Inland Water Transport (IWT) Facility at Jogighopa, Assam

General Technical Specifications

National Highways and Infrastructure Development Corporation Limited (NHIDCL)

Project Reference: Assam IWT Terminal /NHIDCL/2020

4, Parliament Street, PTI Building,
New Delhi-110 001

COMPANY CONFIDENTIAL

Quality information

Prepared by	Checked by	Approved by
Shashank Yadav	Saurabh Sharma	J K Ahluwalia

Revision History

Revision	Revision date	Details	Authorized	Name	Position
R0	31.08.2020	-		Shashank Yadav	Engineer III
R1	07.01.2021	-		Shashank Yadav	Engineer III
R2	18.02.2021	-		Shashank Yadav	Engineer III

Distribution List

# Hard Copies	PDF Required	Association / Company Name

Prepared for:

National Highways and Infrastructure Development Corporation Limited (NHIDCL),
4, Parliament Street, PTI Building, New Delhi-110 001

Prepared by:

AECOM India Private Ltd.
3rd Floor, Tower A, Building No. 8,
DLF Cyber City, DLF Phase II
Gurgaon 122002, Haryana
India

T: +91 124 4830250

© 2021 AECOM India Private Limited. All Rights Reserved.

This document has been prepared by AECOM India Private Limited ("AECOM") for sole use of our client (the "Client") in accordance with generally accepted consultancy principles, the budget for fees and the terms of reference agreed between AECOM and the Client. Any information provided by third parties and referred to herein has not been checked or verified by AECOM, unless otherwise expressly stated in the document. No third party may rely upon this document without the prior and express written agreement of AECOM.

TABLE OF CONTENTS

1.0 GENERAL INFORMATION 1-11
1.1 Background 1-11
1.2 Site Information 1-11
2.0 GENERAL REQUIREMENTS 2-1
2.1 Application 2-1
2.2 Abbreviations and Acronyms 2-1
2.3 Units of Measurement 2-2
2.4 Reference Standards 2-2
2.5 Working Drawings 2-2
2.6 Work Covered under Contract 2-3
2.7 Site Acceptance and Mobilisation/ Demobilisation 2-3
2.8 Contractor's Design Work 2-3
2.9 Submittal Procedures 2-10
2.10 Regulatory Requirements 2-11
2.11 Environmental Requirements 2-16
2.12 Quality Management 2-26
2.13 Temporary Facilities and Controls 2-31
2.14 Product/ Materials Requirements 2-39
2.15 Tests and Standard of Acceptance 2-41
2.16 Project Execution 2-42
2.17 Design & Drawing Submissions 2-43
2.18 First Aid and Fire Protection 2-47
2.19 Execution 2-50
2.20 Floating Crafts 2-51
2.21 Cleaning and Waste Management 2-52
2.22 Submittals at Completion 2-55
3.0 SCOPE OF WORK 3-1
3.1 Description of Contractor's Scope of Work 3-1
3.2 Scope of Work 3-2
4.0 DESIGN CRITERIA OF TERMINAL WORKS 4-10
4.1 Jetty and Trestle 4-10
4.2 Shore Protection, Bund and Site filling 4-16
4.3 On-Shore Facilities 4-18
5.0 TECHNICAL SPECIFICATIONS - JETTY AND APPROACH TRESTLE 5-1
5.1 General 5-1
5.2 Concrete 5-1
5.3 Field Tests 5-11
5.4 Form Work 5-18
5.5 Exposed Concrete Work 5-23

5.6 Reinforcement 5-23
5.7 Precast Concrete 5-25
5.8 Bored Piles 5-26
5.9 Earthwork 5-35
5.10 Steel Work 5-37
5.11 Painting 5-38
5.12 Fixtures and Fittings 5-39
5.13 Marine Timbering 5-40
5.14 Bollards 5-40
5.15 Specifications for Casting 5-43
5.16 Testing 5-44
5.17 Type of Test 5-44
5.18 Fenders 5-46
5.19 Accessories 5-48
5.20 PVC Water Stops at Expansion Joints 5-51
5.21 Geotextile Material 5-52
6.0 TECHNICAL SPECIFICATIONS - ONSHORE FACILITIES 6-1
6.1 Materials 6-1
6.2 Aggregate 6-2
6.3 Sand 6-4
6.4 Steel 6-6
6.5 Bricks 6-7
6.6 Stones 6-8
6.7 Admixtures 6-8
6.8 Paint 6-11
6.9 Plain and Reinforced Concrete Works 6-12
6.10 Field Tests 6-22
6.11 Inspection and Testing of Structures 6-25
6.12 Form Work 6-28
6.13 Exposed Concrete Work 6-33
6.14 Reinforcement 6-33
6.15 Pile Foundation 6-37
6.16 Bored cast in-situ Piles 6-37
6.17 Site Grading 6-44
6.18 Material 6-44
6.19 Compaction 6-46
6.20 Road & Pavement Works 6-47
6.21 Water Bound Macadam Layers for Roads & Flexible Pavements 6-48
6.22 Earth Work in Filling 6-48
6.23 Screenings 6-52

6.24 Flexible Pavements 6-54
6.25 Bitumen Premix Carpet 6-54
6.26 Laying 6-55
6.27 Lean Concrete Base 6-56
6.28 Concrete Block Paving 6-57
6.29 Kerbs and Gutters 6-62
6.30 Construction Requirements 6-63
6.31 Traffic Markings 6-66
6.32 Construction Requirements 6-66
6.33 Storm Water Drainage 6-67
6.34 Materials 6-68
6.35 Execution 6-68
6.36 Construction of Catch Basins and Trench Drains 6-69
6.37 Concrete Work 6-69
6.38 Earthwork 6-70
6.39 Brick Masonry Works 6-76
6.40 Construction Procedure 6-77
6.41 Structural Steel Work 6-81
6.42 Steel /Aluminium Doors, Windows and Ventilators 6-86
6.43 Steel Sheet Roofing and Siding 6-94
6.44 Furnitures 6-97
6.45 Woodwork 6-98
6.46 Roofing Treatment 6-105
6.47 Plastering and Pointing 6-106
6.48 Floor Finishing 6-110
6.49 Painting 6-125
6.50 Sanitary and Plumbing Works (Buildings) 6-136
6.51 Internal Electrification Work of Buildings 6-147
6.52 Busbars 6-150
6.53 Panels/Boards' Component Equipment 6-151
6.54 Lighting System Installation Work 6-153
6.55 Ventilation System Equipment 6-153
6.56 Lighting Fitting and Accessories 6-156
6.57 Accessories for Lighting Fittings 6-158
6.58 Lamps 6-159
6.59 Earthing System 6-159
6.60 Testing and Commissioning of Electrical Equipment & Installation 6-161
6.61 Fire Fighting Works 6-163
6.62 Testing 6-166
6.63 Water Supply & Distribution System 6-166

6.64 Material 6-167
6.65 Execution 6-167
6.66 Adjacent Facilities 6-167
6.67 Sewerage Collection & Transfer System 6-168
6.68 Material 6-169
6.69 Execution 6-170
6.70 Masonry Boundary Wall 6-171
6.71 Electrical Distribution System 6-172
6.72 Design and Construction 6-185
6.73 Construction 6-200
6.74 High Mast Lighting System 6-204
6.75 Component Specification of HMSB 6-208
6.76 Engine Auxiliaries 6-214
6.77 Communication System 6-219
6.78 Public Address System 6-219
6.79 Equipment Specifications 6-222
7.0 DRAWINGS 7-1
7.1 Drawing List 7-1

LIST OF FIGURES

Figure 1.1: Proposed Location of IWT Terminal, Jogighopa, Assam 1-12

Figure 1.2: Road Connectivity in North Eastern Region 1-13

Figure 1.3: Road Connectivity at the Proposed IWT Terminal Location 1-13

Figure 1.4: Rail Connectivity in North Eastern Region 1-14

Figure 1.5: Jogighopa Climate Graph and Weather by Month 1-15

Figure 1.6: Jogighopa Average Temperature 1-16

Figure 1.7: Jogighopa Average Monthly Temperature 1-16

LIST OF TABLES

Table 1.1: Meteorological Data (1981-2010) 1-17
Table 1.2: Location of Boreholes 1-18
Table 2.1: Classification of Contractor's Documents 2-7
Table 2.2: List of Approved Vendors 2-56
Table 2.3: Minimum Furniture Quantity 2-67
Table 3.1: Deck Levels and Dimensions 3-4
Table 3.2: Building Design Parameters 3-5
Table 3.3 Details of Internal Roads 3-8
Table 3.4 Load Centres for Electrical System 3-8
Table 4.1: Design Vessel Size 4-10
Table 4.2: Superimposed Load 4-12
Table 4.3: Seismic Parameters 4-12
Table 4.4: ULS Combinations 4-14
Table 4.5: SLS Combinations 4-15
Table 4.6: Allowable Crack Width for Jetty 4-16
Table 4.7: Minimum Cover 4-19
Table 4.8: Material Specifications 4-20
Table 4.9: Material Density 4-20
Table 4.10 Live Loads on Buildings 4-21
Table 4.11: Live Loads 4-21
Table 4.12: Seismic Parameters 4-22
Table 4.13: Parameters adopted for Sewage Network Design 4-24
Table 4.14: Manhole Sizing Criteria 4-24
Table 4.15: Criteria for Manhole Spacing 4-26
Table 5.1: Proportions for Nominal Mix Concrete 5-2
Table 5.2: Grades of Concrete 5-2
Table 5.3: Values of Workability 5-4

Table 5.4: Minimum Cement Content and Maximum Water Cement Ratio for Durability 5-4

Table 5.5: Surface Water Carried by Aggregate 5-7

Table 5.6: Mixing Time 5-7

Table 5.7: Mandatory Tests on Sand & Stone Aggregates 5-11

Table 5.8: Test Requirement of Concrete 5-12

Table 5.9: Sampling Frequency 5-13

Table 5.10: Assumed Standard Deviation 5-15

Table 5.11: Minimum Design Pressure for Vertical Formwork 5-20

Table 5.12: Heavy compaction for various fill materials 5-37

Table 5.13: Testing and acceptance criteria 5-37

Table 5.14 Rubber material specifications and standards 5-47

Table 5.15 Test Requirements for PVC Water-Stops 5-51

Table 5.16 Geotextile specifications 5-53

Table 6.1: Grading of Sand 6-4

Table 6.2: Grade of Concrete 6-12

Table 6.3: Proportions for Nominal mix Concrete 6-13

Table 6.4: Values of Workability 6-14

Table 6.5: Minimum Cement Content and Maximum Water Cement Ratio for Durability 6-15

Table 6.6: Surface Water Carried by Aggregate 6-16

Table 6.7: Mixing Time 6-17

Table 6.8: Mandatory Tests on Sand & Stone Aggregates 6-22

Table 6.9: Test Requirement of Concrete 6-23

Table 6.10: Sampling 6-24

Table 6.11: Assumed Standard Deviation 6-25

Table 6.12: Minimum Design Pressure for Wall Formwork 6-30

Table 6.13: Laboratory Test Frequency 6-47

Table 6.14: Grading Requirements for Screenings 6-52

Table 6.15: Tolerances on Surface Level for Concrete Block Paving 6-62

Table 6.16: Paint for Kerbs 6-66

Table 6.17: Tiles Specifications 6-123

Table 6.18: Trench & Pipe Dimension 6-138

1.0 GENERAL INFORMATION

1.1 Background

Inland Waterways Authority of India (IWAI) is a statutory body of the Ministry of Shipping, Government of India (GoI). IWAI was set up in 1986 for regulation and development of Inland Waterways for the purposes of shipping and navigation. IWAI is primarily responsible for development, maintenance and regulation of Inland Water Transport (IWT) on the National Waterways (NWs) in the country. Presently, there are 111 national waterways (NWs) in the country.

Sadiya to Dhubri (Bangladesh Border) stretch of River Brahmaputra (891 km) was declared as NW-2 in the year 1988 and since then, IWAI has been developing and maintaining basic IWT infrastructure thereon.

IWAI has so far developed permanent RCC terminals at two (2) locations viz. Pandu / Guwahati (both high & low-level jetties) and Dhubri on NW-2. In addition, there are floating jetties at eleven (11) locations viz. Hatsingimari, Jogighopa, Pandu, Tezpur, Silghat, Biswanathghat, Neamati, Bogibeel, Sengajan, Oakland / Dibrugarh and Oriumghat.

National Highways & Infrastructure Development Corporation Limited (NHIDCL) has been entrusted with the development of 2/4 lane connectivity to these locations from the nearest National Highways (NHs). These highways shall be developed under Bharat Mala Pariyojana. NHIDCL has also been assigned the work of Development of Inland Water Transport (IWT) facility at Jogighopa (Assam) as part of Multi-Modal Logistic Park (MMLP) being developed at Jogighopa (Assam).

The layout details of the IWT Terminal at Jogighopa are shown in the **Drawing 60636525-DPR-1005**.

This call for EPC bid being addressed to potential Contractors for the Engineering, Procurement of Materials & Construction of “IWT Terminal at Jogighopa, Assam”.

1.2 Site Information

1.2.1 Site Location

The proposed MMLP at Jogighopa is one of the 35 state-of-the-art Multimodal Logistic Parks (MMLP). The Govt. of Assam has agreed to give 200 acres of land for the development of the proposed MMLP. IWAI is in possession of 143.37 acres of land along the river to the south of NH 17. Out of the 143.37 acres, only 40.7 acres of encumbrance free land is available for immediate development, while the remaining 102.67 acres is under litigation. Hence for an integrated development of the IWT Terminal, the available land of 40.7 acres will be considered. The map showing the locations of MMLP and IWT Terminal site is shown in the **Figure 1.1** below.

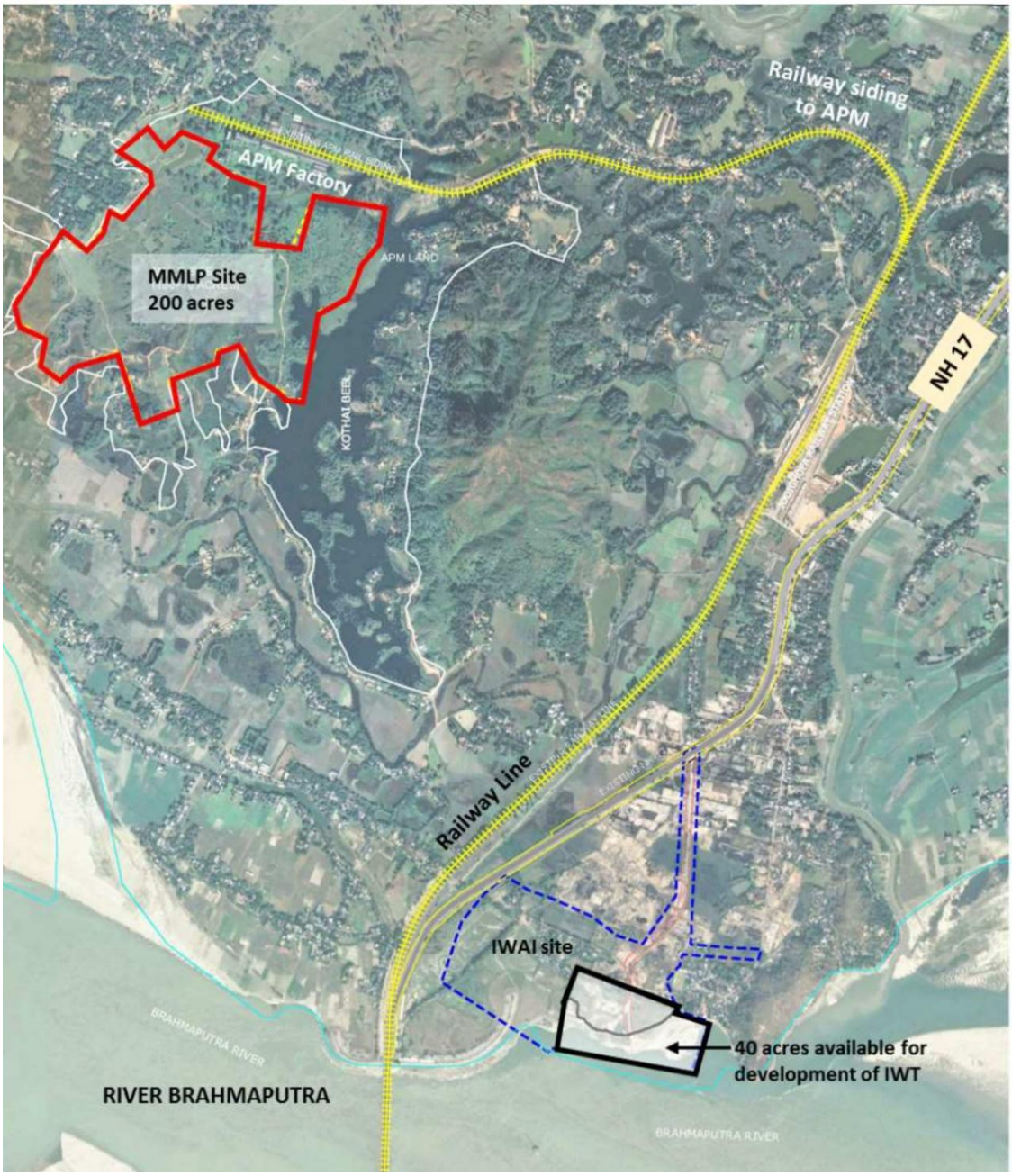

Figure 1.1: Proposed Location of IWT Terminal, Jogighopa, Assam

1.2.2 Connectivity

1.2.2.1 Road

NH-31 connects Siliguri to Guwahati in Assam, which is one of the most critical highways in the region. Additionally, 4-lane East West Corridor passes through this corridor and connects Srirampur and Silchar in Assam, covering major industrial centres. The road connectivity map with key national Highways in North eastern region & road connectivity at the proposed IWT Terminal location is presented in **Figure 1.2** & **Figure 1.3** respectively.

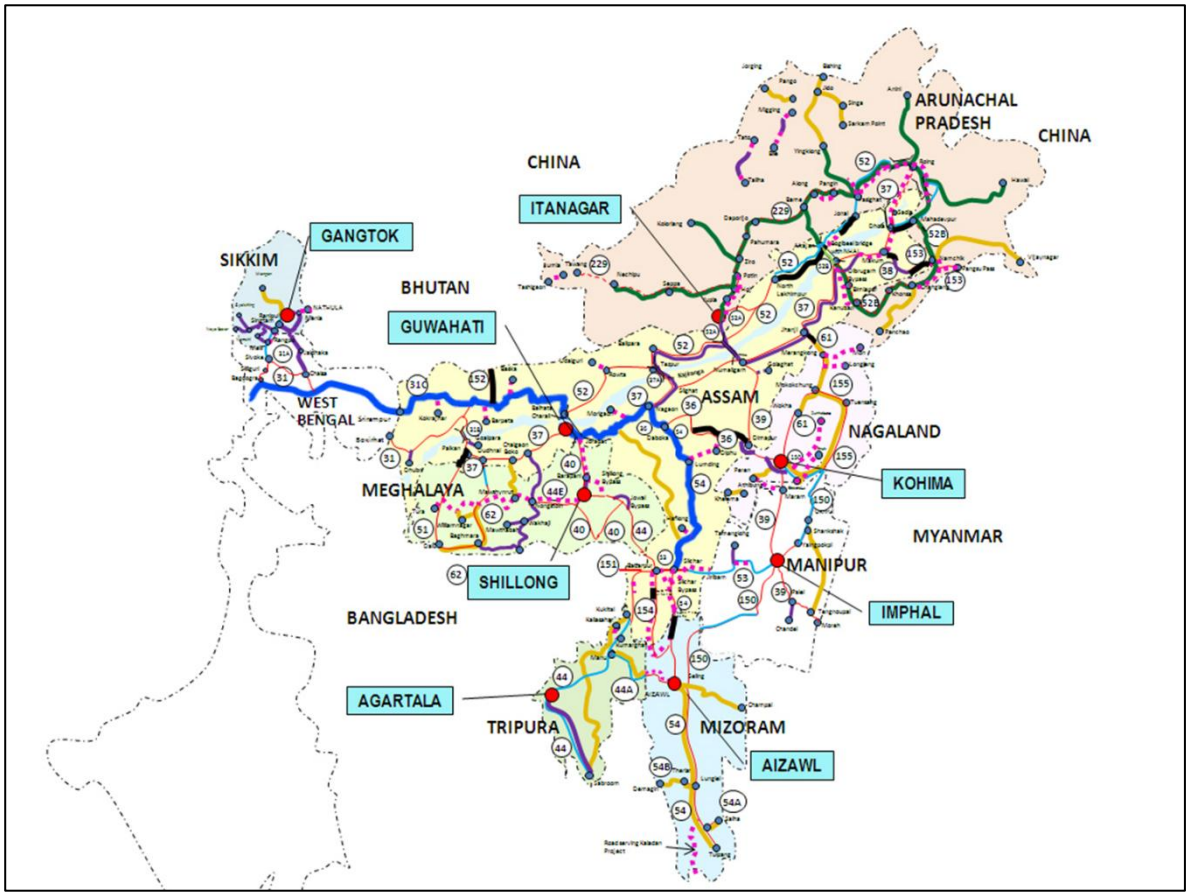

Figure 1.2: Road Connectivity in North Eastern Region

Figure 1.3: Road Connectivity at the Proposed IWT Terminal Location

1.2.2.2 Rail

A double line broad gauge line connects lower Assam to parts of Bengal and other parts of the country. The connectivity within the region is facilitated through a single line broad gauge which extends up to Tripura.

Figure 1.4: Rail Connectivity in North Eastern Region

1.2.3 Meteorological Conditions

1.2.3.1 Temperature & Rainfall

The climate in Jogighopa is warm and temperate. The summers are much rainier than the winters in Jogighopa. The average annual temperature is 24.5°C in Jogighopa.

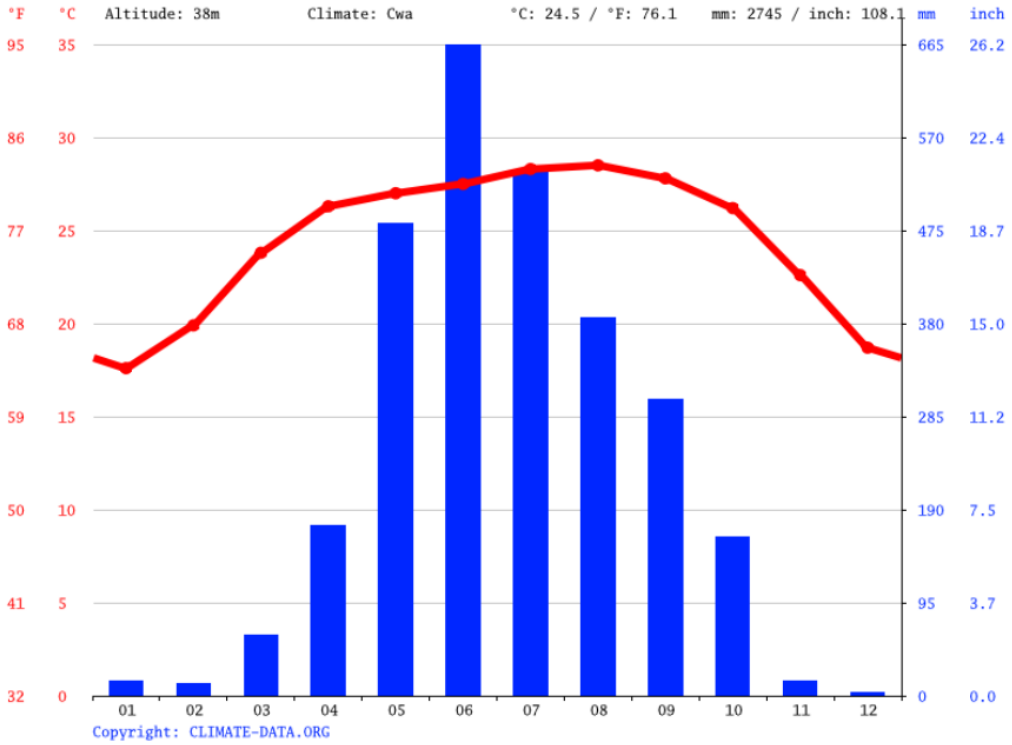

Figure 1.5: Jogighopa Climate Graph and Weather by Month
(Source: en.climate-data.org/asia/india/assam/jogighopa-174982/)

August is the warmest month of the year. The temperature in August averages 28.5°C | 83.3°F. The lowest average temperatures in the year occur in January, when it is around 17.6°C | 63.7°F. in Jogighopa. In a year, the rainfall is 2745 mm | 108.1 inch. August is the warmest month of the year. The temperature in August averages 28.5°C | 83.3°F. The lowest average temperatures in the year occur in January, when it is around 17.6°C | 63.7°F.

