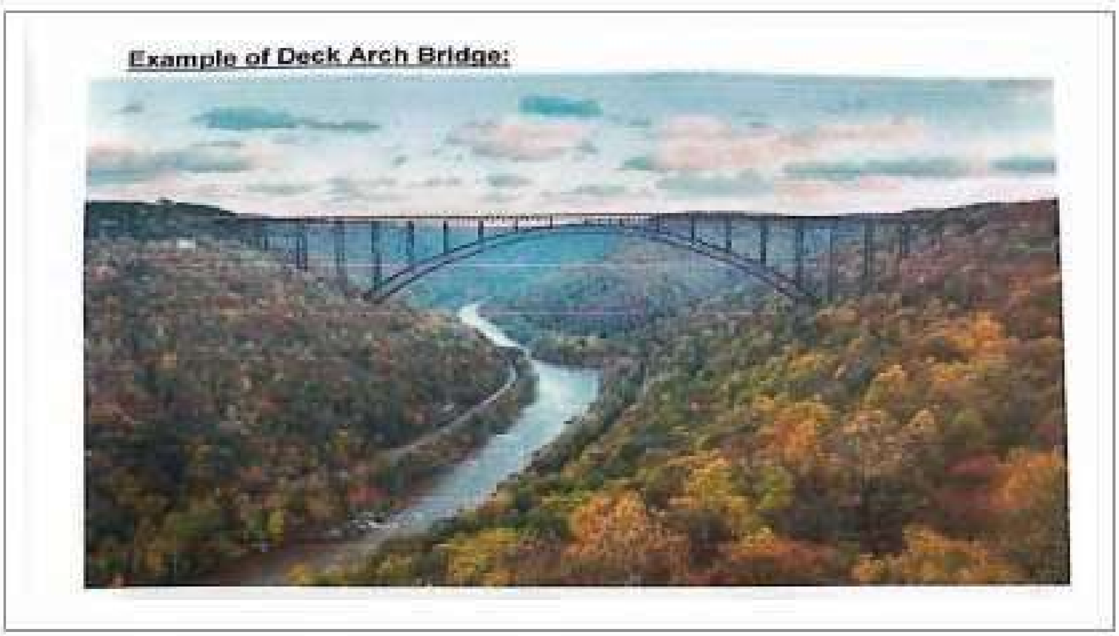
19.2 Different Type of Arch Bridges

There are many different types of arch bridges. The arch bridge can be classified into different types. Following are the types of arch bridges:

1. Deck arch Bridge
2. Through Arch Bridge
3. Moment Tied Arch
4. Fixed-Fixed Concrete Arch
5. Pinned-Pinned Concrete Arch-
6. Bowstring Arch
7. Corbel arch bridge

Example of different types of Arch Bridges shown in the photos below:

<u>**Example of Deck Arch Bridge:**</u>



Arch B

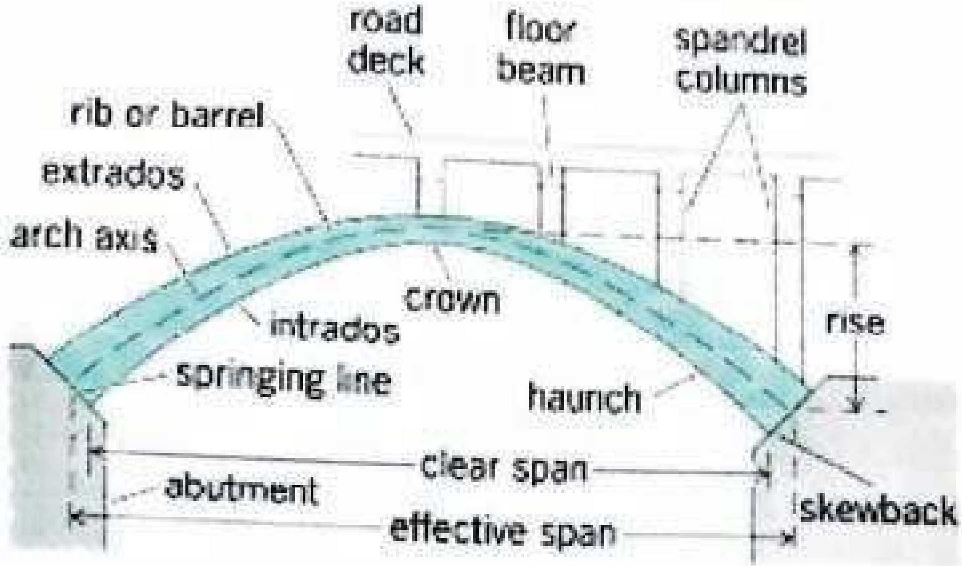
Example of Through Arch Bridge

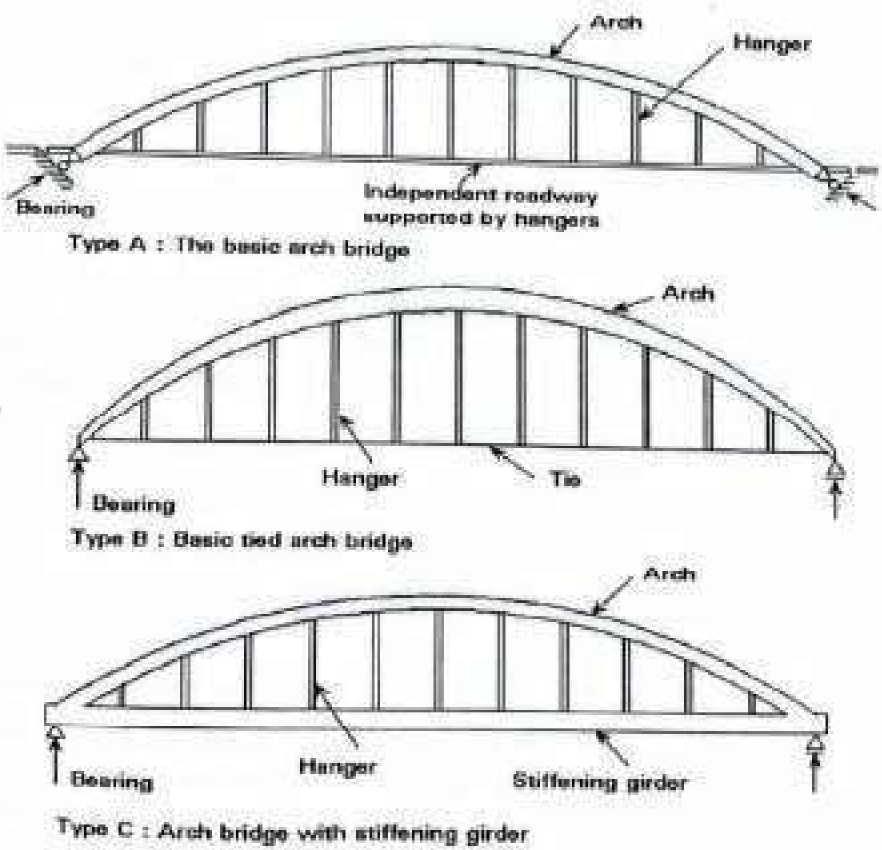
testbook

Example of Tied Arch Bridge

Example of Corbel Arch Bridge

testbook





Types of arch bridge

Selection of Arch Type and Form

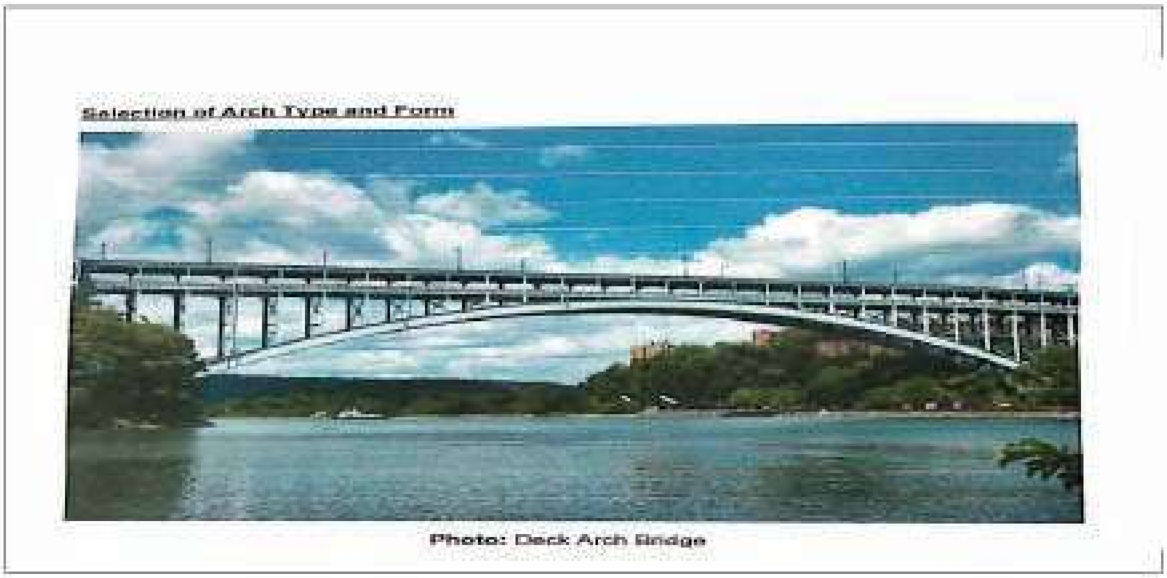


Photo: Deck Arch Bridge

Some of the important elements influencing selection of type and form of arch are as follows.

Foundation Condition: If a bridge is required to carry a roadway or railroad across a deep valley with steep walls, an arch is probably a feasible and economical solution. (This assumes that the required span is within reasonable limits for arch construction.) The condition of steep walls indicates that foundation conditions should be suitable for the construction of small, economical abutments. Generally, it might expected that under these conditions the solution would be a Deck Arch Bridge.

Tied-Arch Construction: At a bridge location where relatively deep foundations are required to carry heavy reactions, a true arch, transmitting reactions directly to buttresses, is not economical, except for short spans. There are two alternatives, however, that may make it feasible to use arch construction.

If a series of relatively short spans can be used, arch construction may be a good solution.

In this case, the bridge would comprise a series of equal or nearly equal spans. Under these conditions, dead-load thrusts at interior supports would be balances or nearly balanced. With the short spans, unbalanced live0load thrusts would not be large. Accordingly, even with fairly deep foundations, intermediate pier construction may be almost as economical as for some other layout with simple or continuous spans.

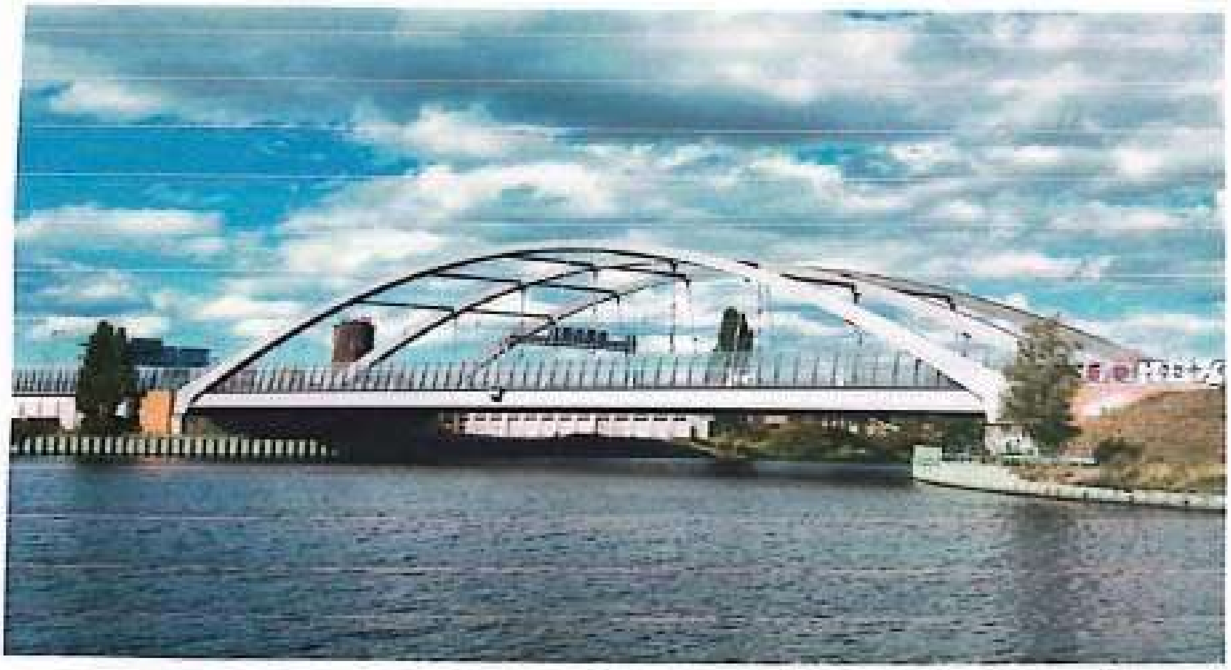


Photo: Tied Arch Bridge

The other alternative to meet deep foundation requirements in tied-arch construction. The tie relieves the foundation of thrust. This places the arch in direct competition with the other types of structures for which only vertical reactions would result from the application of dead and live loading. Tied arches often provide cost effective and esthetically pleasing structures. This type of structure should not be dismissed over these concerns, because it can be easily designed to address them. Tied arches act substantially as two-hinged, regardless of the detail of the connection to the lie.

Length of span: Generally, determination of the best layout for a bridge starts with trial of the shortest feasible main span. Superstructure costs per foot increase rapidly with increase in span. Unless there are large offsetting factors that reduce substructure costs when spans are lengthened, the shortest feasible span will be the most economical.

Arch bridges are applicable over wide range of span lengths. In addition to foundation conditions, many other factors may influence the length of span selected at a particular site. Over navigable waters, span is normally set by clearance requirements of regulatory agencies.

Generally, architects and engineers prefer, when all other things are equal, that deck structures be used for arch bridges. If through or half-through structure must be used, solid ribbed arches are desirable when appearance is of major concern.

Arch Form as Related to Esthetics: For solid-ribbed arches, designers are faced with the decision as to whether the rib should be curved or constructed on segmental chords (straight between panel points). A rib on a smooth curve presents the best appearance. Curved ribs, however, involve some increase in material and fabrication costs.

Another decision is whether to make the rib of constant depth or tapered. An architectural consultant rated these in the following order:

⇒ Tapered rib, curved
⇒ Tapered-rib on chords
⇒ Constant-depth rob, curved
⇒ Constant-depth rib on chords

Photo: Arch Rib of Variable Depth (Tapered Rib)

Photo: Arch Rib of Constant Depth (Tapered Rib)

⇒

19.3 Arch Bridges Construction Guideline

Step – 03 : Arch Rib এর Top Bracing Casting:

3.1. **2nd Stage Scaffolding Construction:** 1st Stage Scffolding অপসারণ না করে, Long Girder, Cross Girder, এবং Deck এর পূর্ণ Strength (fc) অর্জন নিশ্চিত হওয়া সাপেক্ষে অথবা সর্বশেষ ঢালাইয়ের ২৮ দিন পর Deck এর উপর 2nd Stage Scaffolding (ডিজাইন ইউনিট কর্তৃক যাচাই কৃত) নির্মাণ করতে হবে।

2nd Stage Scaffolding নির্মাণের সাথে সাথে Arch Rib এবংTop Bracing এর জন্য Formwork নির্মাণ করতে হবে। Arch Rib এর Formwork প্রস্তুত করার ক্ষেত্রে Hanger Reinforcement, Arch Rib এর সাথে যথাযথ ভাবে (ডিজাইন ড্রইং অনুযায়ী) সংযুক্ত করা হয়েছে কিনা তা যাচাই করা আবশ্যক।

3.2. **Construction of Arch Rib এবং Top Bracing:** Hanger Reinforcement fabrication এর কাজ Arch Rib Casting এর আগে সম্পন্ন করতে হবে।

৭ থেকে ১০ MPa ক্ষমতা সম্পন্ন High Pressure Pump এর সাহায্যে High Strength Non Shrink Admixture সহ Cement Grout দ্বারা Hanger pipe পূর্ণ করতে হবে।

Hanger পাইপের Entrapped Air বের করার জন্য প্রয়োজন অনুযায়ী Ari Vent রাখতে হবে। সমস্ত প্রক্রিয়াটি নির্মাণ প্রতিষ্ঠান কর্তৃক কাজ শুরুর পূর্বে সংশ্লিষ্ট কর্তৃপক্ষকে প্রদর্শন পূর্বক অনুমোদন করে নিতে হবে।

3.3. Arch Rib Top Bracing, এবং Long Girder Construction এর ক্ষেত্রে Construction Joint দেয়ার প্রয়োজন হলে Joint Location এ যথাযথ Treatment এর ব্যবস্থা নিতে হবে।

ঢালাই ২৮ দিনের চেয়ে কম পুরাতন হলে ঢালাইয়ের পূর্বে Surface থেকে সমস্ত ধূলাবালিসহ সকল ধরনের আবর্জনা অপসারন করতে হবে। পরবর্তীতে উক্ত Surface Chipping করে Rough করে নিয়ে Cement Grout দেওয়ার পর ঢালাই করতে হবে।

ঢালাই ২৮ দিনের বেশী পুরাতন হলে Surface পূর্ব মোতাবেক একইভাবে প্রস্তুত করে মানসম্পন্ন Bonding Agent ব্যবহার করতে হবে। এর উপাদন সমূহ Bonding Agent এর Catalog অনুযায়ী সঠিকভাবে Mixture করে Brush এর সাহায্য Painting -করতে হবে। ব্যবহৃ- Bonding Agent Catalog মোতাবেক প্রস্তুত করা যেতে পারে এবং কর্তৃপক্ষের অনুমোদন সাপেক্ষে ব্যবহার করা যাবে।

4.1 Arch Rib এবং Top Bracing এর পূর্ণ -Strength (fc) অর্জন নিশ্চিত হওয়া সাপেক্ষে অথবা ঢালাইয়ের ২৮ দিন পর প্রথমে 2nd Stage এর Cross bracing ও Scaffolding এবং পরে 1st Stage Cross bracing ও Scaffolding অপসারণ করতে হবে।

প্রতি Stage Scaffolding অপসারণের ক্ষেত্রে মাঝ থেকে Support অপসারণ করে ক্রমান্বয়ে উভয় দিকে অগ্রসর হতে হবে।

General Construction Note

১. এই নির্দেশনাটি Tied Arch (অর্থাৎ কেবল মাত্র বিয়ারিং এর উপর অবস্থিত) এর ক্ষেত্রে প্রযোজ্য। Through Arch (অর্থাৎ Pile Cap এর সাথে Rigidly Connected) এর ক্ষেত্রে LGED'র Website এ প্রদত্ত অপর নির্দেশনাটি অনুসরণ করা যেতে পারে।

২. ডিজাইন ড্রইংয়ে Long Girder এ Prestress এর নির্দেশনা থাকলে, Cable Profile, End Block Arrangement, Pre -stressing Force, Elongation, Emergence Angle, Tensioning Sequence, Tensioning এর পর্যায় (Arch Rib নির্মাণের পূর্বে নাকি পরে?) ইত্যাদি ডিজাইন ড্রইং অনুযায়ী নিশ্চিত হওয়ার পর বাস্তবায়ন করা বাঞ্ছনীয়। সেক্ষেত্রে Pre -stressing কাজটি একজন অভিজ্ঞ প্রকৌশলীর তত্ত্বাবধানে করা আবশ্যক।

৩. Steel Scaffolding, Leak Proof Steel Formwork, Needle Vibrator, Form Vibrator, Mix-design এর যথাযথ ব্যবহার, কাজ সম্পাদনের প্রতিটি পর্যায়ে দায়িত্বপ্রাপ্ত প্রকৌশলী কর্তৃক নিশ্চিত করা বাঞ্ছনীয়।

৪. সকল ক্ষেত্রে ডিজাইন ড্রইং অনুসরণ করা আবশ্যক, এক্ষেত্রে কোন সংশয় উদ্ভব হলে সেতু ডিজাইন শাখা, ডিজাইন ইউনিট এর সাথে যোগাযোগ করতে হবে।

৫. Scaffolding design এর ক্ষেত্রে LGED'র Scaffolding design এর নির্দেশনা অনুসরণ করা যেতে পারে। তবে উক্ত ডিজাইনে নির্দেশিত নির্মাণ সামগ্রী ঠিকাদারের Stock এ থাকা নির্মাণ সামগ্রী থেকে ভিন্ন হলে, ঠিকাদার কর্তৃক Scaffolding টি ডিজাইন প্রনয়ণ পূর্বক যথাযথ কর্তৃপক্ষের মাধ্যমে যাচাই করে Scaffolding এর কাজ শুরু করতে হবে।

৬. মাঠ পর্যায়ে Arch নির্মাণের ক্ষেত্রে কোনরুপ অসঙ্গতি পরিলক্ষিত হলে তৎক্ষনাৎ সেতু ডিজাইন শাখা, ডিজাইন ইউনিটকে অবহিত করতে হবে।

৭. নির্মাণ কাজে ব্যবহৃত সকল নির্মাণ সামগ্রী Specification অনুযায়ী Test সম্পন্ন করতে হবে। Test এর Result সন্তোষজনক পাওয়া সাপেক্ষে ব্যবহার করতে হবে।

৮. Arch Rib টি Parabolic বিধায়, Casting এর পূর্বে Arch Rib এর জন্য প্রস্তুতকৃত Formwork ডিজাইনে প্রদত্ত Profile এর সাথে সামঞ্জস্যপূর্ণ কিনা সেটা Check করা আবশ্যক।

৯. এই নির্দেশিকাতে প্রদর্শিত সকল চিত্র সাংকেতিক যা সকল ক্ষেত্রে মূল ডিজাইনের অনুরূপ নাও হতে পারে। নির্মাণের ক্ষেত্রে অনুমোদিত ডিজাইন ড্রইং অনুসরণ করতে হবে।

<u>Note Again:</u> Arch Rib এবং Top Bracing পূর্ণ Strength (f'c) অর্জন না করা পর্যন্ত অথবা ঢালাই করার ২৮ (আটাশ) দিন পূর্বে কোন পর্যায়ের Support বা Scaffolding অপসারণ করা যাবে না।

19.4 Arch Bridge Failure Case

Arch Bridge Centering Shuttering/Formwork	
 Scaffolding using Bamboo (Bad Practice)	 Scaffolding using Steel Prop but no Standard (Bad Practice)

Stanndard Scaffolding for Bridge Works

Some Images of Scaffolding Failure of Arch Bridge

CAUSES OF FAILURE

Causes:

Construction Sequence অনুসরণ না করা, আর্চ ঢালাইয়ের পূর্বেই Scaffolding খুলে ফেলা হয়েছিল।

20. EXPANSION JOINTS

20.1. WORK DESCRIPTION

The quality and maintenance of the expansion joints are vital to the behavior of the bridges and their durability. Accordingly, it should be ensured that expansion joints are waterproofed as well as resistant to leakage.

When water leakage occurs at expansion joints, dirt, soil, gravel and water are collected on the bearing seat locations. This condition will initiate corrosion of steel members including the steel bearings, bottom flanges at ends of steel girder and steel connection accessories.

This repair method is intended for damaged steel type and rubber type expansion joints, which would be replaced with suitable water-proof type expansion joints.

Concrete cutter shall be used to cut both joint edges of the concrete surface to form a straight cutting line pattern. The defective expansion joint shall then be dismantled after chipping off the concrete with an electric jack hammer. The new expansion joint shall be installed with its top level matching the required finish surface. Concrete/grout shall be finally poured, leveled, and then cured.

Photo 3-16-1 and 3-16-2 shows example of water proof type steel expansion joint

Photo 3-16-1 Structure of the Steel Expansion Joints

Photo 3-16-2 After installation

20.2. APPLICATION CRITERIA

Replacement of the steel expansion joint shall be implemented depending on condition of the expansion joint obtained through Bridge Condition Survey and daily maintenance activities or information from road users.

Following conditions can be referred as one of the Standards for decision of replacement of the steel expansion joint.

- Water leakage: detected area >50%
- Abnormal Space/ serious Noise: Detected

- Difference in Elevation: >30mm at expansion gap

Meanwhile, followings can be referred as Standards for decision of replacement of the rubber expansion joint:

- Water leakage: detected area >50%
- Abnormal Space/ Noise: Detected
- Difference in Elevation: >30mm at expansion gap
- Rubber seal dislodge or rupture: detected area >50%

Deriorated Sealant: Pourable joint sealant maybe almost lost off from location

20.3. WORK SEQUENCE

Work sequence of replacement method of the Steel/Rubber expansion joint is as shown in Figure 3-16-1.

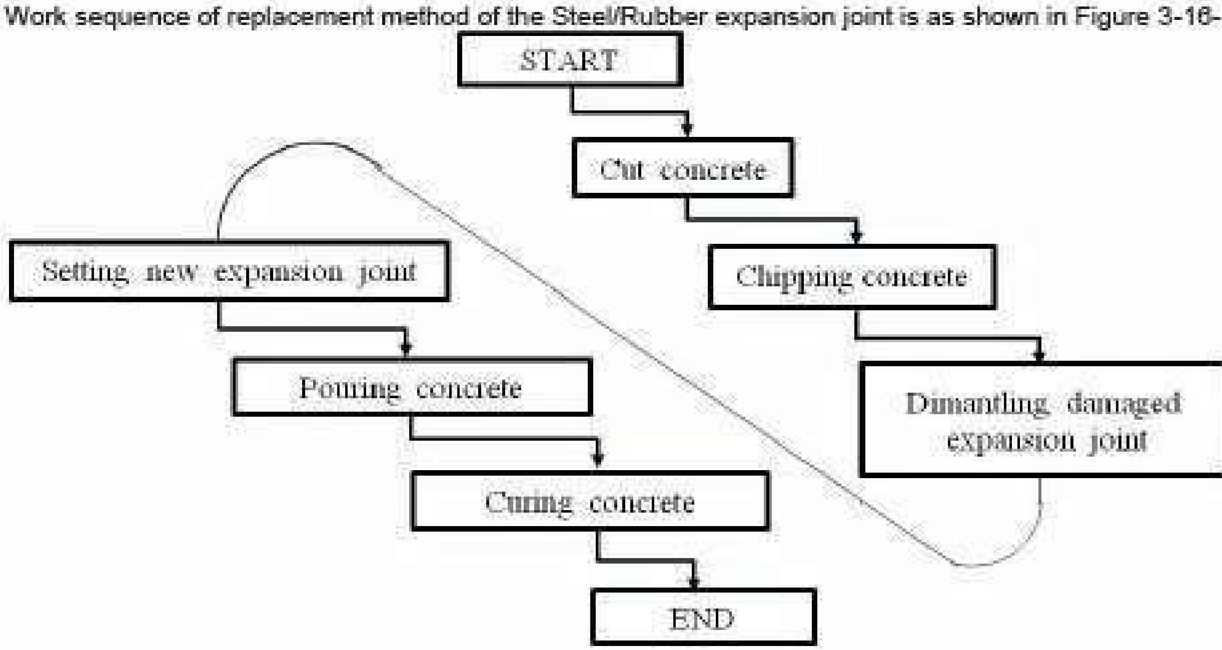


Figure 3-16-1 Work sequence

20.4. REQUIRED EQUIPMENT/TOOL AND MATERIAL

20.4.1 Equipment/Tool

Following equipment/tool will be required for replacement works of the expansion joint.