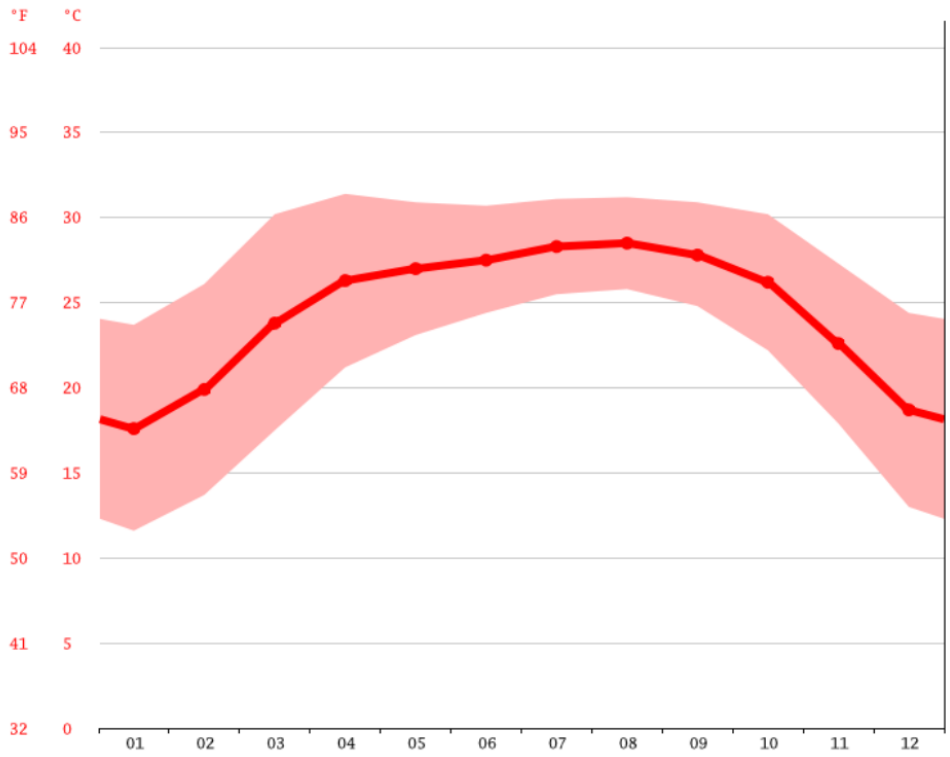

Figure 1.6: Jogighopa Average Temperature
(Source: en.climate-data.org/asia/india/assam/jogighopa-174982/)

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	17.6	19.9	23.8	26.3	27	27.5	28.3	28.5	27.8	26.2	22.6	18.7
Min. Temperature (°C)	11.6	13.7	17.5	21.2	23.1	24.4	25.5	25.8	24.8	22.2	17.9	13
Max. Temperature (°C)	23.7	26.1	30.2	31.4	30.9	30.7	31.1	31.2	30.9	30.2	27.3	24.4
Avg. Temperature (°F)	63.7	67.8	74.8	79.3	80.6	81.5	82.9	83.3	82.0	79.2	72.7	65.7
Min. Temperature (°F)	52.9	56.7	63.5	70.2	73.6	75.9	77.9	78.4	76.6	72.0	64.2	55.4
Max. Temperature (°F)	74.7	79.0	86.4	88.5	87.6	87.3	88.0	88.2	87.6	86.4	81.1	75.9
Precipitation / Rainfall (mm)	14	12	60	170	470	649	523	377	295	158	14	3

Figure 1.7: Jogighopa Average Monthly Temperature
(Source: en.climate-data.org/asia/india/assam/jogighopa-174982/)

1.2.3.2 Wind

M/s Voyants Solutions Pvt. Ltd. in JV with KPMG Advisory Services Pvt. Ltd had carried out the study of the MMLP other than IWT, and the details are obtained from the reports submitted by them. Also, they have collected the Historical Meteorological data for a period of 29 years (1981-2010) from Indian Meteorological Data (IMD) Guwahati. They collected the micrometeorological conditions prevailing in the study area by installing a Micrometeorological Monitoring Station (MMS) at top of the highest roof. The baseline meteorological data was collected as per IS: 8829 and IMD guidelines, from 20, December 2018 to 22, January 2019. Average temperature during study period is find out to be 18.99°C and average wind speed is 1.08 Kmph whereas predominant wind direction is SSE.

Table 1.1: Meteorological Data (1981-2010)

Month	Daily Mean		Relative Humidity (%)	Rainfall (mm)	Cloud Amount (Oktas)	Mean Wind speed (kmph)
	Max	Min				
January I	23.6	11	88	12	2.4	1.6
II			70		3.3	
February I	26.3	12.8	78	22.3	2.5	2.2
II			56		3.2	
March I	29.8	16.4	68	58.4	2.8	3.2
II			50		3.4	
April I	30.6	20.3	75	187.8	4.2	4
II			62		4.1	
May I	31.4	22.9	79	243.1	5.2	3.3
II			70		4.8	
June I	32.2	25.2	83	295	6.3	2.8
II			77		5.9	
July I	32.1	25.8	84	326.2	6.7	2.6
II			80		6.2	
August I	32.6	25.8	83	265.7	6.2	2.6
II			80		6.1	
September I	31.8	24.9	83	197.8	5.8	2.2
II			81		5.7	
October I	30.6	22.3	83	121.3	4.4	2.1
II			79		4.3	
November I	28	17.3	84	16	3	1.8
II			77		3.2	
December I	24.9	12.5	87	6.2	2.2	1.5
II			76		2.9	
Annual Total/ Mean I	29.5	19.8	81	1751.8	4.3	2.5
Mean II			72		4.4	
Number of Years	30	30	30	30	30	30

Source: (Vol I, DPR, MMLP study by M/s Voyants & KPMG Advisory Services Pvt. Ltd.)

1.2.4 Water Levels

The following water levels have been observed at site:

High Flood Level (HFL) - 36.65 m

Lowest Water Level (LWL) - 28.28 m

1.2.5 Hydrographic Survey Details

The hydrographic survey of river near the proposed location during August 2020 are shown in Drawing no. **60636525-DPR-1002** The report is attached as **Appendix-A** of DPR.

1.2.6 Topographic Survey Details

The topographic survey was carried out by M/s Fargo Consultants Pvt. Ltd., Kolkata in September 2020. The area behind the river bank is around 15 acres as shown in Drawing no. **60636525-DPR-1003**. The report is attached as **Appendix-A** of DPR.

1.2.7 Geotechnical Investigation Details

The site-specific geotechnical investigations at the proposed terminal location were carried out by M/s Fargo Consultants Pvt. Ltd. Kolkata. Total four (04) numbers of boreholes at the locations presented in **Table 1.2**.

Table 1.2: Location of Boreholes

S. No.	Field Marking	Northing (m)	Easting (m)
1.	BH-1	2902478.019	256967.973
2.	BH-2	2902374.181	257070.126
3.	BH-3	2902348.240	256943.497
4.	BH-4	2902254.208	257106.934

Borelog Profiles of the boreholes carried out is presented in Drawing no. **60636525-DPR-1004.**

2.0 GENERAL REQUIREMENTS

2.1 Application

These Specifications shall apply to all Works as are required to be executed under the Contract or otherwise directed by the Employer.

The Specifications must be read in conjunction with the Conditions of Contract, scope of works, design criteria, Drawings and other documents forming the Contract documents. Notwithstanding the subdivision of the Specification under different headings, every part of it shall be deemed supplementary to and complementary of every other part. The heading in these Specifications shall not be deemed to be part thereof or be taken into consideration in the interpretation or construction thereof, or of the Contract. Any provision in the draft contract agreement as part of these tender documents shall have priority over that provided in this Section 2-General Requirements.

2.2 Abbreviations and Acronyms

The following abbreviations shall have the meaning as set forth below:

ASTM	American Society for Testing and Materials
IWAI	Inland Waterways Authority of India
BS	British Standard published by British Standards Institution
CD	Chart Datum for the Project Site
CEMP	Construction Environmental Management Plan
CWMS	Construction Work Method Statement
EMP	Environmental Management Plan
HFL	High Flood Level
HAZID	Hazard Identification
SHE	Safety, Health and Environment
IS	Indian Standard published by the Bureau of Indian Standards
ISO	International Standards Organization
ITP	Inspection and Test Plan
LWT	Lowest Water Level
NCR	Non-Conformance Report
NHIDCL	National Highways and Infrastructure Development Corporation Limited
TPR	Third Party Review
PQP	Project Quality Plan
QA	Quality Assurance
QC	Quality Control
RL	Reduced Level
PIMT	Project Implementation and Monitoring Team

PMP	Project Management Plan
CPCB	Central Pollution Control Board
APCB	Assam Pollution Control Board
SEIAA	State Environment Impact Assessment Authority
MoEF&CC	Ministry of Environment, Forest and Climate Change

The Contractor shall use the above abbreviations and nomenclature on its documentation.

2.3 Units of Measurement

The SI system of units shall be used throughout for all documentation, drawings, and calculations. All dimensions shall be shown in millimetres and elevation levels in meters.

2.4 Reference Standards

The Work covered by this Specification shall comply with the latest editions and revision notes of Indian, British and other recognized International Standards as may be specified elsewhere in the Contract Documents.

The latest edition of all Standards till 30 (thirty) days before the final date of submission of the tender, shall be adopted. The Contractor shall maintain a copy of the latest editions of the Standards, Laws and Codes applicable to the work to be undertaken on site.

Indian Standards shall generally be followed. In case, any work or item is not covered by the Indian Standards, following standards shall be adopted in order of preference.

1. British Standards
2. American Standards
3. General Standards

The list of General Codes and References to be adopted for selection of materials, workmanship and design of various components have been provided under relevant **Sections.**

The Contract Documents reference to a number of codes, standards and guidelines. In some cases, these documents may be in disagreement or conflict. Where conflicts or omissions are identified, the Contractor shall notify the Employer who shall make a determination and advise the Contractor accordingly. The Employer's determination will generally adopt the most conservative or stringent requirement.

2.5 Working Drawings

Two hard copies of the Working Drawings (Good for Construction), on the basis of which actual execution of the Works is to proceed along with soft copy in dwg format, shall be furnished free of cost by the Contractor.

The Drawings provided for tendering purposes in the Tender Documents shall be used as a reference only. For Tender Drawings refer Section-8 of Volume-2.

2.6 Work Covered under Contract

The Works under this Contract are covered in Section-3 of Volume-2 (Scope of Works and General Requirements) of the Contract Documents.

2.7 Site Acceptance and Mobilisation/ Demobilisation

2.7.1 Acceptance of Site

In accordance with these specifications, the Contractor shall have examined the site and familiarised himself with all existing conditions. He shall accept the site on “as is where is” basis at the time of award of the Contract.

2.7.2 Mobilisation

Upon award of the Contract and within a reasonable time but not exceeding 2 months the Contractor shall mobilise all such labour, equipment and materials that are necessary to complete the project in due time.

2.7.3 Demobilisation

Upon due performance of the Contract and before the Taking Over Certificate is issued to the Contractor, he (the Contractor) shall demobilise all such labour, equipment and materials that are necessary to clear the site within one (1) month to the Employer’s satisfaction.

2.7.4 Access

The Contractor shall provide and maintain adequate access to the project site and all areas related to the works at his expense. If existing roads are to be used for access to the site, the Contractor shall maintain such roads for the duration of their use.

2.7.5 Permits and Licenses

Except as expressly stated in the Employer’s Responsibilities, the Contractor shall obtain all permits and licenses necessary for the execution and completion of the Works. The Contractor shall pay all associated fees including royalty. He shall also give the Employer a copy of all relevant correspondence and other documents relating to the Contractor’s permits and licenses.

2.8 Contractor’s Design Work

2.8.1 General

It is the Employer’s intent that the Contractor will analyze the Employer’s Requirements thoroughly and use their full creativity to complete the design. The Employer intends to allow the Contractor maximum flexibility to design and produce a set of full, thorough and state-of-the-art, sustainable facilities and infrastructure.

The Employer has provided the Employer’s Requirements as part of the tender documents. These documents are intended to provide the Contractor with sufficient information so as to clearly understand the Employer’s intent, goals and objectives in execution of the works. The Contractor will be required to adopt the general concepts, as provided, and expand and develop the same to

produce complete, thorough, comprehensive and high quality designs, working drawings, and specifications for review and approval by the Employer. While developing the complete and final designs and specifications, the Contractor shall review the concepts design and planning for betterments or improvements which may be incorporated to better achieve the Employer's goals and objectives, and which may result in overall improved functionality. These betterments, if any, shall be submitted by the Contractor to the Employer for review and for the approval, before the final designs are completed.

2.8.2 General Design Obligations

The Contractor shall prepare the full and complete design and drawings for the Works as per the Contract.

2.8.3 Design Method Statement

Prior to the commencement of any design works, the Contractor shall submit to the Employer for approval, as part of the 120-day Preliminary Program, a Design Method Statement as outlined below describing how he intends to manage, control, programme and carry out the necessary design work in accordance with his obligations under the Contract. It will include:

(a) The proposed design organisation.

(b) Programme of the design work.

(c) A Design QA/QC plan, certification and procedures.

(d) An integrated schedule of staged/segmented, sequential design, construction and supporting activities that results in the earliest possible completion and Employer's Taking-Over of complete Works.

For each stage, the Contractor will submit a design package that has all of the elements/components required for 100% design of the stage. All planning documents, calculations, applicable codes and specifications, design guidance and ready-for-construction drawings with complete construction details, must be included.

2.8.4 Design Requirements

Design requirements are contained in multiple parts of the Contract Documents. The Contractor shall scrutinize all of the documents to ascertain all of the design, design process, design quality and design management requirements for inclusion in the Design Method Statement.

The Contractor shall be deemed to have scrutinized, prior to the Commencement Date, the Design Criteria, Specifications and Drawings and all subordinate and supporting documents. The Tender Documents contain concept design drawings and specifications provided by the Employer. The Contractor shall use these concept drawings and specifications provided and develop them further in parts and in the whole to full and final design, ready for construction purposes. The Contractor shall be responsible for the design and specifications of the whole of the Works. They are also responsible for the redesign and re-specification of all parts of the Works described in the Tender issued by the Employer that are affected in any way by the designs of the Contractor, and for the accuracy of that part of the Specifications and the Drawings relating to such design (including design criteria and calculations).

The Employer shall not be responsible for any error, inaccuracy or omission of any kind in the Design Criteria, Concept, Specifications or the Drawings as originally included in the Contract and shall not be deemed to have given any representation of accuracy or completeness of any data or information, except as stated specifically. In the event of, finding a discrepancy, difference or conflict between documents, then the resolution, thereof, shall be interpreted and applied to the benefit and in favour of the Employer. Any data or information received by the Contractor, from the Employer or otherwise, shall not relieve the Contractor from his responsibility for the full, thorough and complete design of that part of the Works to be designed by the Contractor as required under the Contract and for the execution of the Works.

The design calculations shall be written in English. In case any software is utilised to perform the calculations, a sample set of manual calculations with references of various formulae used shall also be submitted for proper verification.

2.8.5 Contractor's Designer(s)

The Contractor shall carry out, and be responsible for, the full and complete design of the Works. Design shall be prepared by a qualified design firm following criteria of having complete the design of following works in a single or different projects, which have been constructed in past 10 (ten) years ending last day of month previous to the Tender Due Date.

(a) Detailed design of jetty/ wharf/ berth designed for the berthing of Handymax vessels

or

(b) Detailed design of jetty/ wharf/ berth designed for the berthing of Barges upto 3,000 tonnes in riverine condition.

The design firm is also required to meet the following eligibility conditions:

(a) The design firm must be a Company with a registered office in India and must have GST, PAN, and ESI / EPF Registration as applicable by Law.

(b) The design firm shall not be a Joint Venture or a Consortium.

(c) The design firms who are blacklisted or De-barred by central or state governments and other government institutions and the blacklisting/debarment as applicable on the date of submission of tender, are not eligible.

(d) The consulting fee received for qualifying projects shall be atleast INR 50 Lakhs or more.

Within 30 days of Commencement Date, the Contractor shall submit the credentials of design firm, who shall carry out the design works for this contract. The following shall be submitted for the approval of the Employer;

(a) Profile, details and experience of the design organisation.

(b) Completion certificates confirming that the design firm meets the qualification criteria as mentioned in A203.5.1

(c) Full and detailed CVs of persons proposed to be deployed.

The appointment of the design firm by the contractor shall be subject to the specific written approval of the Employer.

The Contractor warrants that he, his design firm, designers and design Subcontractors, if any, have the experience and capability necessary for producing a complete, thorough and quality design that meets or exceeds all Employers Requirements and complies with all applicable codes. The Contractor is required to ensure that the key personnel of the design firm shall be available to attend meetings and/or discussions with the Employer, as may be required by the Employer, until the expiry of date of the relevant Defects Notification Period.

2.8.6 Contractor's Documents

All Contractors' Documents shall be submitted to the Employer for review in accordance with the procedures outlined herein and in accordance with the requirements of the Conditions of Contract.

The Contractor shall prepare all and any Contractor's Documents and shall also prepare any other documents necessary for successful completion of the Works with required quality and within established and approved schedules. Such preparation shall include review (including Third Party Review, detailed below), verification and warranting of the Contractor's Documents by Designer(s), approved by the Employer as specified above. The Employer shall have the right to inspect the preparation of these documents, wherever they are being prepared.

Contractor's Documents shall comprise the following items and any other documents that may be requested by the Employer:

(a) Design Basis

(i) This document shall provide all information which the Contractor intends to use as the basis for preparation of approvals, construction drawings, monitoring and construction specifications.

(ii) This document shall also detail the design parameters for each Material to be used in the work and shall include preliminary testing results which verify that the available Material is in accordance with the proposed design parameters.

(b) Detailed Design, Construction Drawings and Specifications

(i) The design shall include full design calculations and construction drawings and shall provide the full and detailed design of the Works showing the Contractor's application of the Employer's Requirements and any other data the Contractor reviewed or obtained, including details of any proprietary products to be used.

(ii) The design shall include clear details of any acceptance criteria, Tolerance limits and settlement triggers, deflections, crack width etc.

(iii) The construction drawings shall be the drawings which the Contractor intends to use for the construction of the Works.

(iv) The specifications shall be the specifications which, when read in conjunction with the drawings, shall describe the materials and workmanship to be used for the construction of the Works.

(c) Testing and Monitoring Regime

(i) The Contractor shall submit with each part of his design, details of the testing regimes that he will implement to demonstrate that the As-Built Works comply with his design.

All Contractors' Documents shall include revision numbering and issue dates.

As part of the Contractor's 120-day Preliminary Programme, and the subsequently detailed and maintained DTP, the Contractor shall submit all Contractor's documents required as per Employer's Requirements, the DMP and other documents as required or directed by the Employer. All design submissions will have been identified and contained in the Design Method Statement.

2.8.7 Design Review

The Employer through PMC will provide a high level review of the detailed design to be undertaken by the contractor. If on structural review by the Employer the design is found to be acceptable, then the Employer will issue a notice of no objection.

The Employer's review is for general compliance with the criteria, scope of work and intent of the Contract in accordance with the Specifications and the Drawings. The Employer's high level review may not cover the technical or engineering part of the Contractor's Documents. The Contractor remains solely and totally responsible for the thoroughness and quality of the Contractor's Documents.

2.8.8 Classification of Contractor's Documents

Following review of the Contractor's Documents, the Employer shall reply to the Contractor with a classification of the Contractor's documents as follows:

Table 2.1: Classification of Contractor's Documents

Classification Category	Definition	Action by Contractor
1.	The Contractor's Document is acceptable without comment.	Contractor may proceed with construction.
2.	The Contractor's Document is acceptable subject to changes or clarification requested by the Employer.	The Contractor shall make the changes requested prior to commencement of construction.
3.	The Contractor's Document is unacceptable for the reasons given by the Employer. Construction work shall not commence.	The Contractor shall revise the document and re-submit to the Employer for further review.

2.8.9 Third Party Reviewer (TPR)

All technical design submittals (designs, drawings, calculation, 2D/3D model, study reports etc. in paragraph above) prepared by Contractor shall be thoroughly reviewed and approved by the TPR prior to submission to the Employer. The TPR shall be an institution of International Repute subject to the approval of the Employer, at no additional cost to the Employer.

The scope, roles and responsibilities of the TPR shall be submitted by the Contractor and approved by the Employer. These primary roles and responsibilities should include, but not be limited to:

(a) Thorough review of all design, technical and specification documents provided from the Contractor design team. The Contractor, at his own discretion, can determine how best to utilise the services of the TPR to maximize efficiency and completeness while maintaining schedule integrity.

(b) The TPR shall endeavour to ensure that the proposed designs and specifications meet the goals and objectives of the Project. The review will also include detailed review for functionality, quality, form and fit, safety, efficiencies, interfaces, technical adequacy and solutions, relationships to adjacent systems and structures, cost effectiveness, sizing, sustainability, etc. Additionally, improvements, if any, shall be noted.

(c) Specifications review to ensure that the technical specifications are properly coordinated with the design, properly describe the components and material to be incorporated into the design and facilities, provide enough and proper detail for the bidders to understand the requirements, and are otherwise thorough and complete.

(d) Identify, review and validate all applicable technical, regulatory and referenced codes and specifications to ensure compliance.

The Contractor will ensure proper and effective coordination of the TPR including related review conferences which may include some combination of the following:

(a) Traditional review - Contractor submits design documents to the TPR and stops work while the review process occurs for each segment/phase of the Contractor's design submission.

(b) In-progress review - Same as traditional review except the Contractor continues design effort while the TPR reviews.

(c) On-board review – TPR and the Contractor visit the activity to review the design documents submitted by Contractor; designated on board/ in progress, or on board/ traditional depending on whether or not the Contractor continues or stops work while the TPR reviews.

If through TPR or other means, it is determined by the Employer that the design is inadequate and deficient and not meeting project goals and objectives, the Employer, will require the Contractor to immediately provide a resolution and correction plan, that will ensure mitigation of the deficiencies and achieve the design quality and standard as required by contract.

The Contractor will account for all TPR reviews and follow-ups in the Contract Programme.

It will be the responsibility of the Contractor, acting in a professional capacity, to ensure accuracy, completeness, and correctness of the design, cost estimate and all engineering concepts and details of the work, including coordination of the various architectural, civil, structural, mechanical, electrical, and other subdivisions thereof with each other and with the specifications.

The Contractor shall establish a review comment capture, tracking, status, responsibility, and resolution tool software (such as MS Excel) that will be used by the TPR, but in any case, TPR shall input all required details (timely and accurately) into the PMIS.

2.8.10 Design Review Process

The Contractor shall submit to the TPR all elements of the Contractor's Documents prior to commencing any work on Site.

Submissions shall be made in stages to the TPR/Employer appropriate to the Contractor's design development and in accordance with the agreed programme.

After the TPR's review achieves a category "2" status, the Contractor's Documents shall be subject to review by the Employer, in accordance with the requirements stated above.

Unless otherwise stated in the Employer's Requirements, each review period shall not exceed 21 days, calculated from the date on which the Employer receives a Contractor's Document and the Contractor's notice. This notice shall state that the Contractor's Document is considered ready, both for review (and approval, if so specified) in accordance with this sub-clause and for use. The notice shall also state that the Contractor's Document complies with the Contract, or the extent to which it does not comply. No extension of time shall be considered for any delay related to this review. No work shall start on site until the TPR/Employer's reviews achieve category "2" status.

If at any time, the Contractor makes a change to any Contractor's Documents, the Contractor shall re-submit the Contractor's Document for further review and the above procedure shall again be adhered to.

The Contractor shall acknowledge and accept any designs which were not prepared by the Contractor and which form part of the Contractor's Documents and takes responsibility for such designs as if they were prepared by the Contractor.

All submissions shall be in electronic format (AutoCAD + working calculation files plus record copy in PDF format) and hardcopy. The design submission shall include detailed design calculations, results / recordings of all investigation works, and detailed drawings.

The Employer may, within the review period, give notice to the Contractor that a Contractor's Document fails (to the extent stated) to comply with the Contract. If a Contractor's Document so fails to comply, it shall be rectified, resubmitted and reviewed again (and, if specified, approved), at the Contractor's cost and time.

2.8.11 Quality Review

The Contractor is required to implement a highly effective and thorough QA/QC program as stated in subsequent paragraph. The Contractor will ensure that the final design is complete and thorough and meets all quality standards as contained in the Contractors Quality Management Plan and meets the Employer's Requirements.

Examination and/or approval by the Employer of any drawings or other documents submitted by the Contractor shall not relieve the Contractor of his obligations, responsibilities or liabilities under the Contract.

If the Employer instructs that further Contractor's Documents are required, the Contractor shall prepare them promptly.

Nothing done or omitted by the Employer shall relieve the Contractor of his duty or responsibilities or liabilities under the Contract.

2.8.12 Contractor's Undertaking

The contractor shall undertake that the design of that part of the Works to be designed by the contractor will be in accordance with:

(a) The Laws, Regulations and Codes of the Country;

(b) All documents forming the Contract; and

(c) All MoEF&CC requirements and obligations.

The Contractor shall be responsible for the completion of the design of the Works, and when the Works are completed for ensuring, that they are fit for such purposes for which the part or whole is intended as are specified in, or implied by, the Contract. Nothing done or omitted by the Employer shall relieve the Contractor of his duty or responsibilities or liabilities under the Contract.