- Concrete Cutter
- Electric impact hammer/small jackhammer
- Electric concrete vibrator
- Trowel

20.4.2 Material

- New Expansion Joint with water proof rubber

- Rebar (16 mm dia.)
- Concrete/grout

20.5 Requirement, Specification

Material

For new expansion joint

- Steel plates, anchor bars: ASTM A36 or equivalent
- Mortar/concrete: refer to Plate 3-3 Polymer cement mortar

The expansion joint rubber seal shall comply with the following specifications:

Table 3-16-1 Specification of Expansion Joint Rubber Seal

Property	Test Method	Unit	Specification
Tensile Strength	ASTM D412	MPa	0.98 (Min)
Elongation at break	ASTM D412	%	100 (Min)

The type and size of rubber seal for expansion joint should be determined based on Elongation to be approved by the Engineer.

Work requirement

(1) Cut concrete surface

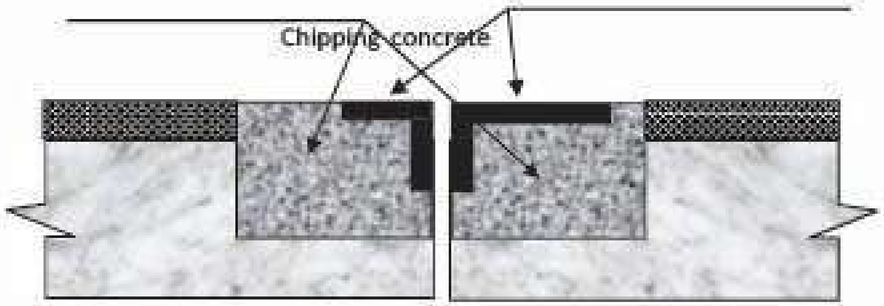
The Contractor shall submit for Engineer's approval, shop drawing for the new water-proofing type expansion joint and the construction plan for the dismantling and installation.

With a concrete cutter device, limits of concrete to be demolished near the existing expansion joints shall be defined in the transverse direction of the bridge deck (300 mm at each edge of the expansion gap).

(2) Chip off concrete and Dismantle Expansion Joint

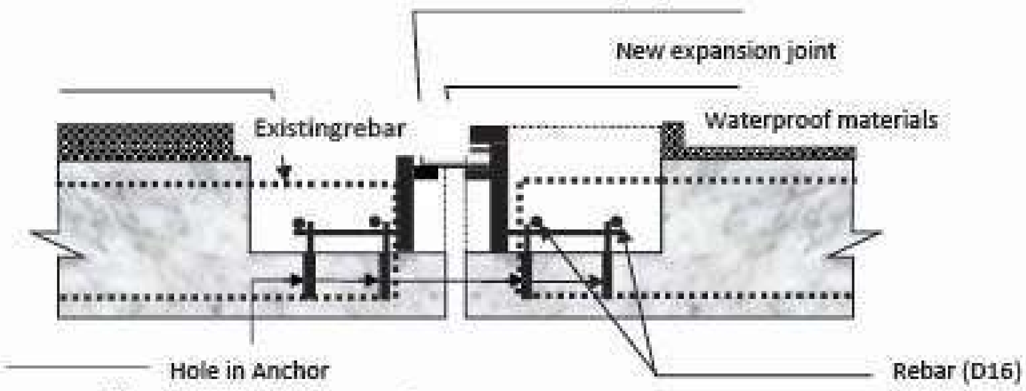
Based on the defined limits, the Contractor shall chip-off further the concrete with a jack hammer to expose the defective joint and portions of the existing reinforcement. After chipping off is accomplished, existing expansion joint material shall be removed from the location.

Dismantling damaged
expansion joint



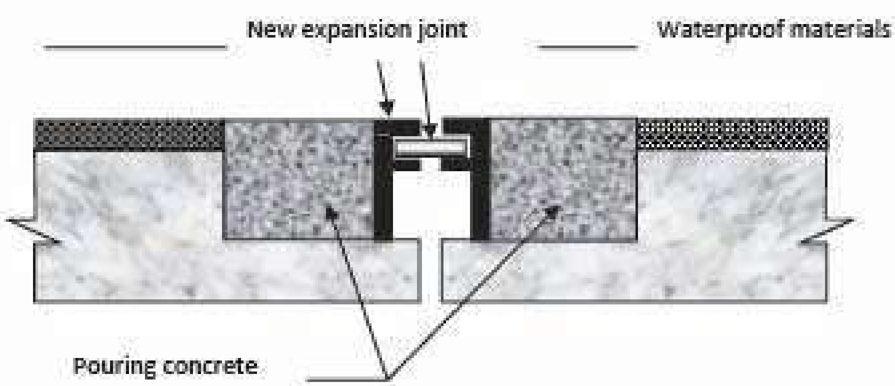
(3) Set up new expansion joint

The new expansion joint shall be installed to proper position considering the required finish level of the deck. The contractor shall submit for Engineers approval, result of measurement verifications for the proposed installation.



(3) Pouring concrete

The contractor shall submit for Engineer's approval,meterials test result of concrete. After approval, the contractor shall commence pouring of the concrete at identified locations near the new expansion joint. Final concrete shall be finished using trowel and shall be subjected to curing process.



20.6 MEASUREMENT AND PAYMENT

6-1 Method of Measurement

The method of measurement for this method shall be by linear meter of joint length which will be defined by the Engineer.

6-2 Basis of Payment

The contract price paid per liner meter of seamless joint shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for executing all related works.

Pay Item No.	Name	Unit of Measurement
3-16-(1)	Replacement of Steel Expansion Joint	Linear Meter (m)
3-16-(2)	Replacement of Rubber Expansion Joint	Linear Meter (m)

BEARINGS

21. BEARINGS

21.1 WORK DESCRIPTION

Function of a bearing shoe is transferring all load from a superstructure including own load of the superstructure to a substructure such as an abutment and a pier.

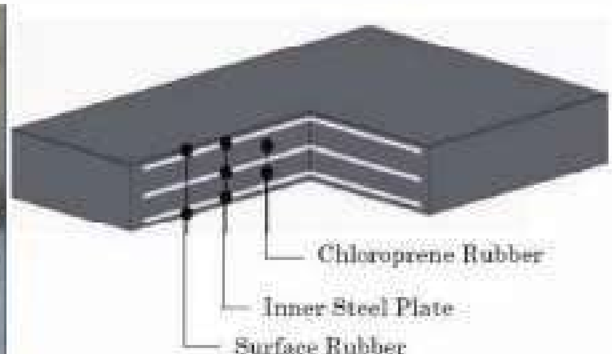
In case the bearing shoe has some defect, a road surface will lose its flatness and causes impact to both of the superstructure and substructures. This impact will to be a cause of damages to the superstructure and substructures.

Meanwhile, rusting condition of the bearing shoe area is one of the most serious areas due to narrow space and concentration of debris and water.

Effective service life of elastomeric bearings is estimated to be 15 25 years. As the material ages during its serviceability period, it exhibits severe bulging or cracking. These are signs that the elastomeric bearings need to be replaced.

Replacement with new bearing shoe should be performed strictly in accordance with the relevant technical requirements and recommendations provided by the bearing manufacturers. Installation should be performed by highly experienced staff subject to close supervision.

Usually, the jack-up girder technique is utilized to allow for replacement of bearings. During replacement of the bearings, traffic may remain opened but with imposed restriction on passing speed as safety precaution. The girder shall be jacked up to around 5 mm to 10 mm, with one jack stroke.



21.2 APPLICATION CRITERIA

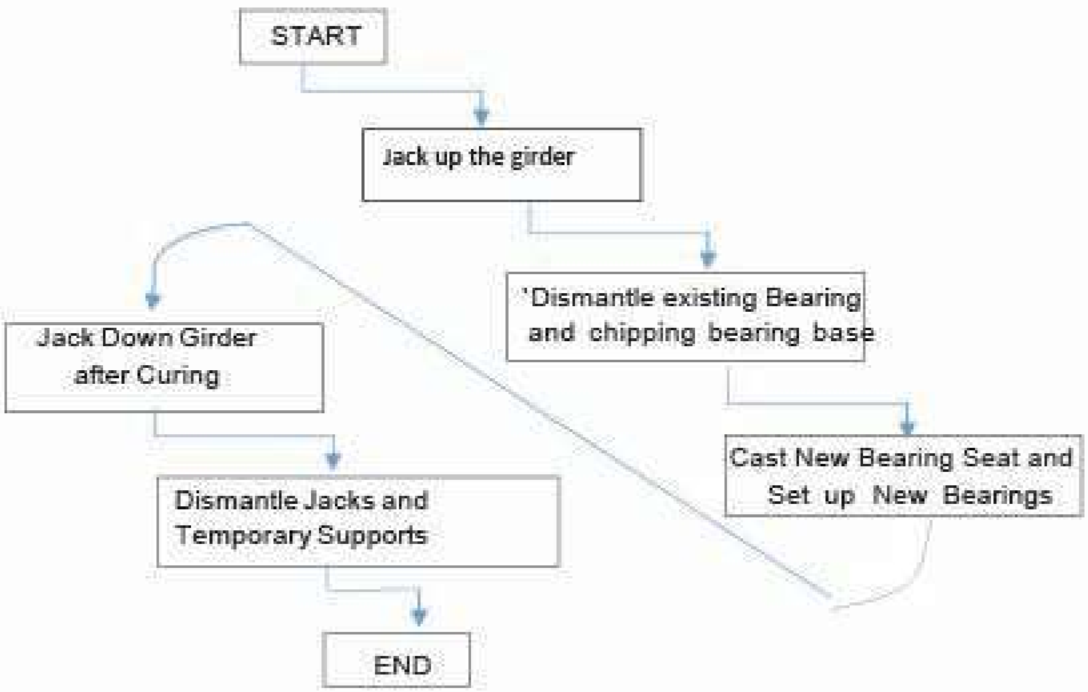
Replacement of bearing shall be implemented if existing rubber bearings already exhibited severe cracks and abnormal bulging. Old steel bearings need to be replaced especially if loose connections

were found.
The capacity of the new bearing should be the same as the old bearing, subject to approval of the Engineer.

21.3 WORK SEQUENCE

Work sequence of replacement method of the Rubber bearing shoe is as shown in Figure 3-19-1.

Figure 3-19-1 Work sequence



21.4 REQUIRED EQUIPMENT/TOOL AND MATERIAL

4-1 Equipment/Tool

Following tools/equipment will be required for replacement works of the bearing shoe.

- Hydraulic Jack
- Electrical Jackhammer
- Portable generator
- Trowel

4-2 Material

Following tools/equipment will be required for replacement works of the bearing shoe.

- Elastomeric bearing pads.

- Rebar
- Mortal/concrete

21.5 REQUIREMENT, SPECIFICATION

Material

(1) Bearing Pads

Elastomeric bearing pads shall be confirmed to AASHTO M251.

Property	Test Method	Uni t	Specificatio n
Hardness, Durometer	ASTM D 2240		60±5

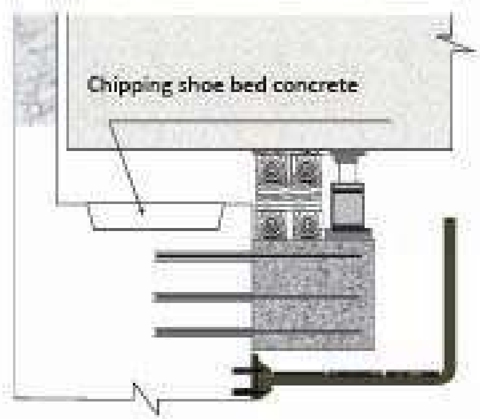
The material test shall be applied for Hardness test to be approved by the Engineer.

Work requirement

(2) Installation of jacking stages

The Contractor shall submit the shop drawings of jack up bracket staging and the working staging to be approved by the Engineer.

The jack up bracket shall strong enough against reaction from jacking load. Concrete of the bracket shall be cured until concrete strength developed required strength.



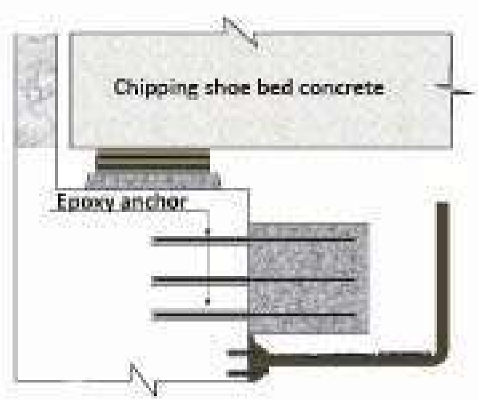
(3) Jack up girder

The jack capacity shall be agreed with the Engineer considering dead load and live load during the replacement work.

The surface of expansion joint shall be secured to provide safety for passing traffic during jacking up process. Moreover, the height difference between surface of abutment and girder shall be kept smaller than 10 mm.

(4) Casting bearing seat and set up new bearings

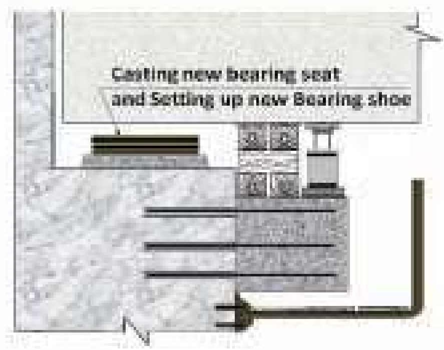
The Contractor shall submit shop drawings for the new bearing seat to be approved by the Engineer, prior to execution of related works including concrete chip off. After providing temporary support for the girders near the bearing locations, old bearings shall be dismantled. Position and level for the new



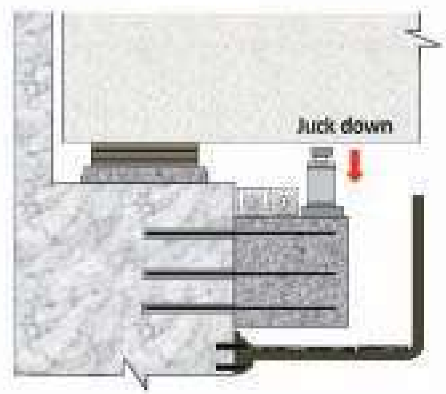
bearings shall be set-up accordingly.

(4) Jack down girder After Curing

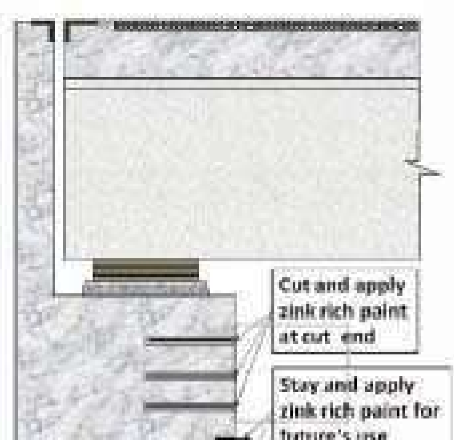
Mortar/concrete shall be cured to achieve sufficient strength for supporting the load reactions. The Contractor shall submit test results of specimen strength in accordance with the specifications, subject to approval of the Engineer. If the test results are acceptable, jack down the girder to consequently release load reactions from the jacking device.



(5) Dismantle Jacks and Temporary Supports
When the reaction is safely transferred from the jack to the new bearing, jacking device shall be dismantled.



Temporary jacking bracket and staging shall be removed, epoxy anchors for bracket shall be cut at the surface of the concrete and cut end shall be applied zinc rich paint. Staging anchor bolts shall be remained with application of zinc rich paint for future's use.



21.6 MEASUREMENT AND PAYMENT

6.1 Method of Measurement

The method of measurement for replacement of bearings shall be by number (quantity) approved by the Engineer.

6.2 Basis of Payment

The quantities, measured as prescribed above shall be paid for at the contract unit price which shall cover full compensation for furnishing, preparing, fabricating, transporting, placing and installation. The new rubber bearing, jack up work, chipping concrete, pouring concrete/grout, jack down work and other activities are deemed included in priced item.

/Pay Item No.	Name	Unit of Measurement
3-19	Replacement of Rubber bearing shoe	Number

COFFERDAMS

22. COFFERDAMS

22.1 COFFERDAM CONSTRUCTION

A cofferdam is temporary wall or structure intended to exclude water from construction work (usually foundation). It must therefore be designed for stability under maximum water level conditions, and should be safe against bursting, sliding, and overturning, Since cofferdams are temporary structure, economy is also major consideration. The selection of the type depends upon the area to be protected, the depth of water to be catered for the possibility of overtopping by floods, and the nature of the material in which the cofferdam is founded (which must be reasonably impervious). In flowing streams, the possibility of scour due to the reduction of the waterway by the cofferdam, and the effect of pressure on the face of the dam, must not be overlooked.

22.1.1 Steel sheet piling

Steel sheet piling is a common material used for the construction of cofferdams. It has the advantage of great strength and is able to be salvage relatively easily at the completion of the work. Except when the bottom is bare rock, a single wall of steel sheet-piling is generally the most effective cofferdam for depths ranging from 5 to 20 meters. Even on bare rock, if the surface is soft enough to permit a minimum of 300mm penetration, steel sheeting may be used successfully.

There have been many shapes of section devised for steel sheet-piling, and all are usually provided with suitable interlocking 'clutches' along each edge.

One advantage of steel sheeting is that it may be driven below the bottom of the excavation to cut off water and to retain soft and unstable material. The depth of cut-off should be at least half the depth of water acting on the cofferdam.

A single wall of steel sheeting is driven by means of a guide frame .In water of up to 10 meters depth, this may take the form of timber piles with wailing bolted into position to provide alignment for the sheeting .In deep water, It is usual to build a framework which will brace the pilling after the cofferdam is pumped out. It is essential to keep the sheets vertical, and this is most easily achieved by standing up a long row of sheets and driving them down a short distance; the whole row being gradually driven to the required depth .Another important point is to place a very heavy grease in the interlocking clutches prior to assembly to prevent rusting and make extraction easier.

22.1.2 Concrete sheet Pilling

Concrete sheet piles are precast members constructed either with or without a jointing system (e.g. tongue and groove).

The points are often cast with a bevel, which tends to wedge each pile against the previous -driven pile. The piles are relatively bulky and they displace a relatively large volume of soil. The larger displacement of soil tends to increase the driving resistance.

By cleaning and grouting the joints after driving, a reasonably watertight seal may be achieved. Grouted walls may need expansion joints along the wall.

22.1.3 Braced Cofferdams

Braced cofferdams are designed so that loads on each set of horizontal waling are equal in order to standardize the size of members.

Waling's are installed by hanging them from the guide frame.

Allowance should be made in design for the possibility of struts being damaged by the digging bucket. It is usual to support them with braces and posts at reasonable intervals in order to reduce their unsupported length as columns. They must also be arranged to avoid fouling the permanent structure as much as possible.

22.1.4 Dikes

Dikes are embankments of earth fill, and designed as gravity dams. They are the simplest form of cofferdam but must be high enough to avoid any chance of overtopping unless suitably protected. Earth is used in quiet water and rock in more turbulent locations. Sealing the latter is often a difficult job, but may be achieved by sandbagging the face with clay. Dikes are usually employed for limited periods, particularly to enable installation of a more permanent cofferdam behind them.

22.1.5 Suspended Cofferdams

Suspended cofferdams are used when piles or caissons have to be capped below low water, and the depth to the river bed is large. A watertight box is constructed, generally of timber, with suitable holes in the floor to fit over the caisson or pile heads.

22.2 DEWATERING OF COFFERDAMS

Dewatering of coffer dams must be carried out with great care and attention. As soon as the cofferdam is closed, The water should be pumped down in stages, with accurate observations of inflow of water between pumping periods. Sealing of bed leakages and installation of bracing (As required) can proceed during these stages. Cofferdams pumps are usually of the centrifugal type with wide clearances since sand, silt and other foreign matter are generally contained in water.

After the inside of the cofferdam is dry, it should be kept dry unless a blow -in occurs as a result of the floor being forced up by water pressure from outside. If this occurs, as a result of the floor being forced up by water pressure from outside. if this occurs, there is obviously not enough cut-off below the toe of the sheeting, and further driving to achieve a better seal may be necessary. The foundation area must be observed at all times for signs of weakness which may lead to a blow-in, and personal should not be permitted to stay in the area if danger is suspected. At the first sign of severe leakage or weakening of the bottom, the area should be flooded and steps taken to obtain a better seal. On rock foundation, grouting may be effective in blocking leakage through fissures. If this is not possible, or if a cofferdam cannot be dewatered completely, excavation will have to proceed under water, and a concrete seal (designed against up lift) installed on the finished bottom, thus enabling the cofferdam to be pumped dry so that further construction work may proceed as planned.

Overtopping of cofferdams should be avoided, if possible, flood hazards should be soundly investigated, and the height of the cofferdam determined by judgment. The economical height is that at which the cost of additional protection will be more than the cost of delay and damage due to overtopping and flood. If a cofferdam is in danger of overtopping, similar action must be taken as with a blow -in or serious leakage. Water should be pumped into the workings to prevent serious damage which may result from sudden ingress of large volumes of water. When danger has passed, the area may again be dewatered.

Generally, it is expected that after a cofferdam is dewatered, work should proceed to its conclusion inside as fast as possible, with the inside of the cofferdam maintained as dry as practicable.

22.3 REMOVAL OF COFFERDAMS

The design of a cofferdam must take into account its removals on completion of the permanent works. There must not only be sufficient clearance inside the cofferdam to permit its removal without damage to the completed permanent structure, but also to enable work to proceed with reasonable access to all parts of the structure during the construction period. Bracing locations must be carefully chosen so that the braces may be removed without fouling.

Sheet pilling if pulled with extractors, care being taken not to damage the sheeting. The greatest effort will be required at the start in loosening the pilling both from the ground and the interlocks and difficult sheets may be left until neighboring ones have been extracted.

Annexes:

Supervision/Monitoring Check list for:

i. Drilling Bore hole & lowering of reinforcement Cages:

Sl no		Items/Steps	Guideline Description
1		Borehole Types	a) Borehole at dry land shall be partially case type by driving temporary steel casing at the upper part of borehole to prevent collapsing of hole Plus to ensure smooth boring and concreting of the pile successfully. b) Borehole through the water and soft upper soil layers shall be case with Permanent steel casing if shown in the drawing.
2		Drilling Equipment Types	a) Percussion drilling equipment (Tripod rig system) shall generally be used For piles having diameters up to 800mm. b) Hydraulic Rotary drilling equipment shall be used for piles having Diameters above 800mm. • Drilling bit/cutter diameter of the boring tools shall not be less than pile design diameter to ensure the design diameter of pile. • Drilling bit bottom shape should be flat for easy cleaning of sand deposition from the hole bottom plus to avoid any unnecessary deposition of soil at bottom. • Prior to commencing boring works well function of drilling equipment, drilling bit diameter, bottom shape/size to be verified and ensure to be acceptable condition
3		Drilling Fluid/Mud (Material)	a) Fresh Bentonite powder shall be used for preparation of drilling slurry/mud required to be circulated inside the hole during boring to Stabilize borehole and to prevent any caving of borehole wall. b) To get the approval from Client, Contractor should submit to client the manufacturer certificate of fresh bentonite indicating the manufacturer's name, material type, date & place of manufacture, details of bentonite Properties (liquid limit, swell index, viscosity range, gel strength, pH value etc.).

			c) The liquid limit of fresh bentonite powder shall be not less than 400% and Swell index shall be not less than 450% d) The density of fresh bentonite shall be less than 1.1 (g/ml), Viscosity shall be 32 to 40 sec and pH value to be 7 to 9. e) The Manufacturer certificate and the Client's approval shall be made available at site during preparation of bentonite slurry. f) Bentonite shall be handled and store at site acceptable to the Client and in a manner which will not results in spillages on the site.
4		Temporary Steel Casing (Material/ Geometry)	a) Temporary steel casing shall be used for piles need to be constructed at dry land. b) Temporary casing length shall be selected based on the depth of upper soft soil layer to protect caving of borehole at upper level. However, the length of the casing pipe shall not be less than 8.0m. c) Inner diameter of the casing shall be more than drilling bit/cutter diameter to ensure smooth/free passing of cutter through casing pipe. d) The casing pipe shall be fabricated to the specified size and shape from mild steel plus to be agreed by Client. e) The casing pipe shall be smooth, clean, watertight, and sufficiently strong (with adequate wall thickness) to withstand both handling and driving stress plus the pressure of both concrete and earth material. f) It shall be free from significant distortion and shall have uniform cross- section throughout the continuous length.
5		Permanent Steel Casing (Material & Fabrication)	a) Piles when need to be constructed at water or very soft soil permanent steel casing (if shown in the drawings) are required to be installed. b) The permanent casing shall be made from new steel plate material conforming to the ASTM A36 plus complying Specification, & drawings. c) Manufacturer's certificate of steel casing materials including properties and test results to be submitted by the contractor to the Client for review and approval. d) The minimum wall thickness, inner & outer diameter and length of the casing pipe shall not be less than as specified in the design/drawings.