2.8.13 Technical Standards and Regulations

The design of the Works to be designed by the Contractor shall comply with the country's technical standards, building, construction and environmental laws, laws applicable to the product being produced from the Works and other standards specified in the Employer's Requirements, applicable to the works, or defined by the applicable laws.

If changed or new applicable standards come into force in the Country after the prescribed dates mentioned in Employer's Requirements, the Contractor shall give notice to the Employer and (if appropriate) submit proposals for compliance. In the event that:

(a) The Employer determines that compliance is required,

(b) The proposals for compliance constitute a Variation, and

(c) Then the Employer shall initiate a Variation in accordance with relevant Clause.

2.8.14 Design Error

If errors, omissions, ambiguities, inconsistencies, inadequacies or other defects are found in the Contractor's Documents, they and that part of the Works to be designed by the Contractor shall, subject to the approval of the Employer, be corrected at the Contractor's cost and time, notwithstanding any consent or approval under this Clause.

2.9 Submittal Procedures

2.9.1 General

All Communications submitted by the Contractor as defined in the Conditions of Contract shall have a unique sequential reference number to facilitate tracking of the Contractors submissions and correspondence by the Employer.

Contractor's submission shall be made in both hard and native soft copy format to the Employer, as specified or requested by the Employer. The cost of submissions to the Employer in all formats shall be deemed to have been included in the Contract Price.

2.9.2 Requests for Information

Where the Contractor requires additional information or clarification in order to carry out the Works, or where he identifies any ambiguity or inconsistency in the Contract Documents, he shall immediately submit to the Employer a Request for Information (RFI). The response for RFI shall normally be given within seven (7) days after receiving the same.

The Request for Information forms shall be provided with a sequential number or reference to facilitate tracking by the Employer.

2.9.3 Notice to the Employer

Unless specified otherwise elsewhere in this Specification, the Contractor shall give the Employer not less than 24 hours' notice in writing of the intended time for commencement of any construction activities to enable the Employer to make his arrangements for the inspection of operations on the Site.

The Contractor shall also give the Employer not less than thirty (30) days' notice in writing of the commencement of any preparation, construction or manufacturing activity occurring at the manufacturer's or supplier's site, or at a location not within the manufacturer's or supplier's site, of any article or material to be used in the works, whether by the Contractor or any Subcontractor, stating the time and place of the works such that the Employer may make his arrangements for the supervision or inspection of such works at the manufacturer's or supplier's site.

2.10 Regulatory Requirements

2.10.1 Permits, Permissions and Statutory Approvals

The Contractor shall comply with all statutory obligations and regulations of relevant Authorities or services or utility providers, or any other relevant body or organization with authority or jurisdiction in India relating to the execution of the Works.

Where any conflict arises between the requirements of the various relevant authorities, the more stringent provision shall apply subject to the agreement of the relevant authorities.

The Contractor shall allow sufficient time in his programme for the issue of any statutory notices by the relevant Authorities which may be required prior to the commencement of the relevant Works. The Contractor shall provide the Employer with documents of evidence that the relevant Authorities have been notified of the proposed Works in accordance with relevant regulations and ordinances.

The Contractor shall give notice to the relevant Authorities at least one month or as appropriate to get the necessary approvals in advance of commencement of any new activity and shall keep the relevant Authorities regularly informed of the Works. The Contractor shall liaise with the relevant Authorities to give all information on working areas, types of plant and durations of activities, deemed necessary by the Authorities. The Contractor shall if required, also advice the Authorities on completion of each and every separate activity. In particular, at least one months' notice shall be given to the Authorities for the removal or relocation of any navigation affected by the Works.

The Contractor shall identify the permissions and submissions that are required by the regulatory Authorities for the performance of the Works. Where required, the Contractor shall prepare and submit to the relevant Authorities for their endorsement details of the proposed construction sequence and methods to be employed on the Works and an action plan as required in the Contract. No construction work shall be commenced prior to the endorsement and approval of the relevant submissions by Authorities. In this respect the Contractor shall note that the Authorities' requirements may include the submission of the following for their approval at least one month in advance of the commencement date of the Works.

- Detailed plans of the landside and riverine Works showing the proposed overall limits of the working area(s) and the space requirements of each of the operations.
- List of all personnel who would be working at site.

- Name of the person(s) in charge of the Works who can be contacted by the relevant Authorities on a 24-hour basis and means and procedures to contact them.
- Proposed schedule of all Works carried out under the Contract indicating different types of operations, their number, duration, space requirements and phasing.
- A full description of the method for all work activities including the number and type of plant / craft to be employed, together with a complete list of vessels and craft to be used for all types of marine Works.
- Details of weather conditions in which operations would cease and all working river craft would be removed from the working area; Other as may be required.

Health Safety & Environment permits, and all related issues are the responsibility of the Contractor. All correspondence between the Contractor and relevant Authorities including all submissions shall be copied to the Employer. All environmental permitting issues will be dealt through Employer.

2.10.2 Health and Safety Requirements

2.10.2.1 General

The Contractor shall comply with all health and safety requirements of the Contract including statutory requirements, requirements of Assam State Government Department, requirements stipulated, and any reasonable direction issued by the Employer's safety department or authorized personnel of the Employer from time to time. The Contractor shall document, implement and maintain a safety system complying with international standards acceptable to Employer.

All works shall be carried out in a safe manner and free from any danger and shall comply with the relevant Laws regarding safety of the Works.

The Contractor shall take all precautions necessary to protect the health and safety of persons where works may expose workmen and other persons on, or within the vicinity of the site, to conditions which are dangerous or potentially dangerous to health, including the noxious effects of dust, fumes, liquids, infection, fire, explosion, or other hazards. Any identified hazard posing risk of bodily harm to personnel or property damage shall be rectified immediately.

2.10.2.2 Health and Safety Manager

The Contractor shall have in place a qualified experienced and proactive Health and Safety Manager approved by the Employer prior to commencing the Works. The Contractor's Health and Safety Manager shall have good communication skills (written and spoken). The officer so designated shall be made known to all employees by the posting of his name, designation and photograph in prominent positions on Site. Provision shall be made to provide adequate communication with all members of the work force.

The Health and safety Manager in addition to Employer, or any Employer's representative, shall have full written authority from the Contractor to stop work in the event that he deems necessary or any condition which may pose 'Imminent Danger to Life and Health' (IDLH) to any person or safety. He/she shall be fully familiar with pertinent safety requirements and policy as contained in statutory requirements, the Employer HSE Plan, the Contractor's HSE Plan, and any other regulatory document pertaining to safety in the workplace in India.

2.10.2.3 Health and Safety Management Plan

The Contractor shall prepare and submit for approval a Health and Safety Management Plan (HSMP) complying with the requirements of the Contract, the Employer's HSE Plan, and international best practice and with Indian and local laws and regulations and which shall be implemented throughout the Works. The plan shall describe the responsibilities and procedures for all aspects of the safety management on the Works and shall be capable of regular audit throughout the course of the Works.

The Contractor shall submit the HSMP to the Employer within 28 days of the Contract Commencement Date or at least 14 days prior to the intended commencement of any permanent Works under the Contract, whichever is the earlier. The Employer will take maximum 14 days for issuing comments (if any) to be incorporated by the Contractor.

The resolution of such comments on the HSMP submission to the satisfaction of the Employer and the subsequent acceptance of the HSMP by the Employer shall constitute a Hold Point on the commencement of any permanent Works under the Contract.

2.10.2.4 The Contractor shall ensure its HSMP include

- Safety Policy Statement of Senior Management and a project responsibility matrix;
- Normal protocols for personnel requiring access into and out of working areas;
- Emergency plans (in line with existing Emergency and Disaster Management Plans for the project) for all identifiable potential incidents such as fires, foundering, oil spills and the like;
- Requirements for routine internal safety audits;
- Drills frequency and type. Drills shall be separated into those required for statutory or insurance purposes and additional drills proposed for the Works. Vessels and crew training shall meet the safety requirements of the Contract and all applicable regulatory requirements or as indicated by Central, State or Local Government statutory authorities and bodies;
- Emergency evacuation procedures, lifeboat and evacuation drills and other emergency response equipment;
- Certification of crane drivers/vessel operators, in full compliance with Indian requirements;
- Job Hazard Analysis. The Contractor shall provide written working procedures, directions including Job Hazard Analysis or Job Safety Analysis (JHA/JSA) and undertake drills on all equipment in order to ensure the safe and timely execution of the Works. JHA/JSA, procedure revisions and drills shall be ongoing during the course of the Works according to a programme approved by the Employer and set out in the Health and Safety Management Plan; Based on JSA and anticipated risks, mitigation measures for activities planned, based on hierarchy of control will be developed and submitted to Employer for approval;
- Work over and on water specific risks and mitigations;
- Firefighting and emergency breathing apparatus;

- Hazardous and explosive materials register and storage;
- Project specific Contractor's site safety instructions for Contractor's Personnel, Employer's Personnel Visitors;
- Any onshore or offshore activities which cannot be undertaken 24 hours per day due to safety or other constraints;
- Accident / Near Miss investigation procedures;
- Competency testing;
- Employee training;
- Toolbox Meetings, Work Area Inspections; Signage, First Aid facilities and trained personnel;
- Equipment lock out procedures;
- Confined space access procedures;
- Auditing frequency;
- Reporting;
- Contractors Anti-Child Labour Policy or statement.

2.10.2.5 Training

All personnel shall be suitably qualified, experienced and trained by the Contractor for the equipment or duty that they are engaged on.

A sufficient number of the Contractor's employees who speak the language of the State/region shall be fully qualified in first-aid so that first- aid will be immediately available in case of accident at any time and at any place throughout the Site and any off-site camps, housing or other facility. The persons so designated shall be made known to all employees by the posting of their name, designation and photograph in prominent positions on Site. Such first-aiders or medical service providers shall be trained.

2.10.2.6 Substances Hazardous to Health

The Contractor shall not use or generate any material in the Works which are hazardous to the health of persons, animals or vegetation. Where it is necessary to use some substances, which can cause injury to the health of workers/environment, the Contractor shall provide protective clothing or other appliances for security of his workers or requisite control measures to prevent effect on environment, as approved by the Employer.

2.10.2.7 Safety Audits

The Contractor's Head Office personnel qualified and experienced to do so, shall undertake audits of the site management performance and project operations during the Works in order to evaluate the degree of compliance of the Contractor's site operations to the Contract requirements for Health and Safety.

Audits shall be undertaken by an audit team. The audit team shall consist of the Contractor's Head Office Representative (team leader), a Representative of the Employer and Employer. An audit agenda based on the Contractor's commitments will be prepared and agreed prior to the audit.

Any audit shall follow the normal procedure for this type of activity with an Entry Meeting, the Audit and a Close-out Meeting where preliminary findings will be discussed directly with the Contractor's project staff. An audit report shall be prepared and agreed by the audit team. Non-compliances shall be actioned by the Contractor.

Based on the audit, the audit team will issue an audit report, indicating the site Health and Safety Performance based on performance indicators as internationally acceptable in the industry. The Audit report will also have corrective and preventive action plan based on risk grading. The contractor is to develop the findings closure plan and issue a compliance report fortnightly based on findings and severity.

Contractor shall routinely audit the use of training aids and drills and provide training and direction to the project management staff and to all supervisors and crews.

The Contractor's head office personnel shall arrange regular audits of all project management personnel against documented company procedures and Indian Occupational Health and Safety Law and Regulations.

The Employer shall be entitled to hold a Health and Safety audit of the Contractors safety procedures and the practices on site at any time with no notice. The contractor shall provide all required assistance to the Employer in this respect including access to appropriate information, site areas and personnel. The costs of this assistance shall be borne by the Contractor and no delays shall be attributable to such audit activities. Such audits will be undertaken quarterly or six monthly as per Employers discretion.

2.10.2.8 Incidents and Accidents

Incident and Accident reporting and statistics shall be undertaken to the relevant Indian Standard, Employer's and Contractor's requirements.

The Contractor shall send, to the Employer, details of any accident on or about the Site or in connection with the execution of the Works, as soon as practicable and, in any event within 24 hours after its occurrence. The Contractor shall also report such accident to the appropriate Authority whenever such report is required by the Laws. In the case of any fatality or serious accident, the Contractor shall in addition notify the Employer immediately by the quickest available means. Investigation techniques of Root Cause Analysis (such as Five Why, Causal tree Analysis or Fish bone Analysis, etc.) shall be used by the Contractor.

If an accident results in an injury to an employee or damage to equipment or release of hydrocarbons from the vessel or requires evacuation of personnel from floating equipment, oil spill clean-up, subsequent hospitalization of any individual or major repairs to equipment the Contractor shall arrange for a qualified independent third party investigation and report. The third party investigator shall be approved by the Employer.

A preliminary report shall be prepared and submitted to the Employer within 24 hours and a detailed report shall be submitted within seven (7) calendar days of the occurrence of the accident or incident. Should any construction activity need to stop work for:

- The duration of the investigation, attendance of witnesses etc.;
- Modifications to safety plan, Job Safety/Hazard Analysis;
- Modification and validation of work procedures;
- Government Agency inspections and procedures;
- Any other reason;

All costs associated with the delay shall be at the cost of Contractor.

The Contractor's attention is drawn to the likelihood that any downtime resulting through loss of life, limb or other serious accident or incident may be considered as prima facie evidence that the Contractor's Works and Safety Management Plan and or Environmental Management Plan procedures and recruitment and training system are inadequate and/ or deficient. The Employer and other Agencies may require a complete reworking and independent audit of the Contractor's safety system and job safety analysis sub elements and environmental protection procedures. The cost of such delays and reworking of procedures caused by such activities will be at the cost of Contractor.

2.11 Environmental Requirements

2.11.1 General

The Contractor shall take all precautions for safeguarding the environment during the course of the execution of the Works. He shall abide by all laws, rules and regulations in force governing pollution prevention/abatement and environmental protection that are applicable in the area where the Works are situated/ carried out.

The Contractor is bound to strictly adhere to the Environmental and Social Impact Assessment (ESIA) shared by the Employer. Any violation to the ESIA requirement shall incur a fine of one thousand (Rs. 1000) for the first violation, second violation will attract a fine of ten thousand rupees (Rs. 10,000) and the third violation onwards can lead to a fine of fifty thousand rupees (Rs. 50,000) followed by Termination of Contract.

The Contractor shall observe and comply with all environmental requirements (including all applicable laws, regulations and any requirement of any relevant Authority (central/state or regional regulatory authority) and any directions of the Employer), the requirements of the Environmental Clearance and other Permits for the permanent Works as held by the Employer and any other requirements that apply to the Site generally.

The Contractor shall apply for and obtain Environmental Permits as applicable for the execution of the Works from the relevant Indian Authorities (central/state or regional regulatory authority) before commencing work on site. The Contractor shall submit a copy of such Permissions / Approvals obtained by him for the execution of Works.

The Contractor shall consider all Site conditions and adopt pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment. The principles and techniques applied during the Works shall be tailored to the hazards and risks associated with the nature of the task and consistent with applicable regulatory requirements and Best Management Practices (BMP) as appropriate.

The Contractor shall implement effective measures for improving efficiency in its consumption of energy, water, as well as other resources and material inputs during the execution, with a focus on areas that are considered for Work activities.

The Contractor will avoid the release of pollutants or, when avoidance is not feasible, minimize and/or control the intensity and mass flow of their release in compliance with regulatory requirements. This applies to the release of pollutants to air, water, and land due to routine, non-routine, and accidental circumstances with the potential for local, regional, and trans boundary impacts (if any). In case of any contamination (soil/groundwater/marine), Contractor shall be responsible for adequate clean-up (remediation) in consultation with Employer.

The Contractor shall be responsible for any environmental impact(s) due to its operations and shall be liable to undertake remedial measures in consultation with the Employer//regulatory authorities as the case may be.

2.11.2 Ecological Balance

The Contractor shall maintain ecological balance by preventing de-forestation, water pollution and defacing of natural landscape. The Contractor shall so conduct his construction operation as to prevent any unnecessary destruction, scarring, or defacing of the natural surroundings in the vicinity of the Work. In respect of the ecological balance, Contractor shall observe the following instructions.

(a) Where unnecessary destruction, scarring, damage or defacing may occur, as result of the operation, the same shall be repaired replanted or otherwise corrected at the Contractor's expense. The Contractor shall adopt precautions when using explosives, which will prevent scattering of rocks or other debris outside the work area. All work area including borrow areas shall be smoothened and graded in a manner to conform to the natural appearances of the landscape as directed by the Employer.

(b) All trees and shrubbery which are not specifically required to be cleared or removed for construction purposes shall be preserved and shall be protected from any damage that may be caused by the contractor's construction operation and equipment. The removal of trees and shrubs will be permitted only after prior approval by the Employer. Special care shall be exercised where trees or shrubs are exposed to injuries by construction equipment, blasting, excavating, dumping, chemical usage or other operation and the Contractor shall adequately protect such trees by use of protective barriers or other methods approved by the Employer. Trees shall not be used for anchorages. The Contractor shall be responsible for injuries to trees and shrubs caused by his operations. The term "injury" shall include, without limitation bruising, scarring, tearing and breaking of roots, trunks or branches. All injured trees and shrubs be restored as nearly as practicable without delay to their original condition at the Contractor's expense.

(c) The Contractor's construction activities shall be performed by methods that will prevent entrance or accidental spillage of solid matter contaminants, debris and other objectionable pollutants and wastage into river. Such pollutant and waste include earth and earth products, garbage, cement concrete, sewage effluent, industrial wastes, radio-active substances, mercury, oil and other petroleum products, aggregate processing, mineral salts and thermal pollution. Pollutants and wastes shall be disposed-off in a manner and at sites approved by the Employer.

(d) In the conduct of construction activities and operation of equipment's the Contractor shall utilize such practicable methods and devices as are reasonably available to control, prevent and otherwise minimize the air pollution. The excessive emission of dust into the

atmosphere will not be permitted during the manufacture, handling and storage of concrete aggregates and the Contractor shall use such methods and equipment as are necessary for collection and disposal or prevention of dust during these operations. The Contractor's methods of storing and handling cement shall also include means of eliminating atmospheric discharges of dust. Equipment and vehicles that give objectionable emission of exhaust gases shall not be operated. Burning of materials resulting from clearing of trees, bushes, combustible construction materials and rubbish may be permitted only when atmospheric conditions for burning are considered favourable.

(e) Separate payment will not be made for complying with the provisions of this clause and all cost shall be deemed to have been included in the unit rates and prices included in the Contract. If any provision is not complied with within a reasonable time even after issue of a notice in this respect, the necessary operations would be carried out by the Employer at the cost of the Contractor, Orders of the Employer in this respect would be final and binding on the Contractor.

2.11.3 Preservation of Existing Vegetation

The Contractor will preserve and protect all existing vegetation such as trees, on or adjacent to the Site which do not unreasonably interfere with the construction as may be determined by the Employer. The Contractor will be held responsible for all unauthorized cutting or damage of trees, including damage due to careless operation of equipment, stockpiling of materials or trekking of grass areas by equipment. Care shall be taken by the Contractor in felling trees authorized for removal to avoid any unnecessary damages to vegetation and tress that are to remain in place and to structures under construction or in existence.

All the produce from such cutting of trees by the Contractor shall remain the property of Government and shall be properly stacked at site, approved by the Employer. No payment whatsoever shall be made for such cutting and its stacking by the Contractor. If any produce from such cutting is not handed over to the Government by the Contractor, he shall be charged for the same at the rates to be decided by the Employer. The recovery of this amount shall be made in full, from the intermediate bill that follows.

The Contractor shall also make arrangements of fuel deposits for supply of required fuel for the labourer to be employed for cooking purpose at his own cost in order to prevent destruction of vegetation growth in the surrounding area of the work site.

2.11.4 Construction Environmental Management Plan (CEMP)

The contractor shall submit a Construction Environmental Management Plan within 28 days of the Contract Commencement Date or at least 14 days prior to the intended commencement of any permanent Works under the Contract, whichever is the earlier. The Employer will take maximum 14 days for issuing comments (if any) to be incorporated by the Contractor.

2.11.5 General Environment Management

Permits: Contractor, in consultation with Employer, shall ensure that all applicable Permits/Licenses/Certificates/No Objection Certificate required for construction works shall be obtained prior to commencement of works.

The Contractor shall ensure that applicable Permits (as and when applicable) are obtained well on time and provide copy of application submitted along/or with license obtained to Employer. The Contractor shall ensure that the permits are valid at any given point of time.

2.11.6 CEMP shall include the following:

Adequate precautions shall be taken during transportation of the construction material so that it does not affect the environment adversely.

All the recommendations mentioned in the EIA/EMP shall be implemented.

The Contractor shall undertake monitoring of various aspects through an agency approved by MoEF&CC / CPCB / APCB or as defined in the permits obtained by the Contractor and furnish reports to the Employer.

Notification of Accident/Incident: APCB shall be kept informed of any accident of unforeseen act or event as a result of such water or air is being polluted.

If noise and gaseous pollutants exceeds permissible limits, the Contractor shall propose and implement mitigation plan as per approval of the Employer.

The Contractor must take all reasonable steps to minimize dust nuisance during the construction of the Works.

Any structural damage caused to the existing roads by the Contractor's construction equipment shall be made good by the Contractor without any extra cost to the Employer. The wheels of the vehicles which are carrying construction material / demolished material are to be cleaned before entering the main road.
Dumping of debris in or nearby water bodies shall be strictly avoided. Waste products shall be collected, stored and taken to approved disposal sites as per norms.

Noise, Vibration, pollution measuring instruments to be calibrated properly and certificates to be produced while conducting test.

2.11.7 Air Emissions Management

The Contractor must take all reasonable steps to minimize dust nuisance during the construction of the Works.

All existing roads used by vehicle of the Contractor or any of his sub-contractors or suppliers of materials or plant, which are being used by traffic, shall be kept clean of all dust/mud or other extraneous materials dropped by the said vehicles or their tyres. Similarly, all dust/mud or other extraneous materials from the Works spreading on these roads shall be immediately cleared by the Contractor.

Clearance shall be affected immediately by manual sweeping and removal of debris, or, if so directed by the Employer, by mechanical sweeping and cleaning equipment, and all dust, mud and other debris shall be removed entirely from the road surface. Additionally, if so directed by the Employer, the road surface shall be hosed or watered using suitable equipment and adequate records of same shall be maintained.

Compliance with the foregoing will not relieve the Contractor of any responsibility for complying with the requirements of all relevant authorities in respect of the roads used by him.

Monitoring plan developed as part of CEMP shall include the following elements on air emissions management.

- Monitoring to be for PM2.5, PM10, SO_2, Pb and NOX carried out at one station in the project site.
- Data on ambient air quality shall be submitted to the IWAI and other regulatory and statutory bodies as directed by the Employer.
- Monitoring shall be done twice a week, 4 weeks in a season (except monsoon) during construction.
- Procedure for regular monitoring should be installed to ensure that emissions from DG sets are well below the prescribed emission standards for DG sets.
- The Contractor shall maintain logbooks to reflect working condition of Pollution Control Devices (PCDs) and also self-monitoring results and keep it open for inspection.

The Contractor shall ensure sprinkling of water on roads or Project area where general dust emission is high, especially if the construction area is near the residential areas.

Procedure for selection of construction vehicles/ machinery and maintenance shall be developed by the Contractor and shall include the following:

- Vehicles are to be attached with latest pollution control measures and shall comply with relevant IS. Pollution Under Check (PUC) certificate of all vehicles to be maintained and kept.
- Ensure vigorous maintenance and stringent overhauling to minimize gaseous exhaust fumes of dumpers, shovel and other heavy machineries. Develop preventive maintenance schedule of vehicles and submit compliance status at six monthly intervals.

2.11.8 Air Quality Monitoring

Air Quality monitoring in Construction areas shall be undertaken by the Contractor in compliance with EIA guidelines.

Respirable dust sampler with gaseous sampling attachment to be used for sampling of air for PM2.5, PM10, SO_2, NOx for a period of 24 hours duration. Sampling analysis will be carried out as per IS-5182:1999, Indian Standards for measurement of air pollution.

2.11.9 Water and Waste Water Management

2.11.9.1 Water Usage

Contractor shall ensure the following for water usage in general for domestic and works:

There shall not be any groundwater drawl within CRZ area. Provision for water from other sources other than groundwater shall be ensured. No ground water is to be utilized for any construction activity.

2.11.9.2 Industrial Effluent Management

Workshop effluents: Effluents generated by servicing of the vehicles contain pollutants such as suspended solids, oil & grease. Oil and grease trap shall be provided to such effluents.

Settling tanks shall be provided for cleaning the wastewater from the site workshop.

Effluent shall be discharged only to the place mentioned in the CEMP or else effluent to be discharged only on land after treatment for sprinkling or horticulture within the site. No discharge in the sea or any other receptor shall be undertaken until or unless permitted by the APCB.

Water Quality Monitoring: The Contractor shall engage an APCB/CPCB/MoEF&CC approved laboratory to undertake monitoring.