			e) The fabrication of permanent casing pipe shall be carried out by suitable method as approved by the client. f) The casing pipe fabrication works including plate folding, welding joints, assembling, storing, surface finishing, coating (if any) etc. must be inspected and accepted by Client's representative. g) The casing pipe shall be smooth, clean, watertight, free from dirt, oil, grease, rust, mill scale etc. and shall be sufficiently strong to withstand both handling and driving stress plus the pressure of both concrete and Surrounding material. h) It shall be free from significant distortion and shall have uniform cross-section throughout the continuous length. i) The casing pipe shall be stored in a suitable place at construction site preventing from environmental degradation plus handled in a manner that shall prevent buckling and other deformation.
6		Slurry Mixing and Testing	a) Mix ratio of bentonite powder to water for achieving desired slurry properties (density & viscosity) depends on the quality of dry bentonite powder. b) Accordingly, trial mix ratio of bentonite slurry to be established by the Contractor at laboratory for complying the desired test results as required for the actual ground condition. c) Nominally for pile boring operation, quantity of bentonite shall be 4% to 6% by wight of water. However, Contractor shall confirm the mix ratio by trial test complying the desired properties at his own responsibility, and to be witnessed and approved by Client. d) The required slurry properties of trial mix shall be i. Density: < 1.10 (g/ml), ii. Viscosity: 32 to 50 sec and pH value: 7 to 9. Contractor to take special precautions by adjusting/modifying the slurry mix ratio considering the actual soil condition, salinity affect etc. of the borehole so that the slurry is suitable for the support of the borehole wall. e) Contractor is needed to prepare drawings of tank/pit for slurry mixing, delivering, collecting, de-sanding etc. indicating the tank location, size, shape, surface finishing type, delivery & re-circulation system and get it approved by Client.

			f) Bentonite slurry to be prepared in the tank properly maintain the approved mix ratio for satisfying the required properties witnessing plus accepted by Client. g) Bentonite shall be thoroughly mix with water in a colloidal mixer. The water shall be taken from the public supply of potable water or other source of fresh water approved by the Client. h) Contractor shall have to ensure availability of all testing kits in good condition at site for frequently testing slurry properties at his own cost and responsibility. i) The testing Kits (Mud Balance for density, MARSH FUNNEL for viscosity, pH meter, SAND CONTENT SET etc.) are to be inspected and accepted by Client.
7		Borehole Position and Boring Sequence	a) The Contractor shall have to prepare a construction drawing of pile group layout plan precisely indicating the coordinates of each pile center position, alignment etc. reference to established BM co-ordinate for review and acceptance by the Client's representative. b) The Contractor shall have to submit a plan with drawings/sketches indicating the sequence of pile construction in a pile group for approval by the Client. c) Boring of a pile shall not be commenced until 24 hours expired after completion of concrete pouring to a recently constructed pile within a radius of five times the pile diameter. d) The Contractor shall have to identify at ground level the actual borehole position/co-ordinates of a pile complying to the design co-ordinate/center position of the pile and shall be verified plus accepted by Client. e) Contractor shall investigate and establish the ground water table around the pile cluster using suitable tools & method acceptable to Client.
8		Driving of Steel Casing (Temporary/ Permanent)	a) Contractor is required to submit procedure of driving steel casing pipe indicating the casing driving equipment type, pipe lifting & positioning system, in-situ splicing system in multi-segment pipe for permanent casing, pipe verticality maintaining/checking system, soil removal during pipe driving etc. for review and approval by the Client. b) The casing pipe geometry and quality (length, diameter, thickness, segment, joint quality, coating, surface condition etc.) to be checked and confirmed prior to commencing driving.

			c) Center position of driving casing pipe at ground to be checked and confirmed to the co-ordinate of the design pile center. d) Casing to be driven very carefully to ensure the verticality of the pipe avoiding any inclination. The verticality of the driven pipe shall be frequently checked by using a Clinometer, Inverted pendulum etc. during the driving time. e) For multiple segments of permanent casing, in-situ segment splicing/joining by welding to be carried out by professionally experienced welder. f) After driving of the casing pipe both top & bottom level of pipe to be checked by survey method and to be confirmed with design/drawings. g) For temporary casing pipe at dry land, top level of pipe should be maintained at 0.5m -1.0m above the existing ground. h) Contractor shall assess the required bore hole depth from the top level of driven permanent casing pipe to the proposed pile bottom level as shown in the approved drawing.
9		Slurry Circulation System	The following two methods are used for slurry circulation to the borehole. a) Direct Mud Circulation (DMC): Slurry is directly supplied from the slurry tank to the borehole through the drilling pipe during boring. This DMC method is used in percussion drilling for piles of less than 800mm Diameter. b) Reverse Circulation (RC): Slurry is directly supplied from the slurry tank to the borehole through the top level of casing pipe. This RC method is used in hydraulic rotary drilling for piles above 800mm diameter. • Prior to commencing slurry circulation to borehole, slurry properties (viscosity, density, PH etc.) are to be checked at site taking sample from the slurry supply tank and to be confirmed with the approved properties. • For slurry re-circulation, collected slurry from the borehole is to be deposited in separate tank and shall be de-sanded by settling in the tank. Properties of de-sanded slurry are to be verified and confirmed to the required properties prior to re-circulation to the borehole.

			• Bentonite slurry which will not be re-used for circulation shall be removed from the site as soon as practicable and safely disposed.
10		Boring/Drilling Process	a) Drilling to be done using acceptable equipment and method as described. b) Slurry with proper properties to be continuously supplied from the slurry tank inside the hole c) Slurry top level inside the borehole must be maintained at least 2.0m above the ground water table to avoid bore hole collapse. d) Drilling inside the hole to be carefully/smoothly carried out to maintain borehole verticality avoiding formation of any inclination. e) Used slurry collected from the hole to be de-sanded by suitable means and ensure properties prior to re-circulated inside borehole. f) Drilling bit diameter to be checked time to time and to be adjusted if found less than the initial diameter/size. g) During boring soil sample encountered from the borehole to be frequently collected and checked for soil type. Contractor shall also compile a boring log indicating depths and types of soil layers encountered. h) Drilling time for each drilling segment to be observed and recorded to understand the soil strength i) If any obstruction encountered inside the hole during boring process which makes very hard for drilling progress, the Contractor shall take necessary measures approved by Client to remove the obstruction at his own cost and responsibility. j) The borehole depth to be measured by suitable means and drilling to be continued until the measure depth satisfy the required design depth from the casing top level. k) To avoid any caving or collapse of hole, boring works shall be continuous without any interruption until the final tip level is achieved.
11		Initial Borehole Wash/Cleaning	a) Initial Cleaning/Washing of borehole should be done by an approved method after completion of boring/drilling works up to required design depth. b) Contractor shall submit to client for approval the procedure of borehole washing/cleaning including cleaning equipment, materials, sand content testing tools, time of cleaning etc. to be used.

			c) Cleaning shall be done by flushing the borehole supplying fresh bentonite slurry. Cleaning shall also be done by air lifting method through a process of supplying air to the bottom of hole from air compressor. d) In hydraulic rotary boring, cleaning bucket shall be used to remove sand and mud deposition from the borehole bottom level. e) Slurry sample to be collected from the bottom of borehole using a acceptable tools and sand content to be checked by suitable means (Sand Content Set). f) Cleaning/washing of borehole shall be continued until sand content at the borehole bottom reduced to a satisfactory level (< 2%). g) During borehole cleaning period the slurry top level inside borehole also to be maintained at least 2.0m above the ground water table
12		Borehole Quality Check	a) After completion of drilling holes up to desired depth, the borehole quality i.e. center position, hole diameter, shape, verticality etc. to be checked by suitable tools (KODEN, Soni-caliper, REBAR CAGE , Inverted Pendulum etc.) b) The Contractor shall arrange all equipment and tools plus conducted borehole quality test in presence of the Engineer at the Contractor's own cost & responsibility. c) Deviation of borehole center position more than 50mm in lateral direction and/or pile vertical slope deviated by more than 1% shall not be acceptable. d) Necessary remedial measures of borehole quality deviation including correction of inclination, lateral deviation etc. to be carried out by an acceptable means and tools at Contractor own responsibility.
13		Rebar Cage (Material & Fabrication)	a) Prior to procurement of reinforcing steel intendent to be used in the pile, the Contractor at his own risk/ responsibility shall have to ensure that the rebar grade, quality, and properties will satisfy the design/drawing and Specification requirement. b) Contractor is required to submit the Manufacturer certificates of reinforcing steel including rebar grade, composition & properties details, factory test results of each size of rebar, record plus performance of previous use of the rebar in any project etc. for review and acceptance. c) After delivery of rebar at site, the Contractor at his own cost shall make arrangement to take samples for each

			size of rebar in presence of Client's representative for conducting laboratory test from a reputed organization (BUET/KUET/CUET) acceptable to the Client. d) The conducted laboratory test results of rebar are to be submitted by the Contractor for review & acceptance by the concerned authority complying with the Specification and Design requirement. Similar sampling, testing plus getting approval are to be carried out by the Contractor for each batch and size of rebar when delivered to site. e) Rebar cage fabrication and assembling are to be carried out strictly following the acceptable pile rebar drawings. f) Main rebar & spiral bar, stiffener bar diameter, numbers, length, splicing length, rebar surface quality (no loose rust, no pit) etc. are to be checked and confirmed with the approved drawings. g) Spiral rebar spacing, lap length, binding & tying with main bar etc. are to be carefully checked and to be complied with the approved drawings. h) Concrete cover blocks size, numbers, spacing, strength/quality, fixing with cage etc. to be checked complying with the approved drawings. i) Individual rebar cage length, total cage length, lap length, main rebar bottom protection, rebar cover, straightness of rebar cage, outer/inner cage diameter, stiffener numbers spacing etc. to be checked and confirmed with the drawings. j) Binding wire quality (GI), wire tying, tack & spot-welding nos./size/quality (if any) etc. to be checked and confirmed with the drawings. k) Hoops, links, helical reinforcement shall fix closely/tightly to the main rebar. If wire is used to fix these bar to main rebar the ends of wire to be turned to the interior of rebar cage to ensure rebar cover.
14		Rebar Cage Installation	a) Check and confirm the bore hole depth, bottom level of hole, center position etc. prior to rebar cage lowering inside the hole. b) Contractor shall take remedial measures if any unacceptable sand/soil deposition, less boring depth etc. are identified prior to lowering rebar cage. c) Ensure that each rebar cage remain vertical/straight during lifting and installation inside the bore hole. No excessive bending of rebar cage shall be allowed during

			installation. Contractor shall take necessary measures to avoid any rebar cage bending as acceptable to the Client. d) Ensure that rebar cage center is acceptably match to the borehole center. e) Check and ensure that splicing of successive rebar cage is satisfactorily done by acceptable means as per design/drawings (using coupler, welding etc.) f) Ensure that lap length of vertical rebar and spiral rebar after splicing satisfy the agreed drawings. g) After rebar cage installation, inspect and ensure that clear cover to the outside of rebar cage inside the hole has achieved the minimum cover as shown in the drawings. h) Inspect and ensure that rebar cage tip level is at least 200mm above the borehole tip level, and the full rebar cage is vertically fixed/hanged to the casing top level by suitable means acceptable to the Client.
15		Final Borehole Wash	a) Final washing of borehole must be done after proper installation plus acceptance of all re-bar cages to the borehole. b) Cleaning and washing of the bore hole shall be carried out by air lifting method and/or supplying fresh Bentonite Slurry through Tremie pipe or any other suitable means acceptable to the Client. c) Contractor shall demonstrate the procedure of final borehole cleaning using the tools (air lifting system, air compressor, etc.) for approval of the Client. d) Prior to start of cleaning hole by slurry circulation method, slurry properties to be tested for required density and Viscosity. e) During final washing slurry sample to be collected from the bottom of borehole by an acceptable tools and sand content to be checked by suitable means. f) Borehole cleaning shall be continued until sand content is reduced to satisfactory level (less than 2%). g) Cleaning shall continue until the water inside the hole is clear and free from particles of soil, silt, sand etc. h) Measures shall be taken to prevent the accumulation of silt and other material at the base of the borehole.

			i) During borehole cleaning period the slurry top level inside borehole also to be maintained at least 2.0m above the ground water table
16		Tolerances of Pile Parameters	The Contractor, jointly with the Client representative, shall assess the following parameters of the constructed pile by any suitable method/test/tools acceptable to the Client. The final constructed pile shall not be accepted for the permanent works unless satisfy the following tolerances from the Specified design/drawings: a) Lateral deviation of Center position of pile at Cut-off level: 50mm (Max.) b) Vertical deviation of cut-off level : (±) 25mm c) Pile Tip Level/ Elevation : (±) 200mm d) Pile Diameter at any section : (-) 10mm e) Pile Verticality Deviation : 0.5% (Max.) f) Actual Poured Concrete Volume : (-) 1.0% (Max.) of theoretical volume.

ii. Concreting of Pile Check List

Sl.no	Items/Steps	Guideline Description
1	Tremie Pipe Lowering	a) Check the tremie pipe inner diameter that should be varied from 150mm (for 600mm dia. pile) to 250mm (above 600mm dia. Pile) based on pile diameter as accepted by the Client. b) Check and measure length of each segment of tremie pipe, total segment numbers etc. and to be satisfied to the borehole depth. c) Ensure that the inner/outer surface condition of tremie pipe are clean plus free from any hard mortar or unacceptable material. d) Ensure that both ends of each segment of tremie pipe is properly threaded to ensure proper joining. e) During lowering tremie pipe ensure that successive tremie segments are smoothly/tightly spliced without any leakage. f) Ensure that tip level of tremie pipe is 200mm above the borehole bottom level. g) Ensure that hopper inner surface is smooth, clean and free from any hard material h) Ensure that hopper is perfectly fixed at top of tremie pipe. i) Ensure that tremie pipe full length is fixed/hanged to the casing pipe to properly maintain the bottom level above the borehole tip level.