2.11.9.3 Noise Management

2.11.9.3.1 General Requirements

Installation and operation of Diesel Generator (DG) set shall comply with the guidelines of CPCB. DG Installation Certificate from Electrical Inspectorate shall be obtained.

Acoustic enclosures shall be provided to control noise levels. Necessary Acoustic enclosures or measures to control noise levels generated from the DG sets shall be installed by the Contractor as per Environment Protection Rules, 1986 and subsequent amendments. In case DG set is manufactured before 2005, the Contractor shall ensure acoustic enclosure conforming to CPCB requirements.

Ambient noise levels should be strictly maintained within the standards by adopting appropriate techniques.

Exposure time of the workers to the higher noise level shall be reduced.

Steps shall be taken to control noise levels so as to maintain ambient air quality standard in respect of noise as laid down in Air (Prevention and Control of Pollution) Act, 1981. Regularly monitoring and maintaining DG sets (six monthly) shall be done and it shall be ensured that the noise level does not reach outside the site premises.

Regular preventive maintenance shall be undertaken, and records maintained.

2.11.9.3.2 Noise Monitoring

Adequate measures shall be taken for control of noise levels below 85 dB(A) in the work environment.

Noise generated in the premises shall be within the prescribed limit 75 dB(A) during day and 70dB required during night time.

Ambient noise quality monitoring shall be carried out.

While installing any new DG set (manufactured after January 2005), the maximum permissible sound pressure shall be 75dB(A) at 1m from the enclosure surface.

Compliance with standards stipulated shall be followed for ambient noise.

Noise levels to be monitored between 06:00 a.m. and 10:00 p.m. for daytime and between 10:00 p.m. and 06:00 a.m. for night-time.

The Contractor shall ensure use of vehicles/ equipment with lessor noise pollution potential which shall include the following (but not be limited to) the following:

- Construction techniques and machinery shall be selected to minimize noise.
- The Contractor shall use equipment and vehicle that are in good working order, well maintained and have noise suppression equipment (e.g. Mufflers, noise baffles) intact and in working order.
- Construction vehicles to be used shall not emit noise greater than 90 dB (A).

The Contractor shall ensure that the siting of construction machinery/equipment shall comply with the following:

- At construction sites within 150 m of human settlements, if any, noisy construction shall be stopped between 10:00 pm and 6:00 am, unless specific approval is granted by the Employer.
- Noise producing sources such as the concrete mixers, generators, etc. shall be provided with noise shields around them. The noise shields can be any physical barriers, which provide adequate attenuation of noise levels.

2.11.9.3.3 Waste Management (including hazardous waste)

The Contractor shall implement procedures and processing to pursue a goal of “zero” waste discharge from his construction activities. This will require that the Contractor employ sustainable concepts and practices including recycling, re-use, segregation, and others to minimize, if not eliminate, material and substances into the waste stream. General Measures to include but not be limited to the following:

- There shall not be any disposal of effluent/solid waste etc. into the sea.
- Solid waste shall be segregated from hazardous waste/municipal solid waste and stored separately till treatment/recycling, re-use.
- All solid waste generated from the construction and domestic activities shall be collected, treated and disposed in such a manner so as not to cause environment pollution.
- If no other use is identified for construction waste, it shall be dumped in selected pits, developed on infertile land, if approved by the Employer.
- Solid Waste generated at sites are to be collected and processed for recycling/re-use wherever possible. Disposing it off landfill site should only be a last resort.
- Selection of disposal sites shall be carried out in consultation with APCB, revenue department and forest department in order to ensure that no natural drainage, productive lands or natural habitat is adversely impacted due to disposal of waste.
- Segregation of biodegradable and plastic wastes shall be done.

2.11.9.3.4 Marine Environment Management

Under no circumstances shall, materials including construction debris from the Works under the Contract, be allowed to pollute, or fall into any river, creek or sea. All such material shall be promptly recovered and removed by the Contractor at no cost to the Employer. Floating debris within the site arising from any source shall be collected and disposed appropriately by the Contractor at regular intervals as agreed by the Employer. Floating debris shall be prevented from dispersing outside the Project Site limit.

The Contractor shall keep the Employer indemnified against the cost of any clean-up due to pollution of the marine environment or any Socio-economic and other aspects management.

No explosives shall be used in construction works. The Contractor shall develop management system as part of CEMP, which shall include:

- Implementation and communication procedures.
- procedure for submission of monthly report on number of complaints received, number of days of resolution, pending complaints and associated reasons for pendency.

During the construction phase, the proposed construction activity shall be notified by the Contractor, as per the direction of the Employer. Prior to commencement of construction activity, local residents and fishermen shall be advised about the installation, period of installation and associated activities.

Socio-economic aspects: The Contractor shall take into consideration the following socio-economic aspects:

- Use of local labour to the maximum extent
- Use of district hospital for medical facilities.
- Complaints received by locals or other evidence of illegal harvesting. Illegal wood/vegetation harvesting to be recorded.
- Providing drinking water to workers,
- Providing personal hygiene and first aid facilities,
- Preference to local villagers for non-skilled jobs subject to their willingness.
- Should not cause any hinderance to local population.

The Contractor shall ensure strict compliance of all applicable labour laws of centre/ state government by developing procedures (covering subcontractors also):

- Provision of minimum wages for construction workers as per the Assam State Government norms.
- Ensure that the movement of fishing boats or fishermen communities shall not be disturbed during operation of the project.

2.11.9.3.5 Monitoring

Monitoring of aspects as detailed in this Document shall be undertaken.

The Contractor shall develop a detailed monitoring plan as part of CEMP and the guidelines of MoEF&CC.

All the equipment utilized for monitoring shall be duly calibrated as per approved QA Plan of the Contractor.

Monitoring standards to be followed are detailed under detailed Standards and Formats of Reporting. The Contractor shall ensure that for monitoring parameters, where national/ regional/ local regulatory requirements are silent, and compliance with the baseline values as detailed in the EIA undertaken for the Project are compared. Compliance shall be determined for such aspects based on baseline changes.

2.11.9.3.6 Organisation Structure

The Contractor shall ensure appointment of competent Environmental Officer(s), who shall work in coordination with Employer, and his staff, for effective environment management and implementation of CEMP.

The Environmental Officer(s) shall be responsible for:

- Preparing CEMP specific to work type and submit to the Employer for review prior to commencement of work;
- Ensuring compliance with regulatory framework and best practices as identified in the CEMP;
- Obtaining all pertinent environmental permits and approvals prior to commencement of work onsite after due approvals from Employer;
- Conduct continual checks for validity of environmental permits and approvals and obtain necessary extension(s) in advance so as to ensure smooth flow of work;
- Ensure compliance with environmental monitoring as prescribed in Annexure-Check off list, assess data, maintain records and generate timely reports for further submission to the Employer;
- Conduct regular checks for compliance against management measures and address environmental concerns onsite. Additionally, report any noncompliance to the Employer;
- Provide training to working staff and initiate sensitization sessions on environment practices to be followed onsite for effective environment management; and
- Inscribe corrective action measures into existing environment management structure and ensure compliance to the same with approval from the Employer.
- Actively participate in Environment Management Cell meetings and provide status of implementation of Construction Environment Management Plan, associated monitoring activities, difficulties/ issues in implementation, other aspects of importance, etc.
- Working with and through the Employer, liaise with APCB, District Collector and other agencies on all matters concerning pollution affecting establishments and units.
- Coordinate activities towards award of environment protection incentives.
- Meet regularly with the Employer, and/or his staff, and Employer as requested. The Employer shall organize regular coordination meetings for passing of information, reporting of issues, review of current and upcoming events, status of open issues, coordination and reporting of environmental concerns, reports, notices, etc. and other matters relating to the Project and environmental aspects of the same.
- Adequate funds shall be earmarked for implementing Environment Management Plan in a time-bound manner. The budget allocated shall not be diverted for any other purpose. Capex earmarked for implementation of CEMP shall be submitted as part of six monthly reports for review to Employer.

He/she shall be fully familiar with pertinent safety requirements and policy as contained in statutory requirements, the Employer HSE Plan, the Contractor's HSE Plan, and any other regulatory document pertaining to safety in the workplace in India.

2.12 Quality Management

2.12.1 Quality Management Program Requirements

The Contractor shall be responsible for all quality management in the planning and execution of the Works. The quality management shall cover all stages of work such as setting out, selection of materials, selection of construction methods, selection of equipment and plant, deployment of personnel and supervisory staff, quality control testing, etc.

The Contractor shall be responsible for the following work under the quality provisions of this Contract:

- Implementing their corporate Quality Management System and providing evidence of third party assessment and endorsement;
- Developing and implementing an effective and comprehensive Project Quality Plan (PQP) to cover all Works under the Contract, whether permanent or temporary both on-site and off-site;
- This PQP shall be submitted to "The Employer" for his/her review and approval prior to using in the contracted Works. The Contractor shall make changes and adjustments to the PQP as recommended by the Employer.
- Operating, maintaining and reviewing the Project Quality Plan and associated quality management system procedures; and
- Keeping Quality Records in accordance with Project Quality Plan.

2.12.2 Project Quality Plan

The Contractor shall prepare a project specific Project Quality Plan in line with his Corporate Quality System. The PQP shall be Contract-specific and shall include specific quality practices, resources, activities and responsibilities relevant to the Contract Works.

The Contractor shall submit the PQP to the Employer within 45 days of the Contract Commencement Date or at least 14 days prior to the intended commencement of any permanent Works under the Contract, whichever is earlier. The Employer will take maximum 7 days for issuing comments (if any) to be incorporated by the Contractor.

Detailed Quality Procedures for each element or item of work must be submitted to the Employer for review at least four weeks before that work is due to commence. Detailed Quality Procedures are required for all items manufactured prior to delivery to site.

The resolution of such comments on the PQP submission to the satisfaction of the Employer and the subsequent acceptance of the PQP by the Employer shall constitute a Hold Point on the commencement of any permanent Works under the Contract.

2.12.3 System Element Procedures

Quality System Procedures shall be prepared to meet the requirements of Employer's Quality Plan. These Procedures and Instructions shall be submitted to the Employer for approval 14 days prior to the commencement of the relevant activity.

2.12.4 Hold Points & Witness Points

Hold Points are those points beyond which the work may not proceed without review and comment by the Employer.

Witness Points are those points beyond which the work may not proceed without approval of the Employer.

As a minimum requirement, the specified Hold Points shall be included in the Inspection and Test Plans where identified in the technical Clauses of the Specification by the words "to the approval of the Employer", "Employer for Approval", "and "agreement of the Employer" or similar.

The Employer may nominate additional Witness and Hold Points in the Contractor's Inspection and Test Plans.

Where Hold Points are nominated, no work shall proceed unless agreed by the Employer.

For avoidance of doubt, the review by the Employer of any Hold Point or Witness Point will not relieve the Contractor of any responsibility for the satisfactory execution or performance of the work that is the subject of the review.

2.12.5 Documentation

In addition to the documentation required by ISO 9001, copies of all relevant Codes of Practice, Test Methods and Standards referred shall be kept on Site.

2.12.6 Inspection and Test Plans (ITPs)

Inspection and Test Plans (ITP's) shall be prepared for each of all on- site and off-site construction activities/processes for which the Contract requires inspections of test to be performed. ITPs shall describe all inspections and tests required, the criteria for acceptance and the person in charge and responsible for each inspection or test. ITPs shall note any Hold Points or Witness Points that require the Employer's approval or presence.

Proforma ITPs shall be submitted to the Employer for review and approval within 14 days (unless specified otherwise) before the subject operation/activity is first undertaken. Operations which are subject to inspection or test shall not commence until the relevant ITP is accepted by the Employer.

The ITPs shall cover all inspection and testing required by the Contract and shall include surveying and measuring verification processes, as well as sampling procedures. All quality control laboratory tests shall be performed in accordance with the relevant Indian or other standards approved in writing by the Employer for the relevant test. Test reports shall be certified by an approved signatory.

The ITPs shall clearly state the times within which each activity will be completed. All test reports shall be made available immediately on its receipt. Failure to produce satisfactory test reports within the specified time may be considered to demonstrate that the work to which the test report relates is unsatisfactory, and remedial work may be ordered to be undertaken forthwith.

2.12.7 Sampling and Testing

All sampling and testing required by the Contract or instructed by the Employer shall be carried out only by such independent commercial testing facilities as may be approved by the Employer.

The Contractor shall submit to the Employer the name(s) of the independent commercial testing facilities that are proposed. The submission shall contain such data as is necessary to fully demonstrate to the Employer that (each) such testing facility is adequately equipped, supervised and staffed and has relevant previous experience. The testing facility shall obtain the accreditation from the National Accreditation Board for Testing and Calibration Laboratories (NABL) for the relevant tests unless otherwise approved by the Employer, and where appropriate, shall be on a list approved by the relevant Authorities. The Contractor's submission shall also include the lists of sampling and tests proposed to be undertaken by the testing facility (or facilities) together with a statement for each test regarding whether it is to be executed at the testing facility or elsewhere (including on Site). In the latter case, and for all sampling, attendance of personnel from the testing facility shall be provided during the sampling and/or execution of the test. Once any testing facility has been approved in writing by the Employer, it shall be appointed by the Contractor and then will be termed an Approved Laboratory for the tests listed within such approval.

The Contractor may propose to undertake testing at the Field Laboratory on Site, provided these meet all the above requirements, and in particular that the testing facility is operated, managed and staffed by independent commercial testing company. Should the Employer at any time be dissatisfied with the quality of testing carried out at the testing facilities established on Site, he may require such tests to be performed at a permanent independent commercial testing facility away from the Site until such time as the Contractor can demonstrate to the Employer‘s satisfaction that the necessary improvements have been made at the testing facilities on Site.

Should the Contractor have reasonable cause to change testing facilities, he may propose an acceptable alternative to the Employer. Should the Employer at any time have reasonable cause to be dissatisfied with the performance of any Approved Laboratory, he will so inform the Contractor who shall propose an acceptable alternative independent testing facility. In either case, after receiving written approval of the new testing facility (and upon completion of any test or series of tests already committed) the Contractor shall make the necessary change in appointment. Costs, if any, of or associated with any such change shall be borne by the Contractor.

The management of each Approved Laboratory shall nominate in writing the person or persons who are authorized by them to sign test reports, and a copy of this authorization shall be sent to the Employer. No test report shall be accepted by the Employer as valid without the signature of a person whom the Employer has been informed in writing, is so authorized to sign test reports from that Approved Laboratory.

Where tests or other samples are required to be made, prepared or selected, such work as is necessary to cut or otherwise make or prepare the selected specimen(s) shall be executed by the Contractor under the supervision of the Approved Laboratory unless specifically agreed otherwise by the Employer. If any test or sample preparation, making or selection proceeds without such supervision they shall not be accepted and the work re-executed. The Employer shall be notified prior to the carrying out of such work so that he can be present. The Employer may also instruct that the Contractor carry out additional sampling or testing in order to verify that the requirements of the Contract are being met.

The Employer shall reserve the right to carry out his own independent sampling and testing for the purposes of cross–checking and verification of the Contractor's sampling and testing. The Contractor shall provide all reasonable access to the Works for the Employer to carry out such independent sampling and testing. Where the findings of the Employer's independent sampling and testing indicate a non-conformance with the Contract Requirements, the Contractor shall immediately raise a Non-Conformance Report covering the work represented by the non-conforming results.

Any additional sampling or testing related to replacement of damaged or lost samples, to the methods of working or construction, to previously failed tests or any other cause whatsoever, shall be executed by an Approved Laboratory.

The Contractor shall clearly identify methods of sampling and testing and the party or parties responsible in the ITPs for the relevant construction activity.

2.12.8 Storage of Samples

Where samples are required by the Contract, the Contractor shall provide and maintain a suitable facility or facilities to temporarily store such samples on Site. The samples shall be kept as long as the Employer requires, and then taken to an Approved Laboratory for testing and/or disposed of, by the Contractor.

2.12.9 Inspection

The Contractor shall provide the Employer with access to all laboratories and other facilities used for quality control tests such that it can be verified that the specified requirements are being met.

2.12.10 Identification and Traceability

All test samples shall be marked with a unique reference and in a manner such that the reference will not be erased or otherwise lost prior to testing. Should it not be appropriate for the samples to be immediately collected by the Approved Laboratory, the Contractor shall deliver them to an approved sample store(s) on Site. Such sample store(s) shall be provided and maintained by the Contractor. The Contractor shall provide and maintain within the sample store(s), all necessary racks and/or equipment and keep them in good repair.

All quality records shall be traceable from the Inspection and Test Procedures to the deliverable set.

2.12.11 Records

The Contractor shall generate quality records covering all construction / execution activities.

Conformance records shall be stored and maintained such that they are readily retrievable in facilities that provide a suitable environment to minimize deterioration or damage, and to prevent loss. Records shall be retained progressively and handed over completely, within four weeks of the issue of the Taking-over Certificate for the completed Works.

Conformance records shall be available at all reasonable times, and copies provided within 24 hours of receipt of the test results.

2.12.12 Non-conformance

The Contractor shall notify the Employer of any product or service non-conformance. Notification shall be submitted as Non-Conformance Reports (NCR) and shall indicate the proposed method of rectification and shall be subject to acceptance by the Employer. Additionally, the Employer may require the Contractor to raise an NCR for any work that is in the opinion of the Employer not in conformance to the requirements of the Contract. The Contractor shall prepare Standard forms for use as Non-Conformance Reports; the format of these forms shall be agreed with the Employer prior to the Works.

Work which is the subject of a Non-conformance Report shall not be covered prior to inspection and agreement with the Employer.

2.12.13 Surveillance and Audit

The Employer, or his representative, shall carry out Quality Surveillance and Audits (scheduled and unscheduled) to ensure conformance to the requirements of the Contract. These will involve system element audits, product and service audits, and process and technical procedure audits.

The audits to be undertaken will be in addition to the Contractor's audits and will not relieve the Contractor of its responsibilities under the Contract. The Employer will carry out audits in accordance with ISO 19011:2011 at times to be determined by the Employer. The Contractor will be given at least five (05) days' notice that a quality audit is to be carried out. The Contractor shall provide or arrange to be available all necessary facilities, documents etc. including Sub-Contractors etc. for audits.

2.12.14 Sub-Contractors

The Contractor shall be fully responsible for integrating all Sub-Contractors' Quality Systems into its own Quality System or alternatively for arranging for the Sub-Contractor to work within a Quality system developed and provided by the Contractor.

The Contractor shall be the single point of responsibility for the production, implementation and auditing of the Quality System required under the Contract.

2.12.15 Improper Certification of Unsatisfactory Work

If the Contractor or its personnel repeatedly confirms/declares a work as being satisfactory when such work is not satisfactory, the Employer may reject such work any time during the Contract and instruct the Contractor to re-execute such work in full or a part thereof without any implication to the Employer. In case of improper certification and/or Contractor's failure to rectify, the Employer may proceed as per the Contract including termination of the Contract.

2.12.16 Submission and Certification of Construction Documents

The Contractor shall submit a Design Certificate (in duplicate) and Design Check Certificate, whenever he is submitting Construction Documents to the Employer for review. Construction Documents submitted without the relevant Design Certificate will not be reviewed.

The Contractor is to ensure that all Construction Documents submissions are in a form that enables the Employer to review the Construction Documents as required by the Contract without delaying completion of the Works.

2.12.17 Certificates for Work Item Completion

Readily identifiable Work Items must be certified as checked and found satisfactory by:

(a) Contractor's surveyor responsible for checking, and

(b) Contractor's supervisor responsible for checking temporary works, material cleanliness, dimensions (not checked in (a) above), workmanship and all other matters to enable him to certify that the item of work complies in every respect to the Contract.

The Work Item Completion Certificate shall be checked and approved by the Contractor's Quality Manager.

Each Work Item Completion Certificate must be identified by a unique and appropriate reference number.

If the Employer is not satisfied with the works have been carried out satisfactorily as certified, the Employer shall raise a non-conformance report to which the Contractor shall respond stating his proposals for rectifying the non-conforming item and what action will be taken to prevent recurrence. The Employer may reject such work any time during the Contract and instruct the Contractor to re-execute such work in full or a part thereof without any implication to the Employer. In case of recurrence/failure of the Contractor to rectify, the Employer may adjust the Contract price by deducting value of such work.
Any consequences in respect of any revisions arising out of Work Item Completion Certificates being returned with comments shall not be treated as a compensation event.

2.12.18 Certificates for Activity Completion

When a section of work has been completed satisfactorily, the Contractor shall certify that the activity has been completed in accordance with the Contract.

The Activity Completion Certificate shall be checked by the Contractor's Quality Manager and confirmed by the Contractor. The Designer's Representative shall also certify that the activity has been completed in conformance with the relevant Construction Documents and the Employer's Requirements.

The Activity Completion Certificate shall list the reference numbers and dates of Work Item Completion certificates that have been relied upon by the signatories to the Activity Completion Certificate.

Each Activity Completion Certificate shall have attached to it, copies of any materials test certificates which were received after signing the relevant Work Item Completion Certificates and which have not been submitted to the Employer under separate cover during the period between the signing of the Work Item Completion Certificate and the preparation of the Activity Completion Certificate.

2.13 Temporary Facilities and Controls

2.13.1 Contractor's Site Establishment Plan

The Contractor shall design, install and maintain all temporary facilities required for the construction of facilities under this Contract Package, which he requires on or at the site throughout the execution of the work, and remove the same on completion of the works. He shall provide all such buoying, fencing, watching, lighting, connections to public utilities etc. as he needs or as required by

authorities and shall install and use his temporary facilities in accordance with all statutory regulations and the requirement of the relevant authorities.

The Contractor shall submit his own Site Establishment Plan to the Employer for approval at least thirty (30) days prior to the commencement of any site establishment, temporary or any other Works under the Contract.

This submission shall include confirmation of the Contractor's intended date for the commencement of site establishment and any other site work.

The Contractor's Site Establishment Plan shall include details of the proposed facilities including but not limited to the following items:

- General layout of site fencing (8 m high fencing), site access points, stacking and storage of construction material, other security arrangements;
- General layout of construction facilities including the Contractor's field offices, sheds, sanitary and first aid facilities and Field Laboratory;
- Details of arrangements for emergency access/egress and evacuation points;
- General layout of work areas, batching plant, casting yards, fabrication or coating workshops, if Contractor's Work Plan defines onshore casting/fabrication/coating;
- Dust protection measures from adjacent bulk stockpiles of materials; and;
- All other details relating to the site establishment as required under the Contract or by any relevant authority.

The approval of the Site Establishment Plan by the Employer shall constitute a Hold Point on the commencement of site establishment, temporary or any other Works under the Contract.

Labour camp, and stone crushing plant are not allowed inside the Project Site.

Any request by the Contractor to change the agreed proposals shall be subject to the agreement of the Employer.

The Contractor shall submit details of any temporary works associated with the Works.

The Contractor's local office, his own working area and all the Contractors Works shall be subject to compliance with IWAI established guidelines and applicable local authorities' rules and regulations.

2.13.2 Permissions and Permits

The Contractor shall at all times comply with the latest requirements of:

- Navigation, Shipping and Rules;
- IWAI;
- Marine Oil Pollution Management Plan;
- Marine Oil Pollution Contingency Plan;
- Emergency Response Plan;

- Cyclone Contingency Plan;
- State and National Environment Regulations.

The Contractor shall obtain advance approvals from the required authorities prior to executing the Works.

The Contractor shall make all arrangements with and obtain the necessary approvals from the Relevant Authorities for temporary riverine traffic arrangements and control.

The Contractor shall install and commission temporary structures, as directed by the Employer, to ensure the safety of the Contractor's riverine plant and the continued safe operation of the waterfront.

2.13.3 Navigational Aids

During the time of work, the Contractor shall not interfere with shipping and navigation or other traffic activities around the IWT site.

The Contractor shall provide all temporary and navigational aids, markers, lights and notices required for the works or required by law, regulations, and all authorities having jurisdiction over the area covered by the work on land or at river. The Contractor shall replace at his own expense/cost any navigational or other facilities damaged by Contractor or his sub-contractors.

2.13.4 Marking of Landside Works

The Contractor shall exhibit such marks and keep illuminated during the darkness hours near the various parts of the Works as the relevant authorities or the Employer may from time to time require or approve.

2.13.5 Temporary Utilities

It is the responsibility of the Contractor to arrange and obtain permission from the relevant Authorities for the installation, connection and disconnection of temporary services and utilities such as power, water, and any other services the Contractor deems necessary to execute the Works. The Contractor shall be responsible for all costs associated with the supply of these services.

Temporary utilities used for construction shall have to be adequate for the intended uses and not to be overloaded or otherwise used or arranged in any manner endangering persons, premises or works. Connections shall be properly made, lines and wiring securely anchored in place and protected against accidents.

The Contractor shall install, maintain and pay for such services like water and power and any other facility/service required for the construction of Works. The Contractor shall lay cables/pipelines from nearest connection points up to the Site at his own cost. In case of the realignment of utilities due to the construction constraints, the same shall be carried out by the Contractor at this own cost and nothing extra shall be payable on this account.