2	Concrete (Material & Preparation)	a) All material (Cement, sand, aggregate, water, admixture) brand, type, properties including laboratory test results etc. must be checked and accepted by the concerned authority. b) The contractor shall ensure that all material test results, certificate, approval letter etc. are available at site for review by the inspection team. c) Check and confirm mix design of concrete including, mixing ratio, water cement ratio, cement content, admixture dose, concrete grade, strength at 28 days, initial & final setting time, design slump etc. d) Nominally initial setting time shall be 8 to 10 hours to ensure that pile concrete pouring could be finished within the initial setting time. e) Check and confirm the mixing equipment (Mixture machine/Batching plant), calibration, functioning, material measuring system etc. are acceptable. f) Ensure the inner surface of mixing drum is clean plus free from any hard material (grout, mortar etc.) g) Calculate required quantity of concrete to be manufactured based on actual bore hole depth, concrete top level, wastage etc. h) Ensure all concrete material quantity based on required concrete volume are available at site plus accepted by the Client. i) Required concrete volume shall be computed based on borehole tip level to pile cut-off plus 2.0m of pile length above cut-off level. The actual volume of concrete to be poured in the borehole should not be less than required volume. j) Check and confirm the concrete delivery system (transit truck, pump, head load etc.) to borehole from mixing plant as acceptable to Client. k) The Contractor shall ensure availability of all tools & equipment at site to measure/test required fresh concrete properties (slump, temperature, cube/cylinder mold etc.) to be done immediately after production. l) Mark the desired concrete top level inside the casing pipe prior to concrete pouring accordingly.
3	Concrete Pouring to Pile Borehole	a) Each pile borehole shall be commenced for concrete pouring immediately after completion of final borehole cleaning and accepted by the Client. b) Prior to concrete pouring to tremie pipe hopper, the tremie pipe top opening shall be closed by foam/plastic ball/any suitable means which must be flush out or remove during the 1st charging of concrete and shall be commence only after the full volume of hopper is filled by concrete. c) After then concrete shall be continuously poured in the bore hole through tremie hopper. Ensure that there shall not be any excessive delay or time gap between pouring of successive batch. d) Check fresh concrete temperature, slump, quantity etc. of each batch of concrete satisfy the design requirement prior to pouring. e) Nominally temperature of fresh concrete should not be more than 32oC, and slump shall be 180mm to 220mm to ensure free and smooth pouring through tremie pipe.

		f) Properties (temperature and slump) of fresh concrete delivered at site if do not satisfy the requirement shall be rejected and cannot be used. g) At least three concrete samples (cube/cylinder) per 10.0 cum of fresh concrete are to be taken from the mixed concrete prior to pouring for laboratory test. h) Measure and record top level of concrete inside hole after pouring of each batch of concrete. i) Ensure that during pouring concrete, the tremie pipe tip level must be embedded inside at least 2.0m from poured concrete top level inside the hole. Tremie pipe shall not be raised more than this limit accordingly. j) During concrete pouring small external vibrations/shocking may be applied to the tremie pipe to ensure that there is no clogging/blocking inside the tremie pipe during concreting. k) Contractor to take remedial measures as acceptable to the Client to avoid any clogging/blocking if identified. In no way, tremie pipe shall be removed from the poured concrete, and it shall be embedded 2.0m inside concrete top level. l) Concrete pouring shall be continued until the poured concrete top level is reached at least 2.0m above the pile design cut-off level (as marked earlier) m) The concrete volume of the last batch should be such that the actual total poured concrete volume shall not be less than the theoretical required concrete volume. n) After confirming the pouring of required concrete, tremie pipe tip shall be gradually raised to ensure that fresh good quality concrete level is above the pile cut-off level and top level of poured concrete reached at 2.0m above the pile design cut-off level. o) The Contractor is required to record starting & finishing time of each batch of concrete pouring, and to be ensured that full concrete pouring is finished within the initial setting time of 1st batch of concrete pouring

iii. Bore Log Format

Local Government Engineering Department

Bored Pile Installation Record

A. General Data

Structure Name :	Project Name :

District :	Upazila :	Contract No. :	Contractor :
Pile Location :	Pile No. :	Pile Length :	Pile Diameter :
Pile Cut off Level :	Pile Toe Level :	Ground Level :	Water Level :

B. Boring Data :

Drilling Type :	Chisel/ Bucket dia :	Temp. Casing length :	Inner dia of Temp. Casing :
Casing top RL :	Req. boring @ Casing top :	Bentonite brand :	Liquid limit of Bentonite :
Bentonite dosage :	Initial Slurry Sp. Gravity :	Initial Slurry Viscosity :	Initial Slurry Density :
Numbers of Slurry tank :	De-sander used :	Boring start date/time :	Boring Finish date/time :

C. Boring Record :

Step No.	Time	Boring depth @ casing top	Segment depth	Time elapsed for segment	Density & Viscosity of supplied slurry	Slurry level @ casing top	Type of material	Chisel teeth dia	Remarks (problems)

D. Re-bar Cage Data :

Design length of Rebar cage :	Design nos. of Cage :	Actual nos. of cages :	Length of cages :
Total length of actual cages :	Outer dia of cage :	Nos. of main bar accepted :	Spiral spacing OK :
Spiral tying with main bar found OK :	Spiral tied with welding or GI wire :	Sufficient spacer block attached :	Strength of spacer block acceptable :
Boring depth @ casing :	Depth of deposition :	Start date & time of caging :	Finish date & time :

E. Re-bar Cage Installation :

Cage No.	Start Time	Cage Length	Splicing by welding/coupler	Splicing length	Splicing accepted	Finish Time	Remarks (Problem)

F. Tremie Pipe Lowering Data: Tremie pipe must be fully cleaned from any hard concrete prior to lowering.

Total length of Pipe used :	Nos. of pipe segment :	Segments lengths :	Inner dia of tremie :
Start date/ time of lowering :	Finish date/time :	Tremie top depth @ casing :	

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iv. Bore Log & Concreting Format work out

G. Borehole Wash: Washing of borehole should be done after proper installation of all re-bar cages. Flush with fresh Bentonite Slurry. Before Start of the flushing, slurry to be tested for SP. Gravity and Viscosity. Flushing shall be continued until sand content reduced to satisfactory level.

Start Time (min.)	Borehole depth @ casing top	Depth of sediment (if any)	Slurry's Sp. Gravity & viscosity	Collect slurry sample at hole toe	Sand content (%)	Sand content satisfactory	Remarks with problems if any
0.0							
10.00							
20.00							
30.00							
40.00							

H. Concreting Data

Concrete Class/Grade :	Mix Proportion (C:S:A):	W/C Ratio:	Admixture dosage:
Design Slump:	Total Tremie length & nos.	Tremie toe depth @ casing top :	Inner Dia of Tremie
Truck/Hopper Volume:	Proposed top level of Concrete:	Ht. of Conc. Top:	Required Vol. of Con.
Concrete Placing Date:	Concrete Placing Time:	Final Toe level:	Final Sand content:
Con. Finish Date:	Concrete Finish Time:	Actual vol. of concrete:	Differ. of conc. volume:

I. Concrete Pouring Record:

Batch No.	Volume (Cum)	Concrete preparation & Placing Time		Concrete Slump Record		Concrete Temperature Record		Depth of conc top @ casing top	Raised Ht. of Concrete top level	Equiv. Dia. of raised concrete top level	Ht. of tremie toe @ casing top	Depth of tremie Toe @ Conc.	Remarks on Concreting (Problems)
		Plant	Hopper	Plant	Hopper	Plant	Hopper						

Time elapsed for concreting :	Total concrete consumed:	Difference of Volume:
Extraction of Temporary Steel Casing:	Start Time	Completed at (time)........................
General Remarks (problems encountered, etc.):		
Contractor's Representative	Consultant's Representative	LGED's Representative

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District	:	Tangail	Upazila	:	Mirzapur

Name of Work	:	Construction of 20.00m RCC Grider Bridge on Mirzapur GC(Termohan Khaya Ghat) – Hatubhanga GC Road via Latifp[ur UPC road at ch.2+950km

Road ID No.	:	393662009	Package Code	:	MRRIDP/22/TANG/MIRZ/BRDG/373
Pile Diameter	:	800 mm	Chisel Diameter 790	:	Temporary Casing Diameter : 816 mm
Abutment/Pier Location	:	A2/P6	Location of Pile : P6	:	Pile Length : 28.300m
Date of Casting	:	16.12.2023	Temporary Casing Top RL	:	4.236m
Pile Top RL/Cut Off Level	:	5.236m	Existing Ground Level (EGL)	:	5.096m

Boring Depth (m) from Casing Top [Measured by Every Drilling Rod]				Clock Time of Boring at different Depth
Length of Drilling Rod		Cumulative Length of Drilling Rod		
4.900	m	4.90	m	7.00 - 7.20 am
5.100	m	10.00	m	7.25am - 7.50am
5.100	m	15.100	m	7.55am - 8.25am
5.07	m	20.17	m	8.30am - 8.55am
4.77	m	24.94	m	9.00am - 9.30am
4.40	m	29.34	m	9.35am - 10.05 am
	m		m	
	m		m	

Washing Time		Time Allowed
Start at	Completed at	
10.05 am	10.45am	40 min

Depth after Washing	:	m 28.300	Depth before Concreting Started : 28.300	:	28.800 m

Pouring Time and Depth [For Every Tremie Pipe Length]					Cement Consumed [For Every Tremie Pipe Length]	
Time	Length of Tremie Pipe		Cumulative Length of Tremie Pipe/Depth			
12-00PM-12-30PM	4.5	m	4.500	m	22	Bags
12-35PM-1-00PM	4.6	m	9.100	m	17	Bags
1-05 - 1-35PM	4.5	m	13.60	m	19	Bags
1-40 - 2-15PM	4.5	m	18.10	m	18	Bags
2-20 - 2-55PM	4.9	m	23.00	m	17	Bags
3-00 - 3-40PM	5.00	m	28.00	m	18	Bags
		m		m		

SAE,Mirzapur UE,Mirzapur Executive Engineer, Tangail

v. **Pile Load Test (Statiq2c)**

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

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

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

৩। Pressure Gauge এর Calibration BUET থেকে Test করে 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 efficiency 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) থাকতে হবে।

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 2wU Dial Gauge এর 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।

vi. Pile Integrity Test

Pile Integrity Test (PIT) Execution:

A. Test Procedure:

- Follow the approved PIT test procedure (e.g., ASTM D5882).
- Ensure that the test is performed by qualified personnel.

B. Data Acquisition and Interpretation:

- Record the test data accurately and store it securely.
- Interpret the test results and identify any potential defects or anomalies.

C. Documentation:

- Prepare a comprehensive test report, including test procedures, data, and interpretations.
- Submit the test report to the relevant parties (e.g., consultant, client).

A. Pile Layout and Coordinates:

- Verify pile layout and coordinates against approved drawings.
- Confirm that pile locations are accurately marked on the ground.

B. Access and Safety:

- Ensure safe access to the pile location for testing equipment and personnel.
- Implement necessary safety measures, including barricades, signage, and personal protective equipment (PPE).

C. Cleaning:

- Ensure the pile top and surrounding area are free from debris, loose soil, or obstructions that could interfere with the testing.

D. Dewatering System (if applicable):

- Verify that the dewatering system is functioning correctly and maintaining the required water level.

II. Equipment and Materials:

A. Testing Equipment:

- Confirm that the PIT equipment (hammer, accelerometer, data acquisition system) is calibrated and in good working order.
- Ensure adequate power supply and communication devices are available.

B. Materials:

- Check for availability of necessary materials such as hammer pads, cables, and data storage devices.

III. Document Review:

A. Piling Inspection Approval:

- Verify that the piling inspection approval from the consultant or relevant authority is obtained.

B. Valid Building Permit:

- Confirm that the valid building permit for the project is in place.

C. Concrete Cube Test Reports:

- Review and verify the concrete cube test reports to ensure the concrete strength meets the design requirements.

D. Previous Test Reports:

- Review any previous test reports (e.g., dynamic or static load tests) for the pile.