2.13.6 Water

The Contractor shall provide his own arrangements for sourcing and for distribution adequate supply water for the Project including:

- drinking water: providing and maintaining canisters, coolers or connected drinking fountains of sufficient number to reasonably serve the Project.
- construction water: providing and maintaining temporary water service and distribution of adequate capacity for construction

2.13.7 Electricity

The Contractor shall make his own arrangement for power supply.

If found necessary, the Contractor shall provide and maintain generators including a stand-by generator of adequate capacity to meet his Project requirements.

The Contractor shall make his own arrangements of properly and safely perform work at enclosed spaces or under hazardous conditions. Temporary systems shall comply with the local codes and regulations.

All temporary services shall be removed and made good on completion of the Works, as per the directions of the Employer.

2.13.8 Construction Facilities

2.13.8.1 Contractor's Site Compound

The entire Contractor's Site Compound including Contractor's site offices, sanitary and first aid facilities, car parking, field laboratory, security facilities, Employer's Field Offices and the like shall be confined within the area designated for the Contractor's site establishment as instructed by the Employer.

The Contractor shall take all necessary measures to reduce dust from adjacent areas, including from bulk stockpiles and batching plant by means of barriers or other suitable systems. Special precautions are to be taken during the monsoon period taking into account the prevailing wind directions.

The Contractor shall submit the proposed location and layout of the Contractor's Site Compound to the Employer for approval as part of his Site Establishment Plan.

2.13.8.2 Temporary Jetty

The Contractor may construct temporary jetty(ies) for loading/unloading of materials from barges as per his construction methodology.

2.13.8.3 Sanitary Facilities

The Contractor shall provide and maintain to the satisfaction of the Employer, sufficient sanitary facilities and ablutions for all personnel engaged on the Works who shall use these provided facilities exclusively. The Contractor shall be responsible for arranging for the proposed handling and disposal of sewage from the site and for obtaining all required permissions from the relevant authorities.

No sewage or effluent shall be discharged into any river, creek, backwaters or the waters of the sea. Sewage should be treated so as to achieve the required standards prescribed by the applicable regulatory agencies and reused/recycled within the Works to the extent feasible.

2.13.8.4 Provision of Field Laboratory

The Contractor shall submit the details of the Site Laboratory to be set up by him for the successful completion of the Work. The Contractor shall obtain the approval within 28 days after award of work by the Employer prior to commencement of such laboratory set up.

The laboratory shall be equipped with the required testing equipment. The testing equipment shall be calibrated as per QA Plan of the Contractor.

The Contractor is encouraged to use the approved construction material testing laboratories located in close vicinity for fulfilling the testing requirements on day to day basis required under the Contract for site control on the quality of materials and the Works. In case the contractor sets up his own laboratory at site it shall meet the requirements as mentioned in **clause 2.12.7.**

The Contractor shall be responsible for all aspects of maintenance and operation of the Laboratories, including all associated costs with purchase, delivery, erection, calibration of equipment, operation, including sampling, storage, curing and testing of materials, periodic re-calibration of equipment, supply of consumables, recording and submitting test results to the Employer and removal on completion of the Works.

The field laboratory shall be provided with equipment including but not limited to the following:

2.13.8.5 General

(a)	Oven - Electrically operated, thermostatically controlled range upto 200°C sensitivity 1°C	1 No.
(b)	Platform balance 300 kg capacity	1 No.
(c)	Balance 20 kg capacity- self indicating type	1 No.
(d)	Electronic Balance 5 kg capacity accuracy 0.5 gm	1 No.
(e)	Water bath - electrically operated and thermostatically controlled with adjustable shelves, sensitivity 1°C	1 No.
(f)	Thermometers: Mercury-in-glass thermometer range 0°C to 250°C Mercury-in-steel thermometer with 30cm stem, range upto 300°C	2 Nos.
(g)	Gas stove or electric hot plate	1 No.
(h)	Glassware, spatulas, wire gauzes, steel scales, measuring tape, casseroles, karahis, enameled trays of assorted sizes, pestle-mortar, porcelain dishes, gunny bags, plastic bags, chemicals, digging tools like pickaxes, shovels etc.	As required
(i)	Set of IS sieves with lid and pan: 450mm diameter: 106 mm, 75.0 mm, 63 mm, 53 mm, 37.5 mm, 26.5 mm, 19.0 mm, 13.2 mm, 9.5 mm, 6.7 mm, and 4.75 mm size 200 mm diameter: 2.36 mm, 2.0 mm, 1.18 mm, 600 micron, 425 micron, 300 micron,150 micron, and 75 micron	 1 set 1 set
(j)	Water testing kit	1 set
(k)	First aid box	1 set

(l)	GPS set	2 sets

2.13.8.6 For Soils and Stones

(a)	Riffle Box	1 No.
(b)	Atterberg Limits (liquid and plastic limits) determination Apparatus	1 set
(c)	Compaction Test Equipment both 2.5 kg and 4.5 kg rammers (Light and Heavy compactive efforts)	1 set
(d)	Dry Bulk Density Test apparatus (sand pouring cylinder, tray, can etc.) complete	1 set
(e)	Speedy Moisture Meter complete with chemicals	1 set
(f)	Post-hole Auger with extensions	1 set
(g)	Core cutter apparatus 10 cm dia, 10/15 cm height, complete with dolly, rammer etc.	1 set
(h)	Aggregate Impact Value Test apparatus/Los Angeles Abrasion Test apparatus	1 set
(i)	Flakiness and Elongation Test Gauges	1 set
(j)	Standard measures of 30, 15 and 3 liters capacity along with standard tamping rod	1 set
(k)	California Bearing Ratio test apparatus	1 set

2.13.8.7 For Cement & Cement Concrete:

(a)	Vicat apparatus for testing setting times	1 Set
(b)	Slump testing apparatus	2 sets
(c)	Compression and Flexural strength testing machine of 200 ton capacity with additional dial for flexural testing	1 No.
(d)	Needle Vibrator	2 Sets
(e)	Air Meter	1 No.

2.13.8.8 Provision for Security Operation

The Contractor shall be responsible for physical security of the assets and persons at his Work Site. The security personnel deployment shall be carried out based on the requirement. The security posture shall consist of security processes, guarding manpower and technology control which shall be decided in consultation with the Employer.

All compliances need for manpower deployment shall be followed by the Contractor. All supervisory control shall remain with the Employer.

2.13.8.9 Contractor's Site Access Management Plan

The Contractor shall submit his Site Access Management Plan to the Employer for approval at least 30 days prior to the commencement of any site establishment, temporary or any other Works under the Contract. The Contractor shall follow the overall Project Site Management Plan. Contractor's Site Access Management Plan will be reviewed and approved by the Employer.

The Contractor's Site Access Management Plan shall include figures or drawings and accompanying notes detailing the proposed site traffic management Works (subject to the further requirements of this section of the Specification) including but not limited to the following items:

- General methodology and route for accessing Site;
- Arrangement and approximate timing for the delivery of materials and equipment throughout the course of the Works as well as any special arrangements or controls for mobilisation of oversize plant or delivery of oversize equipment;
- Labour timing;
- Proposed internal construction traffic controls (signage, line-marking, signals etc.) both for internal site roads and at interfaces with existing external roads;
- Any proposed temporary traffic controls for existing external roads that may be necessary from time to time to facilitate delivery of materials or equipment to site or any other Works on such roads; and
- Arrangement for river access to riverine construction work and Site Portions including navigational arrangement, temporary aids to navigation, anchoring and mooring arrangement.

The contractor shall be responsible for construction of any temporary works, improvement of roads, culverts, bridges etc. required for transport of rock from quarries to Project Site

The Contractor shall prepare the Site Access Management Plan with a view to minimizing interference with existing traffic in the vicinity of the site. All vehicles or marine craft using the existing public roads/ waters external to the site shall comply with the prevailing local and port rules and regulations as well as the requirements of any other relevant authorities.

The approval of the Site Access Management Plan by the Employer shall constitute a Hold Point on the commencement of site establishment, temporary or any other Site Works under the Contract as well as mobilization of plant and delivery of any materials or equipment to the site.

Any request by the Contractor to change the agreed proposals shall be subject to the agreement of the Employer.

The Contractor shall be responsible for safety of his stores / items / works. The Employer / will not be responsible for the Contractor's stores / items / works.

2.13.8.10 Temporary Barriers and Enclosures

The Contractor shall maintain fencing, employ watchmen and any other measures necessary so as to maintain the security of the Field Office, Work Site, and all other facilities related with this Contract, at all times pursuant to the requirements of Conditions of Contract.

Temporary fencing shall be installed and maintained by the Contractor for the security of plant, equipment and materials used in connection with the Works.

The temporary fence shall be completed as soon as practical following initial Possession of the Site and removed immediately prior to issue of the Taking-Over Certificate for the Works (or part thereof).

It remains the responsibility of the Contractor to establish the type of fencing that the Contractor requires to separate the construction area from public areas, other sites and to provide the level of site security/safety the Contractor deems necessary for the site and work areas.

Construction work shall be confined to areas within the fenced construction site area except with the written approval of the Employer.

2.13.8.11 Project Information Sign Board

The Contractor shall erect two signboards at prominent locations on the Site to identify the site to occasional visitors. The size, layout and location of the signboards shall be agreed with the Employer.

The Contractor shall not erect within or near the site or elsewhere on the Employer's/ any sign or notice board without prior approval, except safety signs.

The Contractor shall dismantle, remove and dispose of all such signs off site upon issue of the Taking-Over Certificate for the Works.

2.14 Product/ Materials Requirements

2.14.1 Common Requirements

2.14.1.1 General

Materials to be used in the Work shall conform to the specifications mentioned on the drawings, the requirements laid down in this section and specifications for relevant items of work covered under these Specifications.

Only new products, materials or equipment shall be supplied for use in the permanent Works. Pre-owned or pre-used products, materials or equipment shall not be supplied unless specifically accepted in writing by the Employer.

Products, materials and equipment to be incorporated in the permanent Works shall not be used in any temporary Works prior to their incorporation into the permanent Works unless specifically accepted in writing by the Employer.

If any material, not covered in these Specifications, is required to be used in the Work, it shall conform to relevant Indian Standards, if there are any, or to the requirements specified by the Employer.

2.14.1.2 Approval of Manufacturers and Suppliers

The Contractor shall submit details of the proposed source, manufacturer or supplier of all products, materials or equipment to be used in the permanent Works to the Employer for approval. The details to be submitted by the Contractor shall include but not be limited to the following:

- Name of the product, material or equipment to which the submission relates including reference to relevant sections of the Contract Documents;
- Name of the proposed source, manufacturer or supplier; Certificates, test results or any other information or evidence demonstrating that the proposed product, material or equipment confirms to the requirements of the Contract;

- Declaration that the product, material or equipment shall be supplied in accordance with the requirements of the Contract including all specified markings and certificates;
- Instructions or directions for the handling, storage or usage of the product, material or equipment from the source, manufacturer or supplier;
- Any other relevant technical details as may be required under the Contract or by the Employer.
- Supply of hired/leased products, materials or equipment to be incorporated in the Permanent Works is not allowed and the Contractor shall give an undertaking for the same in the format to be provided by the Employer during execution stage.

The Contractor shall submit such details to the Employer for approval at least 14 days prior to placing orders for the subject product, materials or equipment. The approval of the submission by the Employer shall constitute a Hold Point on the delivery of the subject product, materials or equipment to site. Irrespective of any such approval, the Contractor shall remain responsible for the quality and conformance of the subject product, material or equipment to the requirements of the Contract.

Once approved, sources shall not be changed without the written approval of the Employer. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any other source proves unacceptable at any time, the Contractor shall furnish acceptable material from other sources at his own expense.

2.14.1.3 Samples

Where required by the Employer, the Contractor shall at his own expense, submit to the Employer for approval, samples of any of the materials and components to be used in the Contract Works. The quality of materials and components to be used in the Works shall not be inferior to the approved samples.

Rocks, Aggregates from the quarries shall be submitted by the Contractor to the Employer at no extra cost.

Samples provided to the Employer or his representative for their retention are to be in labelled boxes suitable for storage.

Samples required for approval and testing must be supplied well in advance at least 48 hours or minimum period required for carrying out relevant tests to allow for testing and approval. Delay to Works arising from the late submission of samples will not be acceptable as a reason for delay in the completion of the Works.

If materials are brought from abroad, the cost of sampling/testing whether in India or abroad shall have to be borne by the Contractor.

2.14.1.4 Alternatives or Equivalents

In all cases where the name of a particular type or make of material, product, equipment or item is referred to in the Contract, this indicates the minimum acceptable standard. The Contractor may offer equipment or materials other than those specified and in all such cases, the Contractor’s offer shall be of at least equal quality.

In these instances, the Contractor shall submit to the Employer for approval, a statement detailing the alternative material or equipment and shall include full technical descriptions, drawings and specifications and shall provide such further information as is required to demonstrate to the Employer that the alternatives are equivalent in every way to those specified.

Acceptance of the Contractor's offered alternatives shall be subject to the acceptance and approval of the Employer who shall not be bound to accept any such offer.

2.14.1.5 Delivery, Storage and Handling Requirements

No products, materials or equipment shall be delivered to site until the Contractor has established all traffic and environmental controls on site and has adequate facilities on site for unloading and storage of the products, material and equipment prior to their incorporation into the Works.

All products, materials and equipment delivered to site shall be handled and stored so as to prevent damage or deterioration prior to their incorporation into the permanent Works. All stockpiles and storage stacks shall be maintained by the Contractor in a safe state with sufficient working space provided to permit safe access by the Employer for inspection and checking of the delivered products, materials and equipment.

All proprietary products, materials and equipment used on the Works shall be handled, stored, used, fixed or applied strictly in accordance with the manufacturer's instructions and to the satisfaction of the Employer. The Contractor shall obtain the manufacturer's instructions in this regard at the time of ordering and shall submit to the Employer along with his submission of the proposed source.

2.15 Tests and Standard of Acceptance

2.15.1 General

All materials, even though stored in an approved manner, shall be subjected to an acceptance test prior to their immediate use.

Independent testing of cement for every consignment shall be done by the Contractor at site in the laboratory approved by the Employer before use. Any cement with lower quality than those shown in manufacturer's certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

2.15.2 Testing and Approval of Material

The Contractor shall furnish test certificates from the manufacturer/supplier of materials along with each batch of material(s) delivered to site.

The Contractor shall be responsible or testing of all materials, finished products used in the construction as per requirements of Conditions of Contract and the relevant Specifications. The testing of all the materials shall be carried out by the Employer or his representative for whom the Contractor shall make all the necessary arrangements and bear the entire cost.

Tests which cannot be carried out in the field laboratory have to be got done at the Contractor's expense at any recognized laboratory/testing establishments in India or abroad, as approved by the Employer. All necessary cost for witnessing the test by Employer's representative shall have to be borne by the Contractor.

2.15.3 Rejection of Materials not conforming to the Specifications

Any stack or batch of material(s) of which sample(s) do not conform to the prescribed tests and quality, shall be rejected by the Employer, or his representative, and such materials shall be removed from site by the Contractor at his own cost. Such rejected materials shall not be made acceptable by any modifications.

2.15.4 Testing and Approval of Plant and Equipment

All plant and equipment used for preparing, testing and production of materials for incorporation into the permanent Works shall be in accordance with manufacturer's specifications and shall be got approved by the Employer before use.

2.16 Project Execution

2.16.1 Submission of Documents During Project Execution

2.16.1.1 Programme of Works

The Contractor shall prepare and submit (both hard copy and soft copy) to the Employer within 30 days of receipt of Letter of Award the following:

- Detailed CPM Schedule using MS Project for all sub-contractors as and when engaged.
- Detailed resource (manpower and equipment) allocation and raw material planned as per the CPM Schedule including those of the sub-contractors.
- List of designs/drawings/documents along with their schedule of submission.
- List of Vendors / Suppliers of Bought-out items

The above shall be updated every month and submitted to the Employer.

2.16.1.2 Work Schedules, Survey Data & Drawings

The Contractor shall prepare and submit construction schedules, detail resource (manpower and equipment) allocation and raw material planned as per CPM schedule, including those of sub-contractors, survey data, and field drawings to illustrate the appropriate portion of work. The work items shall be described and related to responsibility, fabrication, layout, and setting or erection details as specified in appropriate Sections.

The Contractor shall keep allowance in program of works for any stoppages during monsoon period, and he has to take all necessary measures to protect his equipment and the partly completed structures. The Contractor is expected to build such stoppages of work during monsoon in his overall schedule for completion. The Employer will not entertain any claims from the Contractor on this account.

Drawings shall be submitted in three sets in paper prints, maximum size 610 mm x 810 mm and on CD or pen drive (in AutoCAD format).

2.16.1.3 3D Walkthrough Models

The Contractor shall submit 3D models and walkthrough of entire project facilities (service galleries, marine structures, buildings, etc.) with proper GIS referencing details while ensuring confidentiality. The 3D model shall be provided along with the final designs and shall be updated in case of any changes. The soft copy of the 3D models in the editable version shall be provided as and when requested by the Employer. All the utility services and their interfacing shall be duly checked for any conflicts through the 3D model before submission to engineer for design review and installation at site.

2.16.1.4 Maintenance Plan

2.16.1.4.1 General

The Contractor shall prepare maintenance plan covering all aspects of the works for the review of the Employer. This plan shall be prepared to ensure that the design life periods stated are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life.

2.16.1.4.2 Maintenance Document

The Contractor shall provide six copies of the maintenance plan and manuals to the Employer to retain by the Employer upon the request of the Employer or following receipt of attention to the Employer's comments.

2.16.1.4.3 Weekly and Monthly Progress Reports

The Contractor shall maintain a daily log describing the important events pertaining to the Works, (*the working hours, the number of laborers employed, effective operation time of equipment, overtime hours*), progress made in the Works. This daily log shall be submitted to the Employer by 1:00 PM of the following day. Compilation of these logs and their summary shall be submitted to the Employer as Weekly Progress Report in three (3) copies by middle of the next week.

The monthly progress reports shall include progress photographs taken at a fixed point and angle. The photographs shall be sufficient in numbers and locations to record the exact progress of works. The colour photographs shall be in size 200 mm x 250 mm and the CD or pen drive containing the digital version of the same shall be provided.

The Contractor shall furnish the Employer with five (5) copies of the monthly progress reports within seven (7) days after the end of every month.

2.17 Design & Drawing Submissions

2.17.1 Design Submission – General

The scope drawings listed in this Volume is issued for information and guidance to the extent mentioned in the Tender document. Contractor shall make all arrangement and design drawings to suit his equipment and submit the same for approval to the Employer. Detailed Engineering shall be done by the Contractor. It shall be the responsibility of the contractor to take approval the Employer on his design and drawing submissions. The contractor shall not be entitled to any extension of time

for completing construction/commissioning or any other relief on account of delay caused due to providing any clarifications or in resubmitting any designs and drawings.

The contractor shall not change any design and drawings reviewed by the Employer, without submitting such revised designs and drawings for the review of Employer.

The list of submission will however be discussed with the Contractor after the award. All the requirements with respect to the documentation, design and drawing submissions and review have to be fully complied with by the Contractor.

2.17.2 Submission of Calculations

The Contractor shall submit for the approval of Employer progressively from the date of receipt of the Letter of Award, Three (3) copies of the following:

1. Each calculation page shall be uniquely numbered.
2. Each section of calculations shall have a cover sheet, listing the subject of the calculations, document number and date of submission, name and qualifications of the Designer(s), the name and qualifications of the Design Verification engineer(s), and the relevant Indian/other Standards, books and drawings which are the basis of the calculations.
3. Each section of calculations shall have a Table of Contents, including page numbers.
4. Calculations shall be accompanied by all necessary sketches or extracts from drawings.
5. Calculations shall include introductions explaining the purpose of the calculations and the methods and design philosophies adopted. This shall clearly state the Standards on which the calculations are based.
6. Equations and values from Standards and Codes of Practice are to be clearly referenced. Extracts from publications other than Indian Standards or British Standards which are used in the design shall be attached to the submission. The relevant Indian/other Standards forming the basis of the design shall be quoted.
7. Where values used in the calculations are brought forward from previous calculation pages, the page reference shall be included.
8. At the end of each section there shall be a summary, listing the conclusions of the calculations, and referring to construction drawings.
9. If calculations are revised due to design changes or corrections or comments of the Employer, the calculations sheets shall be clearly marked with a revision letter.
10. All calculations shall be signed / initialed by the designer and design verification engineer.

2.17.3 Submission of Drawings

All drawings submitted for the Employer’s approval shall comply with the following:

1. All drawings shall be in metric millimeter dimensions and be finally prepared in ink with legible lettering on either A0 1189mm x 841mm using AutoCAD format compatible with AutoCAD 2020 or lower version. The submitted prints shall be clearly legible throughout and there shall be no ambiguity.

2. All drawings shall be submitted in digital format on compact disc, as well as three paper prints.
3. Drafting Standards employed in the preparation of all drawings shall be sufficient to produce legible 297mm x 420mm (A3) reduced drawings.
4. Drawings from various sub-contracting services, specialist suppliers etc. shall also be presented in a similar manner (identical title blocks/format etc.) to provide a matched set of drawings.
5. All drawings shall clearly show the status and revision of the drawings. Revised drawings shall clearly indicate the nature and details of the revision work and also revision cloud & revision mark shall be marked wherever revised.
6. All drawings shall clearly identify the drafts-person responsible together with the identity of the drawings checker.
7. Each drawing shall show the scale(s) of the components illustrated by the drawing related to the original drawing size, A0, A1, A3 etc.

2.17.4 Examination and Preparation

2.17.4.1 Construction Work Method Statements

In addition to the submission of the Detailed Construction Sequence and Methodology as defined in this Section, the Contractor shall submit separate individual Construction Work Method Statements (CWMS) detailing the sequence and method of working he intends to adopt for various items of works. The CWMS shall be consistent with the overall Detailed Construction Sequence and Methodology and shall comply with any additional construction sequence or phasing requirements nominated on the Drawings and/or elsewhere in this Specification. The purpose of the CWMS is to aid the planning and integration of activities and correct technical execution of the Works within the requirements of the Contract. In this regard, it shall be written such that it can be understood completely by the labour and supervisory personnel responsible for the Works.

The CWMS shall provide detailed information regarding materials, equipment and plant to be utilized, labour requirements, time frame and schedule of the Works including Sub-Contractors, prerequisite conditions, details and order of activities for each operation, safety measures, environmental controls and any other relevant technical aspects including those detailed elsewhere in the Specification or Drawings.

The CWMS shall be consistent with the requirements of the approved Project Quality Plan and shall include a description of testing and inspection records, reporting channels (including names of responsible supervisory personnel) and frequency and actions where records indicate non-conformance with the Specification. The relevant agreed ITPs for the subject Works shall be appended to the CWMS for easy reference.

Proposed repair methods for the rectification of any anticipated minor defects or damage shall also be appended to the CWMS.

Where any construction activity includes an interface with either any existing operations, or with an associated contract, the CWMS shall also include the procedures to be followed by his staff and equipment for the management of such interfaces.

Unless specifically noted otherwise in the relevant sections of this Specification, the Contractor shall submit the proposed CWMS to the Employer for approval at least 21 days prior to the intended date for first commencement of the construction Works to which the CWMS relates. The Employer will

take maximum 14 days for issuing comments (if any) to be incorporated by the Contractor and resubmit/approval.

The resolution of such comments on the CWMS submission will be to the satisfaction of the Employer and the Employers subsequent approval of the CWMS shall constitute a Hold Point on the commencement of the Works to which the CWMS relates.

Examination and/or approval by the Employer of the CWMS submitted by the Contractor shall not relieve the Contractor of his responsibilities or liabilities under the Contract. The sole responsibility for the safety and adequacy of the methods adopted by the Contractor will remain with the Contractor, irrespective of any approval given by the Employer.

The Contractor shall be responsible for issuing copies of the approved CWMS to the relevant Works personnel and supervisory staff to ensure that they are fully familiar with the CWMS.

Notwithstanding any approval of the CWMS, the Employer shall reserve the right to require further amendment or modification of the CWMS in the event that additional issues are observed on site following commencement of the construction Works to which the CWMS relates. Similarly, the Contractor is free to propose further amendment or modification to the CMWS subject to the approval of the Employer.

2.17.4.2 Contractor Working Area

The Employer shall provide land area limited to 50 acres at one or different locations, near or within the Project Site for the Contractor's working area. No space for the labour camp shall be provided.

2.17.4.3 Construction Safeguards

2.17.4.3.1 Excavations

Trenches intersecting roads shall have to be provided with crossings suitable to carry the type of traffic involved. Vehicular curbs and pedestrian railings shall be provided as necessary. Open pits and in openings in floors and other accessible surfaces shall be protected by barricades or railings.

2.17.4.3.2 Access

Access to structures such as scaffolds, ladders, ramps, hoists etc. shall be provided, maintained and operated as necessary.

2.17.4.3.3 Storage Areas

Storage and shop areas shall be provided, arranged and maintained at approved locations as necessary to properly store, handle and fabricate the various materials and equipment required.

2.17.4.3.4 Weather Safeguards

The Contractor has to take all the necessary precautions and measures to protect his equipment and the completed sections / structures before the onset of monsoon.

2.17.4.3.5 Protection of the Public

The Contractor shall provide barricades and enclosures as necessary for public protection.

2.18 First Aid and Fire Protection

2.18.1 Emergencies

The Contractor shall maintain the lists of nearest available police, hospital or medical services at the Contractor's Site Office and the same are to be displayed at a number of locations & work places.

2.18.2 Fire Protection

The Contractor shall establish and submit the following measures to the Employer.

- establish appropriate emergency escape routes and procedures;
- maintain fire extinguishers, connected hoses and other facilities necessary for reasonable fire-fighting action at the site and temporary work yard;
- Provide and maintain a first aid kit containing bandages, medicines and sterilised materials for first aid treatment of minor injuries at the Contractor's Site Office.

2.18.3 Quarry for Rock Sourcing

The Contractor shall identify and establish suitable quarry/quarries with adequate supply of rock satisfying the requirements of the related sections of the Tender. The Contractor shall be wholly responsible for identifying the quarry and sourcing of rocks to complete the works as per the Tender. The Contractor shall submit along with his tender, preliminary details of the proposed quarry locations for rock and shall submit his final proposals within 60 days of award of the Contract. The proposal shall contain details of the location of the quarry, expected yield, material test certificates, production capacity, testing facilities and means of transportation to the site. The Contractor shall also submit for the approval of the Employer a quarry analysis report which meets the grading requirements specified in the Tender for all grades of rock prior to commencement of regular quarrying operations.

2.18.4 Field Surveys and Investigations

2.18.4.1 General

The Contractor shall carryout the engineering design and prepare drawings for the various components under the Package based on the data on field surveys and investigations, including that of Temporary Works.

The Contractor shall carry out all necessary investigations to supplement and complete his design data, in case he feels necessary:

- Topographic survey to supplement the survey carried out by the Employer.
- Bathymetric survey to supplement the survey carried out by the Employer.
- Soil investigation work to supplement the investigations carried out by the Employer to verify that his design assumptions are in accordance with the ground conditions.

The Contractor shall, at his own expense, carry out all the necessary surveys, measurements and setting out of the works and shall for this purpose engage well qualified, experienced and competent land surveyors.

2.18.4.2 Setting Out

The Contractor shall establish working bench marks related to the Reference Bench Mark in the area soon after taking possession of the site. The Employer shall provide the Contractor with one Permanent Bench Mark and its datum. A schedule of reference dimensions shall be prepared and supplied by the Contractor to the Employer. These marks shall be maintained until the works reach finished formation level and are accepted by the Employer.

The Contractor shall be solely responsible for safe-guarding all survey monuments, bench marks etc. All dimensions and levels shown on the drawings or mentioned in documents forming part of or issue under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Employer of any apparent errors or discrepancies in such dimensions and levels.

2.18.4.3 Topographic Surveys

The Contractor shall conduct a precision triangulation survey to establish primary and secondary survey stations and tie these with respect to Spheroid WGS 84 UTM grid for setting out the Works.

Survey stations and other control devices required by the Contractor for his execution of the work shall be established by the Contractor at his own expense, and shall be removed upon completion of the works.

2.18.4.4 Bathymetry Surveys

The Contractor may carry out fresh bathymetry survey in the Works area if he so desires at his own cost and without any implications to the Employer.

2.18.4.5 Geotechnical Investigations

The Contractor may carry out additional geotechnical investigations in the Works area if he so desires at his own cost and without any implications to the Employer.

2.18.4.6 Post Construction Survey

The completion of the works will be examined by the Contractor in the presence of the Employer. During these examinations, the Contractor shall perform the survey, which shall be used to prepare a final drawing showing all dimensions, elevations and cross sections of the “As Built” conditions of the structures. The Contractor shall be required to remove excess materials or place additional materials, as directed by the Employer, in order to comply with the Contract Documents. Contractor shall submit the final location of all structures with reference to the Master Grid, which shall show the actual position of each structure and deviation from the theoretical position.

2.18.4.7 Survey and Layout Data

Levels shall be set out to Chart Datum (CD). Coordinates shall be based on the Indian Geodetic Datum survey grid system as adopted from the Survey of India.

The Reference Bench Mark for the area shall be obtained by the Contractor from the Employer. The Contractor shall establish working Bench Marks tied with the Reference Bench Mark in the area soon after taking possession of the site.

Throughout the duration of the Works, the Contractor shall be responsible for the establishment, maintenance and protection of suitable permanent and temporary benchmarks and control points for the setting out of the Works and for the correctness of all such setting out.

The Contractor shall provide sufficient permanent survey marks to properly set out the Works and shall take all necessary precautions to prevent these marks from being disturbed. The working Bench Marks/levels shall be as approved by the Employer. Checks must be made on these Bench Marks at least once every month and adjustments, if any, agreed with the Employer and recorded. An up-to-date record of all Bench Marks including approved adjustments, if any, shall be maintained by the Contractor and also a copy supplied to the Employer for his record.

2.18.4.8 Damage to Existing Structures

If, in the sole opinion of the Employer, the Contractor has caused damage to any part of an existing structure during transport of material or any other operations, the Contractor shall be responsible for carrying out repairs to the structure to the satisfaction of the Employer/relevant authority.

All costs and expenses associated with the repairs to such damage or the replacement of damaged parts shall be at the cost of Contractor.

2.18.4.9 Monsoon Damages

Damages due to rain or flood either in cutting and banks or any other work shall have to be made good by the Contractor till the work is handed over to the Employer. The responsibility of de-silting and making good the damages due to rain or flood rests with the Contractor. No extra payment is payable for such operations and the Contractor shall, therefore has to take all necessary precautions to protect the Work done during the Construction Period.

2.18.4.10 Existing Utilities and Services

The Contractor has to locate and determine the existing utilities in the project area and making his own assessment of the exact details, lines, levels, nature, type, size, location and all other matters of relevance to the existing utilities and services at the site prior to commencement of any site Works.

Any unidentified services uncovered by the Contractor shall be immediately brought to the attention of the Employer.

The information on affected services and utilities may not be exhaustive and the final position of these services within the Works shall have to be drawn up based on the information furnished by different authorities linked with the utilities as directed by the Employer. The Contractor’s programme must take into account the period of notice and duration of diversion work concerning each authority and the Contractor must also allow for any effect of these services and alterations upon the Works and for arranging regular meetings with the various authorities on commencement of the Contract and throughout the period of the Works in order to maintain the required co-ordination. During the period of the Works, the Contractor shall have no objection if the public utility bodies / authorities vary their decisions in the execution of their proposals in terms of programme and construction, provided that, in the opinion of the Employer, the Contractor has received reasonable notice thereof before the relevant alterations are put into operation.

The Contractor shall take every precaution to avoid damage to existing utilities and services at the site. No clearance or alterations of utilities or services shall be carried out unless specifically ordered by the Employer.

Any services affected by the Works must be temporarily supported by the Contractor who must also take all measures reasonably required by the various bodies to protect their services and property during the progress of the Works. The work of temporarily supporting and protecting the public utility services during execution of the Works shall be deemed to be part of the Contract and no extra payment shall be made for the same.

2.19 Execution

2.19.1 General

In every case, the Works shall be carried out to the satisfaction of the Employer and conform to the location, lines, dimensions, grades and cross-sections shown on the drawings or as indicated by the Employer. The quality of materials, processing of materials as may be needed at the site, salient features of the construction work and quality of finished work shall comply with the requirements set forth in succeeding sections of this Specification.

2.19.2 Radio Communications

Any radio frequencies proposed for use by the Contractor for site communications shall be subject to the approval of the Employer or relevant Authority. The Contractor shall be responsible for arranging all permits and licences required for the operation of radio equipment throughout the Works.

2.19.3 Construction Plant and Equipment

In addition to the general conditions indicated in the Contract Documents, the following conditions regarding use of equipment in executing the works shall be satisfied:

(a) The Contractor shall be required to give a trial run of the equipment for establishing their capability to achieve the laid down Specifications and tolerances to the satisfaction of the Employer before commencement of the Works;

(b) All equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to the Employer;

(c) All the plant/equipment to be deployed on the Works shall be approved by the Employer for ensuring their fitness and efficiency before commencement of work;

(d) Any material or equipment not meeting the approval of the Employer shall be removed from the site forthwith;

(e) No equipment shall be removed from site without permission of the Employer; and the Contractor shall also make available the equipment for site quality control work as directed by the Employer;

(f) All equipment shall comply with the environmental requirements set out in this Document; and.

(g) No batching plant and stone crushing plant are allowed inside the Project Site.

2.20 Floating Crafts

2.20.1 Survey Launch

The survey launch and all survey equipment require the approval of the Employer before being mobilized to Site.

All crafts used for the Contract shall be registered in accordance with applicable laws/regulations and the masters/operators may themselves require local licences and certificates as required by the Employer and any other applicable regulations. All vessels, working craft and other floating equipment shall display appropriate international and local signals to indicate the nature of their work. All work over water must comply with all relevant regulations of IWAI.

Floating equipment shall be maintained in a satisfactory and seaworthy condition and shall have adequate attendance by competent seamen at all times, shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights. At all times, the Contractor shall be wholly responsible for the protection and safety of all floating craft engaged by him.

Where work is carried out from dumb lighters, pontoon or other non-self-propelled floating equipment, a suitably powered craft shall be in attendance at all times.

All marine craft, pontoons or platforms shall be adequately braced, secured and anchored and of such size and construction as to ensure a satisfactory performance of the Work. The marine craft shall also be fitted out to allow the types of investigation, sampling and in-situ testing required to be carried out to the satisfaction of the Employer. The Contractor shall provide the Employer with adequate assistance for gaining access to the marine crafts, pontoons or platforms.

Areas of temporary anchorage of Contractor's marine craft shall be agreed with the Employer, shall be outside any permanent or temporary navigation channel and shall be clearly marked with marker buoys or other system to the satisfaction of the Employer.

All lifesaving, fire equipment, medical facilities shall be maintained as required by relevant code or comparable requirements.

The originals of all statutory certification including but not limited to the following documentation shall be kept on-board all vessels deployed on the Works:

- Certificate of Registry;
- Load Line Certificate;
- Tonnage Certificate;
- Certificate of Class (Hull and Machinery);
- Cargo Ship Safety Certificate;
- Life Saving Apparatus Certificate;
- De-rating Certificate;
- Quarantine Certificates for Ballast Water and Hull Cleanliness prior to entering Indian Waters;

- Radio Certificate; and
- Stability Booklet for loading conditions, as may be foreseen for the Works

Vessels shall be operated at all times during the Works within the limits of its current Vessel Marine Documentation and Certification.

2.20.2 Cranes and Lifting Equipment

All cranes, lifting equipment and winches shall comply with Indian and Local Government requirements and third-party surveyor requirements, for example Lloyds, B.V., DNV, ABS, and Indian Safety Authority or similar approved.

Test certificates, maintenance records and the like for all cranes, wires, slings and winches shall be available for inspection by the Employer and for third party audit. Slings for which test certificates are not available shall not be used and shall be removed from site prior to the commencement of the Works.

2.20.3 Repair Methods

The Contractor shall submit to the Employer for approval, details of all proposed repair methods to be employed as may be necessary to rectify any minor defects or incidental damage in elements of the permanent Works.

Details shall include but not be limited to information on the type and manufacturer of any proprietary products to be used and any specific directions from the manufacturer regarding their use, detailed work methods for affecting the repairs and any other relevant technical information as may be required by the Employer.

The Contractor shall generally submit these details pre-emptively as part of his CWMS for the relevant construction activity. Where additional or unforeseen repairs are required, the Contractor shall make additional submission as directed by the Employer.

2.21 Cleaning and Waste Management

2.21.1 Site Maintenance

The Works includes the housekeeping of the Site including but not limited to:

(a) Daily cleaning of the Site including all amenities and facilities supplied by the Contractor to the Employer;

(b) Collection and disposal of all domestic, toxic and hazardous waste, oils, empty drums and other containers, waste timber, asbestos impregnated products all in accordance with all applicable Laws and regulations governing the disposal of these items or materials;

(c) Retrieval of any waste materials deposited on the seabed by the Contractor;

(d) Collection and storage of all surplus construction material;

(e) Special clean-ups required throughout the monsoon season and tie down Works required for cyclone alerts including any damage preventative measures to both temporary facilities and amenities and to partly or wholly constructed installations and enclosures;

(f) Final clean-up and re-instatement of the Site;

(g) Compliance with all environmental protection requirements.

2.21.2 Construction Waste Management and Disposal

The Contractor is required to implement procedures for waste minimization to reduce, reuse, recycle and recover as much waste material or reuse as is practical. Waste minimization and segregation shall be exercised during mobilization, installation, execution and demobilization phases of the Works.

The Contractor shall endeavour to minimize waste materials such as equipment consumables, packaging and the like. All scrap generated during construction shall be segregated into components such as glass, paper products, aluminium, steel, rubber, insulation materials, plastics, steel, wood and the like.

All demolished and excavated material, excess building materials and waste, other than material designated to be stockpiled on the site, shall be removed from the Site and disposed off, in a legal manner. No waste shall be disposed in the Coastal Regulation Zone (CRZ) area. All permits and approvals necessary for the removal and disposal of demolition materials shall be obtained in advance. The municipal wastes generated by labour during construction, shall be handled, transported and disposed as per the relevant municipal handling rules.

All unused material shall be removed from site in a progressive manner either by use of a weekly emptied dump hopper or similar removal arrangement. The sellable wastes shall be sold only to the authorized vendors. The Site and surrounds shall be kept tidy at all times.

Plastics and rubber shall not be disposed off by burning and is to be handled and disposed as per the draft plastic rules. Asbestos use shall be minimized and shall be disposed off, in accordance with all relevant regulations. Materials infested by vermin, pests or rot shall be destroyed in a way that will minimize the risk of infecting other materials. Hazardous wastes shall be handled, stored, managed and disposed off, in compliance with the relevant regulations.

The Contractor shall take all precautions to ensure that with the exception of materials that will form part of the Works, no materials of any kind being used or transported to or from the Site fall on adjoining property or public thoroughfares or into the water. Any material or item that does so fall shall be removed as early as practical, to the satisfaction of the Employer.

Construction and demolition (C&D) wastes from this Contract shall remain the property of the Contractor and shall be removed by the Contractor from the Site or adjoining area as applicable to the satisfaction of the Employer. All such work shall be carried out at the Contractor's own expense for which payment shall be deemed to have been included in the Contract Sum.

If there is any change in the existing rules and the new rules become effective for the construction, transportation, treatment and disposal for municipal, hazardous, C&D, electrical and electronic and plastic wastes, the new rules have to be followed. All such work shall be carried out at the Contractor's own expense for which payment shall be deemed to have been included in the Contract Price.

2.21.3 Protecting Installed Construction

The Contractor shall follow procedures and assignments as contained in the Project Site Management Plan and will minimize impact to the ongoing operations wherever possible, or as directed by the Employer.

2.21.4 Completion Procedures

2.21.4.1 General

Requirements for Tests on Completion, Employer's Taking Over of the Works and Defects Liability shall be as per the requirements of the Conditions of Contract and subject to the additional requirements outlined in this Specification. The additional requirements specified in the following sections shall not be interpreted as limiting the Contractor's responsibilities under Contract in this regard in any way.

2.21.4.2 Preliminary Inspection of the Works at Completion

In addition to the requirements of the Contract regarding Tests on Completion, the Contractor shall undertake joint general inspection of the completed Section with the Employer, at least 14 days prior to the Contractor's intended submission of application for a Taking-over Certificate for the Section.

The Contractor shall record any and all defects or omissions identified during the joint inspection including any, that in the sole opinion of the Employer, are required to be rectified prior to the issue of a Taking-Over Certificate and those that may be rectified after issue of the Taking-Over Certificate under Defects Liability.

Following the joint inspection, the Contractor shall submit the agreed Draft List of Defects and Minor Omissions including the agreed disposition with respect to the timing and method of rectification of each to the Employer for approval. The Contractor shall also include on the List any outstanding documentation or administrative requirements under the Contract. The Contractor shall advise the date for rectification of each individual item on the Draft List of Defects and Minor Omissions.

The acceptance of this Draft List of Defects and Minor Omissions by the Employer shall constitute a Hold Point on the submission of application for a Taking-Over Certificate for the Section by the Contractor.

2.21.4.3 Inspection of the Works at Completion

Within 7 days following receipt of the Contractor's application for a Taking-Over Certificate for the Section (subject to the requirements above), the Contractor shall undertake a further joint general inspection of the Section with the Employer.

This final inspection shall be to confirm that all items previously identified on the Draft List of Defects and Minor Omissions as being required to be rectified prior to issue of the Taking-Over Certificate, have been rectified and to re-confirm the status of the items permitted to be rectified after issue of the Taking-Over Certification for the Works under Defects Liability.

Following the joint inspection, the Contractor shall submit the agreed Final List of Defects and Minor Omissions including the agreed disposition with respect to the timing and method of rectification of each to the Employer for approval.

The acceptance of this Final List of Defects and Minor Omissions by the Employer as well as completion of all Tests on Completion and submission of all other required documentation and submittals per the requirements of the Contract shall constitute a Hold Point on the issuing of the Taking-over Certificate for the Section.

2.22 Submittals at Completion

2.22.1 Operation and Maintenance Data

The Contractor shall provide a full set of all operations and maintenance manuals as may be required under the Contract in hard copy (03 No. copies) and electronic PDF format to the Employer prior to submittal of the Contractor's application for a Taking-Over Certificate for the completed Section.

These manuals shall provide sufficient detail for the Employer to operate, maintain, dismantle, reassemble, adjust and repair the Structure. The wording of all such manuals shall be agreed with the Employer in advance.

A Section shall not be considered to be completed for the purposes of Taking Over as defined in the Conditions of Contract until the Employer has received in the form required by the Contract, final operation and maintenance manuals in such detail, and any other manuals specified in the Specifications and the Drawings for these purposes.

2.22.2 As-Built Drawings

The Contractor shall prepare, and keep up-to-date, a complete set of "As-Built" records of the execution of the Works, showing the exact as-built locations, sizes and details of the Work as executed. These records shall be kept on the Site and shall not be used by the Contractor for any purpose other than for the purposes of the preparation of the As-Built Drawings in accordance with the requirements of the Contract.

The Contractor shall prepare a full set of As-Built drawings for the whole of the Works based on the Contract Drawings with amendments made to reflect any major changes in set out, design or construction method.

All dimensions, levels and set-out coordinates shall be updated based on the in-survey, progress and As-built surveys undertaken throughout the Works. Additional information on the As-Built pile founding depths and set-out shall be added to the drawings based on the Contract piling records.

The Contractor shall submit the draft As-Built drawings in hard copy (03 No. A3) and electronic CAD and PDF format to the Employer for approval prior to the submittal of the Contractor's application for a Taking-Over Certificate for the completed Works.

The Contractor shall incorporate all comments and amendments required by the Employer and once agreed, shall submit the final As-Built Drawings in hard copy (03 No. A3 and 03 No. A1) and electronic CAD and PDF format to the Employer.

The Works shall not be considered to be completed for the purposes of Taking Over as defined in the Conditions of Contract until the Employer has received these documents in the form required by the Contract.

2.22.3 Warranties

The Contractor shall provide a full set of all warranties for products of workmanship as may be required under the Contract in hard copy (02 No. copies) and electronic original format and PDF format to the Employer prior to submittal of the Contractor's application for a Taking-over Certificate for the completed Section.

The wording of all such warranties shall be agreed with the Employer and the Employer in advance.

2.22.4 Project Record Documents

The Contractor shall provide a full set of the Project Quality Records in hard copy (02 No. copies) and electronic original format and PDF format to the Employer within 28 days of issue of the Taking-Over Certificate for the completed Section.

The Contractor shall maintain separate volume covering Quality Documentation for any outstanding minor Works carried out under Defects Liability Period. This separate volume shall be submitted to the Employer at least 14 days prior to the expiration of the Contract Defects Liability Period.

2.22.5 Works Not Specified

The workmanship of works not fully specified in the Tender documents shall be carried out as per relevant IS Specifications and in absence thereof shall be as per the best standard practice as approved by the Employer.

2.22.6 Vendors/ Makes and quantities

2.22.6.1 List of Approved Vendors

Note: The quality of all Materials intended to form or forming part of the Permanent Works, including the supply-only materials (if any) to be supplied by the Contractor under the Contract, shall conform to the Specifications, Bill of Quantities and Drawings. The list(s) of manufacturer(s)/supplier(s) given in this clause for various Materials are not exhaustive. The Contractor shall procure Materials preferably from the manufacturers stated in the relevant sections. Nevertheless, in case the Contractor wants to procure such Materials from manufacturer(s)/supplier(s) not listed in this clause, the Contractor may procure Materials from other supplier(s)/manufacturer(s) provided that the Materials procured conform to the Specifications, Bill of Quantities and Drawings and are from the reputed manufacturers.

Notwithstanding the above, the Contractor shall submit sample(s) as well as technical data of all materials to be procured for the Works and any more information requested by the Employer, to the Employer for his consent and the Contractor shall obtain such consent of the Employer at least 28 days before his intended date of placing the order for the materials. The decision of the Employer shall be conclusive, final and binding.

The Contractor shall use the following list of approved vendors for the mentioned materials as per the below **Table 2.2**.

Table 2.2: List of Approved Vendors

S. No.	Makes/ Items	Vendors
Civil Works		
1.	Reinforcement Steel (CRS-TMT Bars)	TATA, SAIL, RINL, Jindal Steel, JSW Steel
2.	Structural Steel	TATA, SAIL, RINL, ESSAR, ISPAT
3.	Ordinary Portland Cement	Ultratech, ACC, JK, Shree Cement, Dalmia
4.	White Cement	Birla, JK

S. No.	Makes/ Items	Vendors
5.	Structural Rolled Steel sections-beams, channels, tee, flats, angles, etc.	TATA, SAIL, RINL, ESSAR, ISPAT, Jindal, JSW Steel
6.	Structural Hollow steel sections (Square & Rectangular)	TATA, SAIL, RINL, ESSAR, ISPAT
7.	Structural tubular sections	TATA, SAIL, RINL, Jindal
8.	Shuttering plywood	Century, Mayur, Greenply, Kitply, National, Merino
9.	Waterproof/ Marine grade plywood (as per IS 710)	Archid, Kitply, Century, Mayur, Greenply, National
10.	Commercial Plywood (as per IS 303)	Century, Mayur, Greenply, Kitply, National, Merino
11.	Silicon sealant / Silicon Paint	Dow Corning, Soudal, Bostik, Wacker Anchor Fasteners Hilti, Fischer
12.	Non-shrink general purpose grout	Fosroc, BASF, Sika
13.	Anchoring chemical for rebar dowel bar	Hilti, Fischer
14.	Polysulphide sealant/ P.U sealant	Pidilite, BASF, Sika
15.	Integral water proofing compounds	STP, Pidilite, Fosroc, CICO, Sika, BASF
16.	Bituminous Products	STP, Sika
17.	Floor Hardeners	Ironite, Ferrok, Hardonate
18.	Construction Chemicals	Choksey, CICO, Sika, STP, Roff, Fosroc, BASF
19.	Non-Metallic Surface Hardeners	CICO, Fosroc, STP, Sika, BASF
Riverine/ Marine Facilities		
1.	Expansion Joint System	Sanfield (India) Ltd., Watson Bowman Acme Corp., Metal Engineering & Treatment Co Pvt Ltd. (METCO), Sika India Pvt. Ltd. Deevin Group.
2.	Aluminium Gangways	360 Degree Global Equipments Pvt Ltd, Geeta Engineering Works Pvt. Ltd.
3.	Marine Steel Access Doors	Thormarine, Hellbergs, Deansteel Manufacturing Company, Inc., Seven Star Engineers & Fabricators.
4.	Duckbill Type Non Return Valves	Tideflex Technologies - Measurit, CLA-VAL – Sharp Solutions, Onyx Valve, Elasto-Valve Rubber Products Inc.
5.	Panzerbelt	Cavotec India Private Limited, Conductix-Wampfler, Auxema-Stemmann.
6.	Fender (Excluding Donut Fender)	Trelleborg Sealing Solutions India Private Limited, IRM Offshore and Marine Engineers Private Limited, Shibata Fender Team, FenderTec Marine Fendering (Yokohama