E. Pile Design Drawings:

- Ensure that the pile design drawings are available and accessible for reference.

vii. Pre-concreting

I. Pre-Concreting Checks:

Pile Details:

- Pile number and location
- Pile diameter/dimensions
- Pile type (e.g., bored, driven)
- Design of pile (e.g. test pile report)
- Reinforcement details (cage dimensions, spacing, etc.)
- Depth of pile

Concrete Details:

- Type of mix (RMC/site mix)
- Concrete supplier
- Concrete grade
- Slump test results
- Concrete quantity per pile
- Cubes cast for strength testing

Shuttering/Formwork:

- Shuttering material (steel sheets, etc.)
- Properly erected and secured
- Cleanliness of shuttering surfaces
- Water sprayed on shuttering surfaces
- Height of formwork
- Verticality of shuttering
- Properly tightened and braced
- Check for any damage or deformation

Reinforcement:

- Reinforcement cage in place and secured
- Proper placement of reinforcement
- Clear cover to reinforcement
- Check for any damage or corrosion

Safety:

- Safety equipment (PPE) available and used
- Clear access to the work area
- Proper signage and barricades
- Movement of heavy equipment under supervision

viii. During Concrete

i. During Concreting:

Concrete Placement:

- Continuous concreting from one end to the other
- Concrete placed within 30 minutes of mixing
- Height of free fall within 3 feet
- Avoid frequent movement of laborers over reinforcement

- Use of plain sheet as walkway for carrying concrete

Thickness Check:

- Thickness checked at 3-foot intervals

Curing:

- Proper curing methods implemented
- Ensure concrete is kept moist for the required duration

Documentation:

- Record pile details, concrete mix, and concreting progress
- Maintain a log of all relevant information

ix. **Concrete of Prestressed concrete girder check list**

সংযুক্ত-২
পাতা ১/২

এলজিইডি'র আওতায় প্রিস্ট্রেসড কনক্রিট ব্রীজের গার্ডারের কনক্রিট কাস্টিং এর চেক লিষ্টঃ

১। কর্মসূচী/ প্রকল্পের নাম ঃ____________________

২। ব্রিজের নাম ঃ____________________; ব্রিজের দৈর্ঘ্যঃ__________

৩। গার্ডার নংঃ__________; চেইনেজ ঃ__________; উপজেলা ঃ__________; জেলা ঃ__________

প্রিস্ট্রেসড কনক্রিট কাস্টিং এর চেকলিষ্ট ঃ

কনক্রিট কাস্টিং এর পূর্বে নিম্নবর্ণিত চেকলিষ্ট সমূহ পালন করতে হবে।

SL	Item Name	Issues on the Quality of Work Performed	Opinion
01	Scaffolding & Shuttering System	ক) Staging/Scaffolding/ Formwork System এর ড্রইং নির্দেশনা অনুযায়ী (সংযুক্ত-৩) Calculation সহ ঠিকাদার কর্তৃক প্রণয়ন পূর্বক ডিজাইন ইউনিট/নির্বাহী প্রকৌশলী এর অনুমোদন নেয়া হয়েছে কিনা।	হ্যাঁ ☐ না ☐ • MS Pipe dia : • Spacing- Long dir. Short dir.
		খ) Staging/Scaffolding/Formwork System বাস্তবে অনুমোদিত ড্রইং মোতাবেক তৈরি করা হয়েছে কিনা?	হ্যাঁ ☐ না ☐
		গ) PC গার্ডারের Bottom Shutter এর লেভেল ও Alignment ড্রইং অনুযায়ী সঠিক আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঘ) গার্ডারের Form work এর Shape, Size ও Thickness ডিজাইন মোতাবেক তৈরী করা হয়েছে কিনা ?	হ্যাঁ ☐ না ☐ • Thickness : BWG
		ঙ) গার্ডারের End Shuttering Drawing-এ প্রদত্ত Immergence Angle অনুযায়ী তৈরী হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
02	Materials for Concrete	ক) কনক্রিটের জন্য পাথর ও বালির পরীক্ষা (Gradation, LA, FM) সমূহ করা হয়েছে এবং মান সঠিক আছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) OPC সিমেন্টের গুণগত মান (Brand, Setting Time, Cube Strength) নিশ্চিত করা হয়েছে কিনা?	হ্যাঁ ☐ না ☐ • Brand : • Type :
		গ) Mix Design/Trial Mix করে কনক্রিটের প্রয়োজনীয় Target Strength (1.33 x Specified strength) এর জন্য সিমেন্ট, বালি ও পাথরের অনুপাত ঠিক করা হয়েছে কিনা ?	হ্যাঁ ☐ না ☐ • Mix Ratio :
		ঘ) কনক্রিটের জন্য W/C ratio এবং admixture এর type ও পরিমাণ নিশ্চিত করা হয়েছে কিনা ?	হ্যাঁ ☐ না ☐ • W/C Ratio : • Admixture Type : • Brand : • Dodge :

SL	Item Name	Issues on the Quality of Work Performed	Opinion
		ঙ) Concrete Casting এর জন্য ব্যবহৃত পানির গুণগত মান (Drinkable Water) নিশ্চিত করা হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
03	Pre-stressing Material [সকল টেষ্ট অনুমোদিত সংস্থা হতে সম্পাদন করতে হবে। টেষ্ট রিপোর্ট সাইটে সংরক্ষণ করতে হবে।]	ক) Pre-stressing Steel এর টেষ্ট সমূহের (সংযুক্তি-১) রিপোর্ট সন্তোষ জনক কিনা ?	হ্যাঁ ☐ না ☐
		খ) Pre-stressing Steel এর Manufacturer কর্তৃক সন্তোষ জনক Test Report আছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) Anchorage System এর Brand Freyssinate ও টেষ্ট (সংযুক্তি-১) রিপোর্ট সন্তোষ জনক কিনা ?	হ্যাঁ ☐ না ☐
		ঘ) Anchorage এর Manufacturer Test Report জমা দেয়া হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		ঙ) Sheathing Duct এর Size, Thickness ডিজাইন অনুযায়ী সঠিক আছে কিনা ?	হ্যাঁ ☐ না ☐ • Size (dia) :
04	Cable Profiling	ক) Cable Profile (Vertical এবং Horizontal Ordinate) ড্রইং মোতাবেক বসানো হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) Sheathing Duct Tack Welding করে ১.০মিঃ অন্তর শক্তভাবে বাধা হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) Sheathing Duct এর Joint গুলো Socket (সংযুক্তি-১) এর মাধ্যমে সম্পন্ন করা হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
05	Others	ক) Anchorage ড্রইং মোতাবেক (Imargence Angle) বসানো হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) Stirrups এর Size ও Spacing ড্রইং মোতাবেক বসানো হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) কনক্রিটিং এর Equipment (Mixture Machine, Form vibrator, generator) এর সংখ্যা ও মান সঠিক আছে কিনা ?	হ্যাঁ ☐ না ☐ • Mixture Machine(Nos.) : • Form Vibrator(Nos.):

বিঃ দ্রঃ উল্লেখিত চেক লিষ্ট সমূহ সন্তোষজনকভাবে নিশ্চিত হওয়ার পরই গার্ডারের Concrete Casting সংযুক্তি-১ এর নির্দেশনা অনুযায়ী সম্পন্ন করা যেতে পারে। প্রতিটি PC Girder এর Casting এর পূর্বে উপরোক্ত Check List অবশ্যই সন্তোষজনকভাবে পূরণ করে সংরক্ষণ করতে হবে।

x. **During prestressing operation**

এলজিইডি'র আওতায় প্রিস্ট্রেসড কনক্রিট ব্রীজের গার্ডারের Tensioning Operation এর চেক লিস্টঃ

১। কর্মসূচী/ প্রকল্পের নাম ঃ ____________________

২। ব্রিজের নাম ঃ ____________________ ; ব্রিজের দৈর্ঘ্যঃ ________

৩। গার্ডার নং ________ ; চেইনেজ ঃ ________ ; উপজেলা ঃ ________ ; জেলা ঃ ________

Pre-stressing Steel Tensioning এর পূর্বে নিম্নবর্ণিত চেকলিস্ট সমূহ পালন করতে হবে।

SL	Item Name	Issues on the Quality of Work Performed	Opinion
01	Basic Check	ক) Tensioning এর জন্য গার্ডারের দুই প্রান্তে নিরাপত্তামূলক ব্যবস্থা রাখা আছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) গার্ডারের Surface এ কোন Crack অথবা Honey Comb আছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) Cable এর Steel সমূহ Freely move করে কিনা ?	হ্যাঁ ☐ না ☐
		ঘ) Scaffolding এর কোন Pipe লেগে গিয়েছে কিনা ?	হ্যাঁ ☐ না ☐
02	Test Results	ক) Girder এর Cylinder কনক্রিট Strength ডিজাইন মোতাবেক সন্তোষজনক আছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) Pre-stressing Steel এর Test Result সমূহ সাইটে আছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) ডিজাইনের নির্দেশনা অনুযায়ী Tensioning এর জন্য Girder Concrete এর Age পূর্ণ হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
03	Equipments Check (সকল টেষ্ট অনুমোদিত সংস্থা হতে সম্পাদন করতে হবে। টেষ্ট রিপোর্ট সাইটে সংরক্ষণ করতে হবে।)	ক) Hydraulic Tensioning Jack এর Updated Calibration/Efficiency Test করা আছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) Pressure gauge এর Updated/Calibration Test করা আছে কিনা ?	হ্যাঁ ☐ না ☐
		গ) Jack ও Pump এর Calibration Capacity Test সঠিক আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঘ) Hydraulic Jack এর Manufacturer's Brochure/ Catalog Supply দেয়া হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		ঙ) Tensioning format (সংযুক্ত), graph paper, tape, Cell Phone, Intercom, Stationary ইত্যাদি আছে কিনা ?	হ্যাঁ ☐ না ☐
		চ) প্রয়োজনীয় ক্ষমতা সম্পন্ন Generator Site এ সঠিক অবস্থায় আছে কিনা ?	হ্যাঁ ☐ না ☐
04	Design Information	ক) Cable এর Jacking force ড্রইং এ দেয়া আছে কিনা ?	হ্যাঁ ☐ না ☐
		খ) প্রত্যেক Cable এর জন্য Elongation ড্রইং এ দেয়া আছে কিনা ?	হ্যাঁ ☐ না ☐

SL	Item Name	Issues on the Quality of Work Performed	Opinion
	Design Information	গ) Cable সমূহের Elongation এর জন্য Influence Length ড্রইং বলা হয়েছে কিনা ?	হ্যাঁ ☐ না ☐
		ঘ) Pre-stressing Steel এর Design modules of Elasticity (E), X-Section Area (A) ড্রইং এ দেয়া আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঙ) Drawing এ Design grip length দেয়া আছে কিনা ?	হ্যাঁ ☐ না ☐
		চ) ড্রইং এ Cable সমূহের Tensioning Schedule এবং Sequence দেয়া আছে কিনা ?	হ্যাঁ ☐ না ☐
		ছ) ব্রীজের পূর্ণাঙ্গ ড্রইং সাইটে আছে কিনা ?	হ্যাঁ ☐ না ☐
		জ) Tensioning এর পর Cable সমূহের অতিরিক্ত অংশ কাটার জন্য Electric Grinder সাইটে আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঝ) Grouting করার পূর্বে Cable এর Duct Pipe পরিষ্কার করার জন্য Air Compressure আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঞ) Grouting করার জন্য Non shrinkage admixture সাইটে আছে কিনা ?	হ্যাঁ ☐ না ☐ • Brand :
		ট) Grouting করার জন্য Electric Operated Grout Pump আছে কিনা ?	হ্যাঁ ☐ না ☐
		ঠ) PC Girder এর Scaffolding design, Cable Laying, Concreting, Tensioning, Grouting ও Erection এর জন্য ঠিকাদারের প্রশিক্ষণপ্রাপ্ত দক্ষ জনবল আছে কিনা ?	হ্যাঁ ☐ না ☐

বিঃ দ্রঃ উল্লেখিত চেক লিস্টের আইটেম সমূহ সন্তোষজনকভাবে নিশ্চিত না হওয়া পর্যন্ত Girder এর Cable সমূহ Tensioning করা যাবে না। প্রতিটি PC Girder এর Tensioning এর পূর্বে উপরোক্ত Check List অবশ্যই সন্তোষজনকভাবে পূরণ করে সংরক্ষণ করতে হবে।

xi. During grouting Operation

৭। <u>Grouting of Cable Duct</u> :

- Tensioning প্রক্রিয়া সুষ্ঠুভাবে সম্পন্ন হওয়ার ২৪ (চব্বিশ) ঘন্টা পর Cable এর উভয় প্রান্তে Strand এর অতিরিক্ত অংশ Live Grip এর মাথা থেকে অন্তত ২৫ মিঃ মিঃ রেখে Electric Grinder এর মাধ্যমে কাটতে হবে তবে **কোন ভাবেই GAS Welder দিয়ে কাটা যাবে না।**
- PC Girder এর Cable এর Tensioning Operation সম্পন্ন করার পর Duct-এর Grouting প্রক্রিয়া শুরু করতে হবে।
- Cable এর Duct সমূহ Grout করার জন্য Electric Operated Pump, Agiater এবং Air Compresser সাইটে থাকতে হবে।
- Grout Mix তৈরীর জন্য অবশ্যই Ordinary Portland Cement, Drinkable Water এবং Non-Shrinkage Admixture ব্যবহার করতে হবে।
- Grouting এ Water/Cement Ratio 0.45 হবে এবং Admixture এর পরিমাণ Manufacturer এর Recommendation অনুযায়ী নিশ্চিত করতে হবে।
- Grouting শুরুর পূর্বে Cable Duct এর ময়লা পানি Pump করে পরিষ্কার করতে হবে তারপর Air Compressure এর মাধ্যমে Duct এর ভেতর শুকিয়ে নিতে হবে।
- দক্ষ প্রকৌশলীর উপস্থিতিতে Cable duct এর Grouting প্রক্রিয়া সম্পন্ন করতে হবে।
- PC Girder এর Cable সমূহের Grouting সম্পন্ন করার পর Girder এর Final Position এ Bearing এর উপর না বসানো পর্যন্ত গার্ডারের উভয় পার্শ্বে Support (বালির বস্তা, Re-bar Tie-up etc.) দিয়ে PC Girder কে Stable অবস্থায় রাখতে হবে।

xii. Formwork Inspection Checklist

১। Scaffolding & Formwork :