S. No.	Makes/ Items	Vendors
		Fender)
7.	Bollard	Trelleborg Sealing Solutions India Private Limited, IRM Offshore and Marine Engineers Private Limited, EJ Bean, UK
Mechanical Ventilation and Air-Conditioning System		
1.	Split Unit (5 Star)	Daikin, Carrier, Voltas, Llyod, Samsung, LG
2.	Centrifugal Fan	Kruger, Nicotra, Wolter
3.	Axial Flow Fan	Kruger, Nicotra, Systemair
4.	Inline / Propeller Fan	Ostberg, Systemair, Alstom
5.	GI Sheet	Jindal, SAIL, TATA
6.	Factory Made Duct	Alpha duct, Nuaire Engineers, Radiant Air Systems
7.	Flexible duct	Atco, Titus, Seven star, UP Twiga
8.	Duct supports	Diamond, Hitech, Seven star
9.	Grille/dampers	Caryaire, Ruskin, Systemair
10.	Anchor Fastener	Fischer, Hilti
11.	UV Protective coating	Armacell Armachek, Amicol, Paramount, Polybond
12.	Demineralized Plant	Ion Exchange, Grey, Water Solutions, Thermax, Va Tech Wabag, Envicare
13.	Fire Sealant	Birla 3 M, BTHM Engineering, Hilti, Promat
14.	Vibration Isolator	Dunlop, Easy flex, Resistoflex
15.	Flexible duct connector	Mapro, Easy flex, Resistoflex
16.	Deep Freezer	Godrej, LG, Samsung, Bosch
17.	Water Cooler	Godrej, LG, Samsung, Voltas
18.	Refrigerator	Godrej, LG, Samsung, Bosch, Whirlpool
19.	Elevators	Otis, Schindler, Mitsubishi, Thyssen Kurup, Kone
Acceptable Proprietary Products for Different Applications		
1.	SBS Polymer Modified Membrane system (For external surfaces of lift pit walls, all surfaces of shear / retaining walls and columns in contact with sub-soil)	Dr. Fixit Samshield XL 1500 (Pidilite), Proofex 3100 (Fosroc), Masterpren 1000(BASF), SmartCare Self-adhesive SBS membrane with HDPE lining (Asian Paints)
2.	Acrylic Polymer Modified Cementitious system (For toilets, balconies, utility areas, water tanks, sunken areas etc.)	Dr. Fixit Pidifin 2K (Pidilite), Brushbond (Fosroc), Top Seal-107 (Sika), Masterseal 550(BASF), SmartCare Suprema Damp

S. No.	Makes/ Items	Vendors
		Block 2K (Asian Paints)
3.	Spray applied PU membrane system (For terrace / roof / podium slab)	Dr. Fixit Superseal 4500 PUH (Pidilite), Masterseal M 800 (BASF), Polyurea WH200 (Fosroc), Sikalastic 901 (Sika) (i)(ae) SmartCare Hypertron Hybrid Polyurea (Asian Paints)
Sanitary Fixtures		
1.	Shower	Hindware, Parryware, Cera, Grohe
2.	Cistern	Hindware, Cera, Parryware
3.	Low Level Flushing Cisterns	Commander, Duralite, Parryware
4.	Stainless Steel Sink	Jayna, Nirali, Cobra
5.	Storage Type Geyser	Havells, AOS, Recold, Bajaj
6.	Vitreous China Sanitaryware (W.C, Wash Basin and Urinal)	Cera, Neycer, Parryware
7.	W.C Seat Covers	Admiral, Tara, Cera
8.	W.C Connectors	Multiwik, Viega
9.	C.P Brass Fittings	Jaquar, Kohler, Grohe, Hindware
10.	Flow Control Devices	Jaquar, RST
11.	Toilet Accessories	Akoi, Parko, Ess Ess
12.	Low Flow Fixtures	Hindware, Jaquar, Schell
Cold Water Supply		
13.	CPVC Pipes and Fittings	Supreme, Ashirwad, Astral
14.	GI Pipes (IS: 1239 and IS: 3589)	TATA STEEL, Jindal Hissar, Surya
15.	GI pipes fitting	Crescent, Unik, Zoloto
16.	GI Pipe Protection Wrapping and Coating	IWL – Pypkote, Neotape, Rustech – Coatek
Valves and Fittings		
1.	Air Release Valve	Marck, RB, Zoloto
2.	Ball Float Valve	CSA Atena, Esseti, Prayag
3.	Butterfly valve	CRI, L&T, Zoloto, Advance, Sant
4.	Check Valve – WaferType	Kirloskar, Leader, Advance, Sant
5.	Gate Valve	Advance, Sant, Zoloto, Leader
6.	GI pipe sealant	Henkel - Loctite 55, Holdtite

S. No.	Makes/ Items	Vendors
7.	Brass Ball Valves	RB, Sant, Zoloto
8.	Pressure Reducing Valve	RB, Zoloto, OR, Honeywell, Siemens
9.	Sluice Valves	Kirloskar, Leader, Zoloto
10.	Water meter (SCADA Compatible)	Dasmesh, Kranti, Kent
Hot Water Supply		
1.	CPVC Pipes and Fittings	Astral, Supreme, Ashirwad
2.	Insulation for Hot Water Pipes (Elastomeric nitrile rubber / EPDM)	ALP Aeroflex, Armacell, K-Flex
Internal Drainage		
1.	Cast Iron Pipes and Fittings (IS:3989)	Kapilansh, Neco
2.	CI Class LA Pipes (IS:1536)	Kapilansh, Neco, Electrosteel
3.	CI Fittings (IS:1538)	Kapilansh, Kartar valves and fittings, Neco
4.	C.I. pipe joints	Aqua bond, Drip seal, Mega seal
5.	C.P. Grating for Floor Trap	Chilly, GMGR, Neer, Viega
6.	C. I. grating	Crescent Foundry, Kartar Pipe and fittings, Neco
7.	D. I. grating	Crescent Foundry, Kartar Pipe and fittings, NECO
8.	D. I. Pipes (IS: 8329) and Fittings (IS: 9523)	Electro Steel, Jindal, Neco
9.	Floor Drain Fixture	GMGR, Neer
10.	Rain water outlet	GMGR, Neer
11.	RCC Pipe	Indian Hume Pipe, Pranali, Dhere, OM spun
12.	Gully Trap	Patel Pattern, Neco, Kapilansh
13.	UPVC Pipes (BIS 4985)	Finolex, Prince, Supreme
14.	Urinal Trap	Chilly, Neer
Fire Fighting, Electro - Mechanical Equipment for Water supply and Sewage collection and turnkey sewage treatment Plants		
1.	Coarse Screens	Jash Engg. Ltd., EMICO-KCP
2.	Fine Coarse	Huber Technology, Headworks
3.	Ultra-Fine Screens	Johnson Screen Ind. Ltd., Huber Technology
4.	Screening Conveyance, Compaction and Dewatering / Belt Conveyor	Geo Miller, Voltas, Triveni

S. No.	Makes/ Items	Vendors
5.	Air Blowers -Twin Lobe	Everest, Kay, Swam
6.	Electric Hoist / Chain Pulley	Indef Engg., Reva Engineering, W.H.Brady & Co. Ltd.
7.	Gear Reducers	Radicon, Greaves, Allen Beri
8.	Geared Motors	Bonfigli, SEW, REMI
9.	Submersible Pumps	Flyght, ABS, Grundfos, CRI, Kirloskar
10.	Horizontal Centrifugal Pumps	Mather & Platt, ABS, Grundfos, CRI, Kirloskar
11.	Screw Pump	UT Pumps Pvt. Ltd., Netzsch
12.	Dosing Pumps	Asia LMI, Milton Roy, Shapotools, EDI, REHAU
13.	Sewage Treatment Plant-Turnkey design, supply, installation, commissioning, operation & maintenance	Doshion, Suez (Formerly Degremont), GE, Black & Veatch, Vatech Wabag
14.	Membrane	GE, KOCH, Siemens (MEMCOR), X Flow Membranes (Pentair X-Flow)
15.	Filter’s Nozzles	Guddi Plastcon
16.	Filter Vessels	Voltas, Triveni, Geo Miller
17.	Y-type Strainer	Fluidyne Instruments Pvt. Ltd., Rakdin Engineers
18.	Centrifuge Unit	Humbolt, Alfa Laval, Hiller, Penwalt
19.	Agitators	Voltas, Geo Miller, Triveni
20.	Submersible Mixers	ABS, Grundfos, Xylem
21.	CI/ Aluminum Open Channel Gate	Jash, Shivpad, Yashwant
22.	Sluice Gates	Kirloskar Brothers Ltd., Indian Valve Company, Jash Engineering
23.	Butterfly Valves	Inter Valves, VAG, IVC, R & D Multiple
24.	Knife Gate Valves	Fouress, Jash, Indian Valve Company
25.	Sluice Valve	Kirloskar Brothers Limited, Indian Valves Company, VAG
26.	Pressure Reducing Valve	SPIR, SANMAR, IVC
27.	NRV	Kirloskar Brothers Ltd., Indian Valve Company, VAG
28.	Diaphragm Valves	BDK, Flowtek
29.	Ball Valves	Kirloskar Brothers Ltd., Indian Valve Company, Jash Engineering
30.	Pneumatic Actuator	Schrader and Duncal, Nucon

S. No.	Makes/ Items	Vendors
		Xomox, George Fischer
31.	Hydraulic Actuator	Vickers, Velgin
32.	Gun Metal Gate Valve	Zoloto, Kirloskar Brothers Limited, Indian Valves Company, VAG
33.	Dash Fasteners	Hilti, Fischer
34.	Motors	ABB, Siemens, CGL, Kirloskar Electric
35.	GI Pipes	Jindal, Tata
36.	CI & DI Pipes & Specials	Tata, Jindal Saw Ltd., Electro Steel Castings
37.	MS Pipe	Jindal, Tata
38.	Stainless Steel Pipe	Jindal, Tata
39.	HDPE Pipe	Supreme, Jain Irrigation, Duraline, Penwalt
40.	UPVC Pipes	Supreme, Finolex, Prince
41.	Electromagnetic flow meter	Forbes Marshall, Yokogawa, Siemens, Endress Hauser
42.	Online water/sewer quality Analyser and Transmitter/ Residual Chlorine Measuring System	HACH, Endress Hauser, Yokogawa
43.	Water/Sewer quality testing Laboratory equipments	HACH, Endress Hauser, Yokogawa
44.	Level Transmitter, Level Switch	Siemens, Endress Hauser, ABB, Forbes Marshall
45.	Pressure Gauge	H. Guru, Waaree, FEIBIG, A.N. Instruments
46.	Ultra Violet (UV) System	ALFA UV- Ace Hygiene, Hanovia, Aquafine
47.	Fire/Jockey Pumps	Mather & Platt, ABS, Grundfos, Xylem, Kirloskar
48.	Diesel Engine	Catterpillar, Kirloskar, Cummins, Clarke
49.	Hydrant Valve, Branch Pipes, Hose Reels/Nozzles/	Minimax, Newage, Vijay, Lifeguard, Safeguard
50.	Fire Brigade inlet/drawout, Hose reel drum, shut off nozzle, Branch Pipe, Fire Man Axe Male & Female Coupling, Water Monitor	Minimax, Newage, Safeguard, Lifeguard
51.	Sprinkler Heads	Tyco, Viking, New age, HD Fire, Grinnell
52.	Fire Extinguishers	Eversafe, Minimax, Safex, Safeguard
53.	Clean Gas	Tyco, 3M, Ginge-Kirr
54.	Intelligent Addressable Smoke Detectors (Optical Type +Multi Criteria)	Notfier, Edwards, Cerebrus-siemens, Hochiki, Honeywell (XLS), Johnson, System Sensor,

S. No.	Makes/ Items	Vendors
		Bosch
55.	Intelligent Addressable Rate of rise heat detectors	Notfier, Edwards, Cerebrus-siemens, Hochiki, Honeywell (XLS), Johnson, System Sensor, Bosch
56.	Zero halogen Copper Cables	Finolex, Lapp, Belden, Tyco, Polycab
57.	Addressable Networkable Fire Alarm Panel	Notfier, Edwards, Cerebrus-siemens, Honeywell (XLS), Johnson, Morley, Bosch
58.	Manual Call Stations	Notfier, Edwards, Cerebrus-siemens, Honeywell (XLS), Johnson, Morley, Bosch
59.	Strobe Lights	Edwards, Cerebrus-siemens, Hochiki, Honeywell, Johnson, Bosch
60.	Alarm Valve	Tyco, Wiking, HD fire, Fire Safe
61.	MS conduit	BEC, AKG, Bharat
62.	Cable tray	Slotto, Profab, OBO, MM Enterprises
63.	Communication Cable - Indigenous	Finolex, Lappkabel, Neolex
64.	Rubber pipe for hose reel	Dunlop, Good Year, Lifeguard, National, Padmini
65.	Actuator SCADA compatible	AUMA, Rotork, Marsh, Limitorque, L & T
66.	PLC / SCADA	Schneider, Siemens, ABB, Rockwell Automation, Tata Honeywell
67.	Soft Starter	Rockwell Automation, Schneider, Siemens, Danfoss, Innovative, ABB, L&T, Alstom
68.	LT Variable Frequency Drive (VFD)	Schneider, Siemens, ABB, Danfoss, L&T, Allen Bradley
69.	SMPS	Pheonix, Schneider, ABB, Rockwell Automation
70.	Computers for PLC & Office	HP, Compaq, Dell
71.	Starters for motors	L&T, Siemens, ABB, Schneider, C & S
72.	Cables (Power & Control)	Havells, KEI, KEC International, Universal, Finolex Cables Ltd., Nicco
73.	MCC / L.T Panels / PDB / LDB Panel	Schneider, L & T
74.	Switchgear	ABB, Siemens, Schneider, Bharat Heavy Electricals Ltd., Crompton Greaves, Kirloskar Electric Ltd.
75.	Control Gear	L & T, ABB, Siemens, GE, Schneider, Control and Switchgear, Bhartia Cutler Hammer
76.	Contactor	Electric Control Gear Ltd., ABB, Siemens, Schneider
77.	Over Load Relay	L & T, ABB, Siemens, Schneider

S. No.	Makes/ Items	Vendors
78.	PUSH BUTTONS and Push Button Station	L&T, Siemens, Schneider, Crompton Greaves Ltd.
79.	LT Electronic Over current/ Overload Relay	L&T, ABB, Siemens
80.	MV/HT Electronic Motor Protection Relay	L&T, ABB, Siemens
81.	Vacuum Circuit Breakers	CGL, ABB, Siemens
82.	Air Circuit Breaker	L&T, Schneider, Siemens
83.	Moulded Case Circuit Breaker (MCCB)	Schneider, Siemens, ABB, GE, C&S, Alstom
84.	Street Light / Flood Light Fixtures	CGL, Wipro, Philips
85.	Selector Switch	L&T, Leader, Salzer
86.	LT Capacitors	L&T, ABB, BCH
87.	Battery (Maintenance Free)	Amco Batteries Ltd., Exide, Tata green, Amaron
88.	Battery Charger	Statcom, Automatic Electric ltd., APCO, AEP
89.	DFT	Ashok Leyland, TATA
90.	Hydraulic Platform	Liftmak, Techvos India
91.	Water Lorry	Ashok Leyland, TATA
Electrical Services		
1.	Switchgear Panels	Siemens, ABB, Schneider Electric
2.	Relays for Panels	Siemens, ABB, Schneider Electric, L&T
3.	Dry Type Distribution Transformer	Voltamp, ABB, Rpg-Raychem, Kirloskar, Dtpl, Ames Impex
4.	PCC / MCC / LV PANELS (Factory Assembled)	L&T, Siemens, ABB, Schneider, Tricolite, Neptune
5.	Relays FOR PCC / MCC / LV PANELS	L&T, Siemens, ABB, Schneider
6.	Automatic Transfer Switch	Schneider, ASCO, Socomec, ABB
7.	Air Circuit Breaker (ACB) (Microprocessor Type)	L&T, Siemens, ABB, Mitsubishi, Schneider
8.	Moulded Case Circuit Breaker (MCCB) (Microprocessor Type)	L&T, Siemens, ABB, Mitsubishi, Schneider
9.	Miniature Circuit Breakers (MCB)	Siemens, Mitsubishi, Schneider, Legrand, ABB
10.	RESIDUAL CURRENT CIRCUIT BREAKER (RCCB)	Siemens, Schneider, Mitsubishi Legrand, ABB
11.	Distribution Boards	L&T, Schneider, Mitsubishi, Legrand, ABB

S. No.	Makes/ Items	Vendors
12.	Voltage Conditioner	Jindal, Schneider, Piller (Germany)
13.	Frequency Converter	Piller (Germany), Jindal, Schneider
14.	Main Distribution/ Sub Distribution Panel/Meter Boards	Popular Switchgear, Scoot Engineering, Zenith Engineering, Sterling and Wilson
15.	Power/Aux. Contactors/ Overload Relays with Built in Single Phase Preventer	ABB, Epcos, L&T, Schneider Electric, Siemens
16.	Off-load change over switch	ABB, Legrand, Schneider, Siemens
17.	Potential Transformers	Automatic Electric, Gilbert and Maxwell, Pragati
18.	Current Transformer (Epoxy Cast Resin)	Automatic Electric, Gilbert and Maxwell, Pragati
19.	Indicating Lamps Led Type, Push Button	Altos, Schneider Electric, Siemens, Teknik
20.	Electronic Digital Meters/Dual Source Energy Meters/Tariff Meters (A/V/PF/HZ/KW/KWH) (NETWORKABLE)	Automatic Electric, L&T, Mitsubishi, Schneider, Secure
21.	Power Cables	Kei, Finolex, CMI, RPG, Unistar, Universal, Unicab, Polycab, Havells
22.	LT Jointing Kit / Termination	BIRLA-3M, Raychem, Denson
23.	Cable glands double compression with earthing links	Baliga Lighting, Comet, Cosmos, Dowells
24.	Bimettalic / Copper / Aluminum cable Lug	Comet, Cosmos, Dowell's (Biller India), Hax Brass (Copper Alloy India)
25.	PVC Insulated Copper Conductor Stranded Flexible Stranded Wire	Finolex, Kei, Havells, RPG
26.	PVC Conduit (ISI APPROVED)	AKG, BEC, D PLAST
27.	Cable Trays / Raceways (Prefabricated)	Maheshwari Electricals (MEM), Obo Bettermann, Profab
28.	Polycarbonate Junction Boxes	Hensel, Clipsal, Sintex
29.	Insulating Mats	Commercial Enterprises, DL Miller, Premier Polyfilm, RMG Polyvinyl., Jyoti
30.	Terminal blocks	Connect Well, Elmex, Wago
31.	Industrial socket	Siemens, Legrand, Crompton Greaves, Schneider Electric
32.	LED	Philips, Thorn, Bajaj
33.	External Lighting Fixture	Philips, Thorn, Wipro
34.	Selector switch, Toggle switch	Kaycee, Salzer (L&T)
35.	Lighting Poles	Bombay Tubes and Poles, Bajaj Electricals, Homdec Lighting

S. No.	Makes/ Items	Vendors
36.	Receptacles	Marechal-Electric, Legrand, Eaton, Mennekes, Schneider, Neptune
37.	Earthing system and accessories	MAHESHWARI ELECTRICAL MFRS P.LTD., JMV, DEHN, VNT, BBN ENERGY
38.	Isolators	Siemens, ABB, Schneider, Hensel Electric
39.	Single Phase Transformer Rectifier	Siemens, ABB, Schneider, Hensel Electric
Furnitures		
1.	Chair CBA Steel	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
2.	Executive Chair	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
3.	Ergonomic Chair	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
4.	Revolving Chair	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
5.	Steel Table – Clerk	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
6.	Steel Table with drawers (Engineers)	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
7.	Working Table with drawers (Port Staff)	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
8.	Large Table- Staff Room (CEO and Directors)	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
9.	Steel Almirah (Movable)	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
10.	Steel Almirah	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
11.	Filing Cabinet	Godrej, Featherlite, Ergo Furniture, Cello, Supreme, Nilkamal
Lighting and Ventilation		
1.	LED Wraparound Light with Fixture	Havells, Philips, Wipro, Bajaj, Osram
2.	Ceiling Fan	Usha, Bajaj, Orient, Crompton Greaves, Havells
3.	Split Unit AC (5 Star)	Daikin, Carrier, Voltas, Llyod, Samsung, LG

2.22.7 List of Minimum Furnitures

The Contractor shall use the following list of quantities as minimum required or tentative for the materials mentioned in section 2.22.6.1 as per the below table:

Table 2.3: Minimum Furniture Quantity

S. No.	Makes/ Items	Quantity (Unit Nos)
Administrative Building		
1.	Executive Chair	4
2.	Revolving Chair	8
3.	Visitors Chair (Wooden)	24
4.	Administrative Reception Table	1
5.	Steel Table – Clerk	4
6.	Steel Table with drawers (Engineers)	4
7.	Working Table with drawers (Port Staff)	6
8.	Large Table (6'x 4')	4
9.	Conference Table (Wooden)	1
10.	Conference room chairs (Wooden)	12
11.	Steel Almirah (Movable)	2
12.	Steel Almirah	5
13.	Filing Cabinet	5
14.	LED Wraparound Light with Fixture	5 (Each floor)
15.	Ceiling Fan	8 (Each floor)
16.	Split Unit AC (5 Star)	4 (Each floor)
Security Cabin		
1.	Revolving Chair	2
2.	Steel Table with drawers	2
3.	Steel Almirah	1
4.	LED Wraparound Light with Fixture	1
5.	Ceiling Fan	2
6.	Split Unit AC (5 Star)	2
Substation Office		
1.	Ergonomic Chair	3
2.	Revolving Chair	3
3.	Steel Table with drawers	3
4.	Steel Almirah	2

S. No.	Makes/ Items	Quantity (Unit Nos)
5.	LED Wraparound Light with Fixture	6
6.	Ceiling Fan	11
7.	Split Unit AC (5 Star)	10

2.22.8 List of General Codes and References

The list of general codes and references to be referred for materials, workmanship & design for various elements have been listed below. Though the codes have been categorised into specific elements, If a particular code specific to the element is not included under that section then the code listed under sections of other elements shall be referred as applicable.