- Scaffolding এর জন্য কমপক্ষে ৬" (ছয়) ইঞ্চি diameter ও ১/৪" Thickness এর MS Pipe ব্যবহার করতে হবে।
- একটি Girder Casting এর জন্য MS Pipe সমূহ সর্বোচ্চ ৫' (পাঁচ) ফুট অন্তর Long Direction বরাবর Drive করতে হবে এবং Transverse Direction বরাবর কমপক্ষে ৫(পাঁচ) টি Pipe সর্বোচ্চ ১.০মিটার অন্তর Drive করতে হবে।
- Engineering News Formula (P=WH/6(S+C)) ব্যবহার করে Pipe সমূহের Bearing Capacity নিশ্চিত হওয়ার জন্য driving record সঠিকভাবে সাইটে সংরক্ষণ করতে হবে।
- Driving এর জন্য কমপক্ষে 120 Kg ওজনের Hammer ব্যবহার করতে হবে এবং Height of fall অন্তত ৫' (পাঁচ) ফুট রাখতে হবে।
- Driving এর সময় Pipe সমূহের Settlement গড়ে সর্বোচ্চ প্রতি Blowতে ২মিঃ মিঃ এর নীচে না আসা পর্যন্ত Driving Continue করতে হবে।
- Scaffolding এর X-bracing এর জন্য 2"x 2"x ¼" Size এর MS Angle Welding করে লাগাতে হবে।
- Bracing সমূহ Horizontal এবং Vertical বরাবর সর্বোচ্চ ১.০মিটার অন্তর দিতে হবে।
- উল্লেখিত নির্দেশনা অনুযায়ী Scaffolding এর Calculation সহ ড্রইং প্রস্তুত করে সংশ্লিষ্ট নির্বাহী প্রকৌশলী/ডিজাইন ইউনিটের অনুমোদন নিতে হবে।
- PC Girder এর Formwork এর জন্য MS Sheet এর Thickness Girder Depth ২.০ (দুই) মিটার পর্যন্ত 12 BWG এবং ২.০ দুই মিটারের অধিক Depth এর জন্য 10 BWG হতে হবে।
- Formwork এর বাহির সাইটে অনুভূমিক ও লম্বভাবে 1½"x1½"x ¼" MS Angle এর Bracing ১' (এক) ফুট অন্তর Welding করে বসাতে হবে।
- Formwork এর Size ও Shape design/drawing অনুযায়ী সম্পন্ন করতে হবে।
- PC Girder এর End Shutter ডিজাইন/ড্রইং এ প্রদত্ত Immergence Angle অনুযায়ী বানাতে হবে।

Staging (Prestressing Bed) Inspection Checklist

xiii. Bridge Approach Embankment Construction

- Check Plasticity Index (PI) value of filling earth as per design & specification.
- Check layer by layer compaction of filling earth as per design & specification
- Check RL of formation level as per design & specification
- Check width of embankment as per design.
- Check side slope as per design.
- Check camber of embankment road as per design.
- Check longitudinal slope as per design.
- Check & monitor benching for side slope compaction as per design.

xiv. Bridge Approach Pavement Construction

- Check CBR of sub-grade as per design.
- Check CBR & compacted thickness of improved sub-grade as per design & specification.
- Check CBR & compacted thickness of sub-base as per design & specification.
- Check ratio of AS & gradation of course & fine aggregates as per design
- Check CBR & compacted thickness of base course as per design & specification.
- Check gradation of course aggregates as per design
- Check Camber of paved width & shoulder as per design & specification.
- Check longitudinal slope of paved road as per design
- Check bitumen content of carpeting as per design & specification
- Check penetration of bitumen as per design& specification
- Check thickness of carpeting of pavement
- Check setting of edging as per design & specification
- Check temperature of bitumen during heating as per design & specification
- Check mixing temperature of bitumen & stone chips as per design & specification
- Check gradation of stone chips as per design & specification
- Check mix ratio of different gradation stone chips & dust per design & specification
- Check laying temperature of carpeting on road (min 100^c) as per design
- Check rolling of carpeting by static & pneumatic roller of min 10 tons.
- Check nos, of pass over laying carpeting as per direction of E-in-charge.

xv. Bridge Approach Slope Protection

- Slope Protection work with long Routed road or embankment by Grass Turfing with 1:2 slope & as per Design.
- Slope Protection Work for High Embankment (above 4.5m)/Haor Areas/Coastal Areas by Grass Turfing with 1:1.75 slope& as per Design.
- Slope protection work with Grass Turfing & Geo-Jute on Slope for Sandy Soil with 1:2 slope & as per Design.
- Slope Protection work with grass Turfing Geo-Jute on Slope for Clayey Soil with 1:1.5 slope & as per Design.
- Slope Protection work with Grass Turfing Geo-Jute Slope for Hilly Areas with 1:2 slope & as per Design.
- Temporary Slope Protection work with gunny bagged Rip-Rap and Geo-Textile in Haor Areas/Coastal Areas with 1:2 slope & as per Design.
- Slope Protection work with Gabions in in Haor Areas/Coastal Areas with 1:2 slope & as per Design.
- Slope Protection work with Vegetation, Block and Gabions in Haor Areas/Coastal Areas with 1:2 slope & as per Design.
- Slope Protection work with Palisading and Concrete post in General road/embankment with 1:2 slope & as per Design.
- Slope Protection work with Palisading and Concrete post & Gunny Bags (Haor Areas) in General Road/Embankment with 1:2 slope & as per Design.

xvi. Social, Environmental and OHS safeguards inspection

Checklist for addressing the issues regarding activities to monitor the compliance of social, environmental, road safety, and gender development Perspectives:

Name of Subproject: UZ: Dist.: Date:

SL	Activities	Results		Remarks
		Yes	No	
A	**Social Safeguard Environmental Mitigation and Gender Development:**			
01	Labor Shed(With adequate facilities)			
02	Site office(With signboard)			
03	Safe drinking water facilities / Tube well.			
04	Arsenic testing of tube well water(if required)			
06	Temporary toilet facilities(male/female)			
07	First aid box with related medicine.			

08	Any accident/incident that happened & recorded			
09	Referral Physician in the nearby hospital. (fatal case)			
10	Land problem/dispute/ acquisition.			
11	Personal Protection Equipment (PPE)			
12	Ensure Face masks, Hand Gloves, safety boots, goggles, helmets, etc.			
13	Hand wash materials with soap, water, and a towel.			
14	Installation 2 nos. COVID-19, display sign board.			
15	Ensure 100 no's: COVID-1919 awareness leaflet and poster.			
16	Maintaining a K3 Thermometer.			
17	Roadside tree cutting and plantation.			
18	Contractor manpower as per schedule.			
19	Women Employment			
20	Wages(Equal wages for Equal work)			
21	Resting place for women and working environment.			
22	To make aware the workers of their basic facilities, duties, and rights. (informal training)			
23	Child labor engaged in work.			
24	Gender-based violence, SEA/SH (If any)			
25	**Waste disposal management.**			
	Organic bin and disposal process.			
	Inorganic bin and disposal process.			
26	**Availability of Test Results:**			
	Water			
	Air			
	Noise			
	Cement, Rod, stone, sand, Brick chips, concrete cylinder, etc.			
27	**Control of Pollution:**			
	Water spray			
	Noise monitored			
28	**Books/Registers/Minutes/Photocopy:**			

	Site order book			
	Complaint register			
	Environment Social Management Plan(ESMP)			
	GRM committee			
	Site plan(A4 size)			
	Labor Attendance			
29	**Display Sign Board:**			
	Project Sign Board.			
	COVID-19 Sign Board			
	Traffic cautionary signs & signals			
	Diversion sign board			
	Permanent sign board			
B	**Road Safety:**			
30	Safety management.			
	Typical Traffic Management Plan(TMP)			
	Customize traffic mgt. plan			
	HBB/earthen diversion road and proper sloping.			
	Fencing/protection around the construction area.			
	Diversion road as per specification.			
	Shore piling (if needed)			
	Flag men/women for trafficking.			
	Speed breaker.			
	Lighting facilities.			
	Drainage pipe			
	Guide Post			

AOB/MISC:

Recommendation/Suggestions/Actions performed:

Accomplished by:

xvii. **Accident, Incident Inspection and Reporting**

a. Initial Response & Scene Management:

Ensure Safety:

- **First Aid:** Provide immediate medical assistance to those injured.
- **Scene Security:** Secure the area to prevent further harm and preserve evidence.
- **Emergency Services:** Contact relevant authorities if necessary.

- **Document the Scene:**
  - **Photography/Videography:** Capture the scene with photos or videos, if appropriate.
  - **Sketch:** Create a sketch of the area, noting key features and positions.
  - **Note:** Document the weather conditions, lighting, and any other relevant environmental factors.

Gather Information:

- **Identify Involved Parties:** Note the names, positions, and contact details of those involved.
- **Identify Witnesses:** Gather information from witnesses, including their names and contact information.
- **Collect Evidence:** Carefully collect and preserve any relevant evidence (e.g., damaged equipment, materials).

b. Investigation:

Interview Witnesses:

Conduct interviews with witnesses to gather factual information about the incident.

Analyze the Incident:

- **Determine Root Causes:** Investigate the underlying factors that contributed to the incident.
- **Identify Contributing Factors:** Determine any environmental, human, or procedural factors that played a role.

- **Develop a Report:**
  - **Chronological Order:** Document the events in a clear and chronological order.
  - **Detailed Description:** Provide a detailed description of the incident, including what happened, where, and when.
  - **Injury Details:** Document any injuries sustained, including their severity and treatment.
  - **Recommendations:** Include recommendations for preventing similar incidents in the future.

c. Reporting and Follow-up:

- **Submit Report:**

  Ensure the incident report is submitted to the appropriate authorities or personnel.
- **Implement Corrective Actions:**

  Take action to address the identified root causes and prevent future incidents.
- **Review Risk Assessments:**

  Evaluate and update risk assessments based on the incident investigation findings.
- **Follow-up:**

  Monitor the effectiveness of corrective actions and conduct regular follow-up inspections.

d. Incident Report Checklist

- Incident Details:
- Incident Reporting Information:
- Incident Type:
- Incident Description:
- Safety and Health Implications:
- Property Damage Assessment:

- Witness Statements:
- Root Cause Analysis:

xviii. Completion Inspection etc.

I. Design & Planning:

a. Design Review:

- Verify all design documents (drawings, calculations, specifications) against relevant Bangladesh standards and regulations.
- Confirm compliance with environmental impact assessments (EIA) and other regulatory requirements.
- Ensure design meets the required load capacity, durability, and safety standards.

b. Site Survey & Geotechnical Investigation:

- Verify the accuracy of the site survey data and geotechnical reports.
- Confirm that the design considers the specific site conditions (soil type, groundwater table, etc.).
- Ensure the foundation design is appropriate for the site conditions.

c. Utility Coordination:

- Confirm that all utilities (power lines, water pipes, etc.) are relocated or protected as per design.
- Verify that there are no conflicts between the bridge structure and existing utilities.

II. Construction:

a. Material Quality:

- Ensure that all materials used in construction (concrete, steel, etc.) meet the required quality standards.
- Conduct regular material testing and inspections.

b. Construction Progress:

- Monitor construction progress against the project schedule and ensure timely completion of all stages.
- Maintain accurate records of all construction activities.

c. Safety Measures:

- Ensure that all safety measures are in place on the construction site (personal protective equipment, traffic control, etc.).
- Conduct regular safety inspections and audits.

d. Quality Control:

- Conduct regular inspections and tests to ensure that the construction quality meets the required standards.
- Address any quality control issues promptly.

III. Testing & Inspection:

a. Structural Testing:

- Conduct load tests to verify the structural capacity of the bridge.
- Perform non-destructive testing (NDT) to identify any potential defects.

b. Visual Inspection:

- Conduct thorough visual inspections of the bridge structure to identify any signs of distress or damage.
- Use specialized equipment (drones, cameras, etc.) for remote visual inspections.

c. Environmental Inspection:

- Ensure that the bridge construction has not had any negative impact on the surrounding environment.
- Conduct environmental monitoring and reporting.

d. Utility Inspection:

- Verify that all utilities are functioning correctly and are not affected by the bridge structure.
- Conduct utility inspections and tests.

IV. Handover:

a. Documentation:

- Prepare and submit all project documentation (as-built drawings, test reports, etc.) to the client.
- Ensure that all documentation is complete and accurate.

b. Training:

- Provide training to the client's personnel on the operation and maintenance of the bridge.
- Ensure that the client has all the necessary information to maintain the bridge.

c. Final Inspection:

- Conduct a final inspection of the bridge to ensure that it meets all the requirements.
- Obtain a certificate of completion from the relevant authority.

d. Project Closure:

- Close out all project contracts and ensure that all project costs are reconciled.
- Conduct a post-project review to identify lessons learned.

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