Dredging and Reclamation	
Code of practice for Dredging and Land Reclamation	BS:6349 – Part 5
Code of Practice for Planning and Design of Ports and Harbours – Site Investigation	IS:4651 – Part I
Guidelines for the Design of Armoured Slopes under Open Piles Quay Walls	PIANC
CIRIA Manual	
Coastal Engineering Manual	
Testing of fill materials	BS 812 & BS 1377
Determination of Tensile Strength Nonwoven Geotextiles & elongation parameters.	ISO:10319
Determination of Opening size O90 Geotextile	ISO:12956
Determination of Thickness OF Nonwoven fabrics - Textiles	ISO:9863
Determination of Permeability (H = 50mm)	ISO:11058
Determination of horizontal water flow (20kPa)	ISO:12958
Civil and Marine Works	
Plain and Reinforced Concrete – Code of Practice, Fourth Revision	IS:456
General Construction in Steel – Code of Practice, Third Revision	IS:800
Code of Practice for Design Loads (Other than Earthquake) for Building and Structures - Part 1, Dead Loads – Unit Weight of Building Materials and Stored Materials, Second Revision Incorporating Amendment No.1, Reaffirmed 1997	IS:875 (Part 1)
Code of Practice for Design Loads (Other than Earthquake) for Building and Structures - Part 2, Imposed Loads, Second Revision, Reaffirmed 1997	IS:875 (Part 2)
Code of Practice for Design Loads (Other than Earthquake) for Building and Structures - Part 3, Wind Loads, Second Revision, Reaffirmed 1997	IS:875 (Part 3)
Criteria for Earthquake Resistant Design of Structures	IS:1893

Criteria for Earthquake Resistant Design of Structures - Part 1: General Provisions and Buildings, Fifth Revision	IS:1893 (Part 1)
Criteria for Earthquake Resistant Design of Structures - Part 4: Industrial Structures Including Stack-Like Structures	IS:1893 (Part 4)
Code of Practice for Design and Installation of Joints in Buildings, Reaffirmed 2000	IS:3414
Code of Practice for Planning and Design of Ports and Harbours, Part II Earth Pressures	IS:4651 (Part II)
Code of Practice for Planning and Design of Ports and Harbours, Part III Loading, First Revision, Reaffirmed 2012	IS:4651 (Part III)
Code of Practice for Planning and Design of Ports and Harbours, Part IV, General Design Considerations, Second Revision, Reaffirmed 2005	IS:4651 (Part IV)
Code for Planning and Design of Ports and Harbours Part V, Layout and Functional Requirements, Reaffirmed 2012	IS:4651 (Part V)
Code of Practice for Design and Construction of Bored Cast In situ Piles	IS:2911(Part1/Sec2)
Load Test On Piles	IS:2911 (Part 4)
Code of Practice for Determination of Bearing Capacity of Shallow Foundations	IS:6403
Code of Practice for Concrete Structures for the storage of liquids	IS:3370
British Standard for Maritime Structures, Part 4: Code of Practice for Design of Fendering and Mooring Systems	BS 6349; Part 4
Code of Practice for Protection of Slope for Reservoir Protection	IS:8237
Planning and Design of Revetments – Guidelines	IS:14262
PIANC Guidelines for the Design of Fender System, 2002	PIANC
PIANC Guidelines for Seismic Design of Marine Structures	PIANC
Coastal Engineering Manual, US Army Corps of Engineers, 30 April 2002	EM 1110-2-1100
Guidelines for planning and design of river embankment (levees)	IS:12094
Code of practice for stability analysis of earthen dam	IS:7894
Coastal Engineering Manual 2006 (CEM 2006)	
Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces – Code of Practice	IS:13920
Earthquake Resistant Design & Construction of Buildings – Code of Practice, National Building Code (2005)	IS:4326
The use of Structural Steel in Building (Permissible Stress)	BS 449
Schedule of Weights and Building Materials	BS 648
Protective Coating of Iron and Steel Structures against Corrosion	BS 5493
Structural Use of Steel work in Building (Limit State)	BS 5950

Earthworks	BS 6031
Code of Practice for Drainage of Roads and Paved Areas	BS 6367
Loading for Buildings	BS 6399
Earth Retaining Structures	BS 8002
Foundations	BS 8004
Structural use of Concrete	BS 8110
Site Investigation	BS 5930
RDSO Guidelines for earthwork in Railway projects	
RDSO Guidelines for Design and Specifications of Formation for Heavy Axle Load	
Cast Steel Bollards	
Specifications for carbon steel casting for general engineering purposes	IS:1030
General requirements for supply of metallurgical materials	IS:1387
Code of practice for ultrasonic Pulse Echo Testing by contact and Immersion methods	IS:3664
Method for bend test for steel products other than sheet, strip, wire and tube	IS:1599
Method of tensile testing of steel products	IS:1608
Roads & Pavements	
Methods of Test of Soil	IS:2720
Standard Specifications and Code of Practice for Road Bridges, Section II: Loads and Stresses, Fifth Revision	IRC:6
Standard Specification and Code of Practice for Water Bound Macadam	IRC:19
Guideline for the Design of Flexible Pavements	IRC:37
Standard Specifications and Code of practice for Roads Bridges. Section VII-Foundations and Substructure.	IRC:78
Specification of Paving Bitumen	IS:73
Specification for bitumen mastic for flooring	IS:1195
Specification for bitumen felts for water proofing and damp proofing	IS:1322
Specification for Bituminous compounds for water proofing and caulking purposes	IS:1834
Specification for preformed fillers for expansion joint in concrete pavements and structures	IS:1838
Specification for bitumen mastic for use in water proofing of roofs	IS:3037
Specification for bitumen primer for use in water proofing and damp proofing	IS:3384
Specification for Bitumen Mastic for Tanking and Damp proofing	IS:5871

Specification for Glass fibre base coal tar pitch & bitumen felts	IS:7193
Code of practice for damp proofing using bitumen mastic	IS:7198
Specification for bitumen Mastic, Anti Static and electrically conducting grade	IS:8374
Cement	
Specification for Portland slag cement	IS:45
Specification for Portland pozzolana cement	IS:1489
Specification for Masonry Cement	IS:3466
Specification for high alumina cement for structural use	IS:6452
Specification for super sulphated cement	IS:6909
Specification for rapid hardening portland cement	IS:8041
Specification for 43 grade ordinary portland cement	IS:8112
Specification for 53 grade ordinary portland cement	IS:12269
Specification for Sulphate Resisting Portland cement	IS:12330
Steel Reinforcement	
Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (grade I)	IS:432
Specification for hard drawn steel wire fabric for concrete reinforcement	IS:1566
Specification for plain hand drawn steel wire for pre-stressed concrete	IS:1785
Specification for high strength deformed steel bars and wires for concrete reinforcement	IS:1786
Steel for general structural purpose (Grade A)	IS:2062
Specification for high tensile steel bars used in pre-stressed concrete	IS:2090
Specification for indented wire for pre-stressed concrete	IS:6003
Structural Steel	
Steel tubes for structural purposes	IS:1161
Mild Steel Tubes, tubulars and other wrought steel fittings	IS:1239
Hollow steel sections for structural use	IS:4923
Miscellaneous Steel Materials	
Expanded Metal Steel Sheets for General purposes	IS:412
Hexagonal head bolts, screws & nets of product grade C	IS:1363
Cold formed light gauge structural steel sections	IS:811
Technical supply conditions for threaded steel fasteners	IS:1367
Plain washers	IS:2016

Steel wire ropes for general engineering purposes	IS:2266
Thimbles for wire ropes	IS:2315
Bulldog grips	IS:2361
Drop forged sockets for wire ropes for general engineering purposes	IS:2485
Steel chequered plates	IS:3502
Hexagonal bolts and nuts (M42 to M150)	IS:3138
Admixtures	
Specification for integral cement water proofing compounds	IS:2645
Specification for other admixtures for concrete	IS:9103
Painting	
Specification for building limes.	IS:712
Specification for Ultramarine blue for paints.	IS:55
Specification for whiting for paint and putty.	IS:63
Distemper (dry), colour as required.	IS:427
Distemper (Oil Bound), colour as required.	IS:428
Cement paint, colour as required.	IS:5410
Brushes, paints and varnishes, flat	IS:384
Brushes, sash, tool, for paints and varnishes.	IS:486
Ready mixed paint, brushing, grey filler enamels for use over primers.	IS:110
Paste filter for colour coats.	IS:426
Wood filler, transparent liquid.	IS:345
Ready mixed paint, aluminium brushing priming water resistant for woodwork	IS:3585
Stones	
Method of identification of natural building stones	IS:1123
Recommendations for dimensions and workmanship of natural building stones for masonry work	IS:1127
Recommendations for dressing of natural building stones	IS:1129
Woodwork / Timber	
Classification of commercial timbers and their zonal distribution	IS:399
Specification for ballies for general purposes	IS:3337
Specification for ply wood for concrete shuttering work	IS:4990
Specification for wooden flush door shutters (solid core type) plywood face panels	IS:2202-Part I

Specification for wooden flush door shutters (Solid core type) practice board and hard board face panels.	IS:2202-Part II
Specification for Timber panelled and glazed shutters -Door shutters	IS:1003 Part - I
Specification for wood particle boards (medium density) for general purposes	IS:3087
Specification for Veneered particles board	IS:3097
Specification for synthetic Resin Adhesives for plywood (phenolic and Amino plastic)	IS:848
Specification for nonferrous metal butt hinges	IS:205
Code of Practice for finishing of wood and woodbased materials (Part-1& Part-11)	IS:2338
Specification for steel butt hinges	IS:1341
Specification for timber door, window and ventilator frames	IS:4021
Specification for plywood for general purpose	IS:303
Steel/Aluminium Doors, Windows and Ventilators	
Specification for metal rolling shutters and rolling grill	IS:6248
Code of practice for fixing and glazing of metal (steel and Aluminium) doors, windows and ventilators.	IS:1081
Specifications for steel door frames.	IS:4351
Specifications for Aluminium doors, windows and ventilators.	IS:1948
Specifications for steel windows for Industrial buildings.	IS:1361
Specifications for steel doors/windows and ventilators.	IS:1038
Method of measurement of glazing.	IS:1200 (Part XIV)
Specifications for fire check doors.	IS:3614
Specification for hot rolled steel sections for doors, windows and ventilators.	IS:7452
Flat transparent sheet glass.	IS:2835
Wired and Figured glass.	IS:5437
Safety glass.	IS:25583
Steel Sheet Roofing and Siding	
Specification for sheet metal rainwater pipes upto 100 mm nominal size gutters, fittings and accessories.	IS:1728
Cast iron rainwater pipes & fittings.	IS:1230
Specification for unreinforced corrugated and semi corrugated asbestos cement sheets.	IS:459
Hook bolts for corrugated sheet rooting.	IS:730
Galvanised steel sheet (plain & corrugated)	IS:277

Floor Finishing	
Recommendations for selection of Industrial floor finishes	IS:4971
Code of practice for laying insitu terrazzo floor finish.	IS:2114
Specification for Cement concrete flooring tiles	IS:1237
Specification for glazed earthenware wall tiles	IS:777
Code of practice for laying in situ cement concrete flooring	IS:2571
Code of practice for laying of epoxy resin floor toppings.	IS:4631
Code of practice for unbaked flexible PVC flooring.	IS:3462
Code of practice for laying of flexible PVC sheet and tile flooring	IS:5318
Specifications for PVC asbestos floor tiles.	IS:3461
Code of practice for laying in situ granolithic concrete floor topping.	IS:1443
Code of practice for laying in situ granolithic concrete floor topping.	IS:5491
Code of practice for use of silicate type Chemical resistant mortars.	IS:4441
Code of practice for use of resin type chemical resistant mortar.	IS:4443
Code of practice for laying Bitumen Mastic flooring	IS:1196
Electrical Distribution System	
Colours for Ready Mix Paints	IS:5
Three phase Induction Motors (3 Amendments)	IS:325
Insulating oil for transformer	IS:335
Marking and arrangement of switchgear, bus bar, main connections and auxiliary wiring.	IS:375
Aluminium conductors for overhead transmission purposes	IS:398
PVC Insulated Unsheathed and Sheathed Cables/Cords with rigid and Flexible Conductor for rated voltages upto and including 450/750 V	IS:694
AC electricity meters	IS:722
Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 V.	IS:731
Code of practice for Electrical wiring installation	IS:732
Code of practice for installation and maintenance of induction motors	IS:900
Dimensions of three phase foot mounted induction motors (4 Amendments)	IS:1231
Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 9 : Test Methods	IS:1248
PVC insulated (heavy duty) electric cables (Part I & II)	IS:1554
Power Transformers	IS:2026

Method of high voltage testing	IS:2071
Bushings for alternating voltages above 1000 Volts	IS:2099
Conductors and earth wire accessories for overhead power lines	IS:2121
Degree of protection provided by enclosure for low voltage switch gear and control	IS:2147
Flameproof enclosure of electrical apparatus	IS:2148
Insulation co-ordination for equipments of 110KV and above	IS:2165
HRC cartridge fuse links for voltage upto 650 V.	IS:2208
Code of practice for protection and allied structures against lightning. (1 Amendment)	IS:2309
Porcelain post insulators for systems with nominal voltage greater than 1000 V	IS:2544
Recommended practice for hot-dip galvanizing on iron and steel	IS:2629
Methods for testing uniformity of coating of zinc coated articles	IS:2633
Current Transformer	IS:2705
Tubular Steel Poles	IS:2713
Code of practice for Earthing (2 Amendments)	IS:3043
Voltage Transformers	IS:3156
Code of practice for climate proofing of electrical equipment	IS:3202
Electrical Relays for Power System Protection	IS:3231
Dimensions of porcelain for transformer	IS:3347
AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV	IS:3427
Toggle Switches (3 Amendments)	IS:3452
Waterproof electric lighting fittings	IS:3528
Gas operated relay (1 Amendment)	IS:3637
Fitting and Accessories for power transformers	IS:3639
Code of Practice for Interior Illumination	IS:3646
Resistance wire, tapes and strips for heating elements (3 Amendments).	IS:3725
Application guide for electrical relays for ac systems	IS:3842
Recommended current ratings for cables: Part 2 PVC insulated and PVC sheathed heavy duty cables (Part II-2 Amendments)	IS:3961
Mild steel wires, strips and tapes for armouring cables	IS:3975
Guide for testing three phase induction motors	IS:4029
Push Button Switches (Part 2)	IS:4794

Hot-dipped galvanised coatings on round steel wires	IS:4826
Methods of determination of efficiency of rotating electrical machines (2 Amendments)	IS:4889
Wrought aluminium and aluminium alloy bars, rod, tubes and sections for electrical purposes (2 Amendments)	IS:5082
Guide for safety procedure to practices in Electrical work	IS:5216
Electrical power connectors	IS:5561
Guide for marking of Insulated Conductors	IS:5578
PVC insulation and sheath of electric cables (2 Amendments)	IS:5831
Designation of methods of cooling for rotating electrical machines	IS:6362
Guide for loading of oil immersed transformers	IS:6600
Cross linked polyethylene insulated PVC Sheathed cables	IS:7098
Guide for improvement of power factor in consumer installation: Low and medium supply voltages	IS:7752
Guide for testing insulation resistance of rotating machines	IS:7816
Conductors for insulated electric cables and flexible cords	IS:8130
Low-Voltage Switchgear and Controlgear Assemblies	IS:8623
Values of performance characteristics for three phase induction motors	IS:8789
High Voltage Fuse	IS:9385
Conduits for electrical installations (2 Amendments)	IS:9537
AC Electricity Meters	IS:9792
Alternating current dis-connectors (isolators) and earthing switches for voltages above 1000 V.	IS:9921
High pressure Sodium Vapour Lamps (2 Amendments)	IS:9974
Code of practice for selection, installation and maintenance of Transformers	IS:10028
Code of practice for selection, installation and maintenance of switchgear and control gear	IS:10118
Luminaries (with Amendments)	IS:10322
Dry type Power Transformers	IS:11171
Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals	IS:11353
Control Transformers for Switchgear and Controlgear for Voltages not Exceeding 1000 V ac	IS:12021
Permissible limits of noise level for rotating electrical machines (1 Amendment)	IS:12065
Mechanical Vibration of Rotating Electrical Machines with Shaft Heights 56	IS:12075

mm and Higher - Measurement, Evaluation and Limits of Vibration Severity	
High Voltage alternating current circuit breakers	IS:13118
Low-voltage fuses for voltages not exceeding 1000V AC or 1500 V DC (Part 2)	IS:13703
Low voltage switchgear and control gear	IS:13947
Rotating electrical machines: Part 5 Degrees of protection provided by the integral design of rotating electrical machines (IP CODE) - Classification	IS:60034-5
High-Voltage Switchgear Alternating Current Contactors and Contactor-Based Motor Starters	IS:60470
HVAC circuit breakers	IEC 62271
Bushings for Alternating Voltages above 1000 V	IEC 137
Specification and acceptance of new sulphur hexafluoride	IEC 376
High Voltage testing techniques	IEC 60
Instrument Transformer	IEC 44
Alternating current dis-connectors (isolators) and earthing switches	IEC 129
Insulation co-ordination	IEC 171
Current Transformer	IEC 185
Potential Transformer	IEC 186
Electrical Relays	IEC 255
Partial discharge measurement	IEC 270
Static Meters	IEC 1036
Method for RIV test on high voltage insulators.	IEC 8263
Current Transformer	IEC 60044-1
Guide for safety in alternative current substation grounding Indian Electricity Rules	ANSI/IEEE 80

3.0 SCOPE OF WORK

3.1 Description of Contractor's Scope of Work

3.1.1 Employer's Requirements

The Employer's Requirements are that the Contractor shall carryout the Engineering, Design, Procurement of materials and Construction / installation of all the items listed in this tender document as per the scope, design criteria, specifications and drawings outlined in this tender document. For this purpose, the Tenderer shall conduct all necessary field tests and surveys to satisfy / verify himself regarding the correctness of the data furnished vis-à-vis actual condition. The tenderer may also carry out such surveys and investigations even before the submission of tender. No claim whatsoever will be entertained for any variation between the actual site condition met with during the execution of the work and those indicated herein. The Contractor shall be deemed to have examined the site and familiarized himself with all existing site conditions. He shall accept the Site in the existing condition at the time of award of the Contract.

The specifications provided in the tender together with enclosed scope drawings outlines the functional requirements and the operating characteristics which the structures must fulfil. Alternative technical features/designs other than those specified may be acceptable subject to the approval of the Employer. In any case, the performance of the system/ equipment, if any, delivered shall be guaranteed in every detail by the Contractor. Overall dimensions (boundary dimensions) and functional requirements as specified shall be strictly adhered to. The scope of work outlined below is for overall understanding of the Works and does not absolve the Contractor from successful commissioning and operation of the Works with best available latest technology. Any item/equipment not listed but required for completion of the Works shall be considered as included in the scope of the Contractor.

3.1.2 Items to be Covered under this Tender Package

As part of this tender document the broad items of works covered are listed below:

- Jetty including all fixtures
- Approach trestle connecting the jetty with Onshore terminal area
- Site filing and levelling
- Shore protection works
- Open storage areas
- Buildings viz. Terminal Administration building, Substation & generator room, Canteen & Restroom, Security office, Electrical Substation
- Electrical works
- Roads
- Vehicle parking area
- Water supply

- Storm water drainage
- Sewerage system
- Fire-fighting system

The entire scope of work of the EPC Contractor is split into various groups for the purpose of monitoring. The broad items of works covered under each group are listed below:

Group-1: Shore Protection and Land filling

Group-2: IWT Jetty and Approaches

Group-3: Onshore facilities

Group-4: MEP Works

The contractor while executing the Works shall follow good industry practice, which however shall meet the Employer's Requirements. The Contractor shall adhere to and honour the Conditions of the Contract in all respects.

3.2 Scope of Work

The Detailed scope of work under this Contract Package is given below. This shall be read in conjunction with the specifications, design criteria and tender drawings provided as part of the Package:

3.2.1 Group 1 – Shore Protection and Land filling

The scope shall comprise of the following:

1. providing the shore protection around the boundary of the IWT terminal, for approximate length of 680 m as per details provided in tender document.
2. Land filling to the formation level of +37.5 m CD.
3. Site Clearance, removal and disposal of all non-suitable materials lying at site.
4. Provision, Transport, placing, monitoring, testing of the suitable material, including the dredged material, to form part of reclaimed fill if suitable. The fill material will be identified and transported to location by contractor either by hydraulic filling of the suitable dredged material or from approved quarries / borrowed areas.

3.2.2 Group-2: IWT Jetty and Approach

The contractor shall provide the IWT jetty with one approach trestle as outlined in this tender document and as per broad details given in

Table 3.1**.**

Table 3.1: Deck Levels and Dimensions

Component	Overall Length	Minimum Deck Width	Minimum Dredged Level	Deck Level
IWT Jetty	100 m	21 m	-3.0 m CD	+37.0 m
Approach trestle	136 m	7 m	-	+37.0 m to +37.5

The general arrangement of the jetty and trestle is shown in the Tender drawings.

While the location, alignment, length, deck size and, levels, minimum width of the jetty and trestle are frozen, the contractor can adopt the structural arrangement as per his design. The sections of the berthing structures, member sizes shown in the drawings, if any, are only indicative.

The Jetty structure shall have all the required accessories/fixtures including but not limited to the following:

- Rubber fenders including all its ancillaries as per specifications
- Bollards
- RCC stairs and Safety ladders
- Handrails
- Rubbing strip for the protection of edges of berths from rubbing of mooring ropes
- Rail trench and cable grooves along the length of the berth
- Utility/ Service trench for cables, pipelines etc.
- Drain pipes shall be embedded at regular intervals in the rail trenches and along the proposed berths.
- Galvanised iron edge angles at various locations including on the sides of openings/pits viz. rail grooves, tie down pits, storm anchor pockets, trenches etc.
- Typical details of jetty fixtures are shown in the Section 8 for the information of the Tenderer.
- All the structures shall be design as per the outline design criteria provided in this tender document.
- All necessary inserts/fixtures viz. insert plates, base plates, anchor bolts, crane rails, including fixtures for storm anchors, tie downs etc. shall be procured and provided by the contractor as per the drawings supplied by employer, during construction of structures.

- The jetty and trestle shall be provided with utility trench to carry utilities such as pipelines, cables etc. The trench covers shall be seated properly and shall be intact with the trench side walls. The arrangement of trench, the trench covers etc. shall be designed to ensure that the supply from the respective pipelines/cable can be tapped without detriment to the travel of loaders, unloaders, cranes etc during operation.

3.2.3 Group-3: Onshore Facilities

The Contractor shall provide Onshore Facilities along with associated works as outlined in this tender document:

3.2.3.1 Buildings

The scope of the works under this group includes the design, procurement, construction of Admin Office building, port in call office, Substation & generator room, Pump House, Canteen & Restroom, Customs office building, Guard room, Electrical Substation, Storage Sheds and Weigh Bridge building including all necessary fixtures and fittings to meet the employer's requirements, as per the broad details provided in **Table 3.2**.

Table 3.2: Building Design Parameters

S. No.	Building	Type	Total Minimum Built up Area (Sqm)	Estimated Users
1.	Admin Office building	G + 2 Storied Building	1560 sqm	28
2.	Port in call office	Single Storied Building	70 sqm	4
3.	Substation	Single Storied Building	162 sqm	6
4.	Pump House	Single Storied Building	84 sqm	2
5.	Canteen & Restroom	Single Storied Building	368 sqm	50
6.	Customs office building	Single Storied Building	70 sqm	4
7.	Storage Sheds	Single Storied Building with trussed roof	1080 sqm	5
8.	Guard Room – 1 Nos.	Single Storied Building	25 sqm	4

The Administration building shall have provision of conference rooms, rest rooms, staff rooms, waiting lounges, two elevators, office areas, recreational and dining facilities, customer service desks etc.

All buildings shall have the required power, lighting and illumination, communication, water, sanitary arrangements, air conditioning, IT infrastructure, Architectural finishes, Furnitures, cabinets, firefighting facilities, landscaping and pavements around buildings etc.

The scope shall include providing and laying of LAN cables, wiring etc and suitable slots for electrical and IT infrastructure.

The contractor shall prepare 2 alternative architectural layouts for each building, meeting the requirements as set out in the tender and submit to employer. The detailed design of the buildings shall be taken up only after the Employer's acceptance of the final architectural scheme of the respective building.

The contractor shall develop high quality Furniture and Cabinetry designs, working drawings, and specifications for review and approval by the Engineer.

Some of the design inputs required from the contractor include:

1. Design and sizing of all furniture items – fixed and movable, in all buildings in compliance with National Building Code.

2. Design of shutters, partitions, shelves and drawers in all cabinets

3. Design of joinery and fixing details of all furniture items in all buildings.

4. Preparation of a comprehensive material palette including colour schemes, laminates, sunmica for all furniture.

The Contractor must develop and work out the designs of respective furniture items within the dimensions specified. In case of any conflict or deviations, or in case of missing dimensions, the same will be brought to the notice of the Engineer and his approval will be taken prior to commencement of work.

The contractor shall be aware and consider all factors like climate, moisture, pests and termites which may/will influence the design, material and fixing details.

Contractor shall develop furniture and light fixtures layout for review and approval by the Engineer.

Though the list of minimum furniture and fixtures is provided in **Section 2 of Volume-II** the Contractor shall work out and provide the furniture and electrical fixtures required based on the building occupancy, NBC requirements and guidelines given below.

(a) One Ceiling fan for every 15 sqm of area.

(b) Lights to have average illuminance of 200 lux in all building areas expect control room where the average illuminance shall be 300 lux.

(c) One Split Air conditioner of 1.0T capacity for every 10 sqm of area.

(d) One 230V 5amp 3-pin sockets for every 10 sqm area

3.2.3.2 Main Receiving Station and Substation

The Contractor shall carry out engineering, design and construction of Main receiving station to receive the power supply from the main Power grid line.

Contractor shall plan, design and construct suitable substations equipped with metering systems, circuit breakers, capacitor banks for automatic power factor correction and monitoring the PF. From the substation the feeder pillars shall be provided near the respective building and load centers.

3.2.3.3 Boundary Wall & Fencing

A 2.4 m high boundary wall with barbed wire fencing 0.9 m high over it shall be provided around the terminal as indicated in the tender drawing. The approximate overall length of wall shall be 850 m. Suitable foundation system (either Pile foundation or Strip foundation) for the boundary wall shall be provided by the Contractor based on his design to satisfy the Design Criteria. Layout and Typical Details of Boundary wall are shown in Tender drawings enclosed in **Section 7 of Volume-II.**

3.2.3.4 Gate Complex with Security Cabin/ Guard Room

The gate complex shall comprise a gate house with gate portal structure and entrance/exit area to provide two entry and two exit lanes. The gate complex shall also have traffic control barriers (electrically operated drop-arms) and electrical signage and signalling devices.

Two Security cabins shall be provided near the gates. Typical details and dimensions are shown in Tender drawings enclosed in **Section 8.**

3.2.3.5 Surface Drainage

Contractor shall provide a drainage system for carrying the storm water run-off from the terminal area to the identified outfall point. Typical Layout for Drainage is shown in tender drawings enclosed in **Section 8.**

3.2.3.6 Sewerage

The scope shall include laying of pipelines for collection of the sewage from Buildings to a collection pits and laying the pipelines from collection pits to septic tank. The contractor shall also provide arrangement for disposal of treated sewage to the nearest storm water drain system.

3.2.3.7 Water Supply and Distribution System

The contractor shall provide the main underground reservoir of minimum 50 cum capacity and the complete water supply distribution system within the terminal area including the supply of potable water to buildings, supply of raw water for landscaping, greenery and for fire-fighting system as mentioned below:

- Necessary arrangement for treatment of the raw water before transferring from main underground reservoir to the overhead tank
- A pump house shall be built on main reservoir with two pumps (including one standby) for supply of raw water
- Another pump house on main reservoir with two fire-fighting pumps (including one standby) and jockey pumps on a separate chamber for the supply of fire water to respective locations.
- An Overhead water Tank of min 25 cum for supply of portable water
- All pipelines of required size, fixtures, foundations, brackets, connectors, anchors etc. shall be provided.

3.2.3.8 Open Storage

Open storage areas shall be provided with the flexible pavement to allow storage of cargo upto a UDL of 10 T/sqm and also movement of vehicles carrying the cargo. A storage area of about 11, 375 sqm as shown in the drawing shall be developed.

3.2.3.9 Internal Roads

Internal roads shall be provided as per the layout shown in tender drawings. Any culverts required at the crossing of the drains and drainage system shall be provided. Details of Roads as planned have been provided herein **Table 3.3**.

Table 3.3 Details of Internal Roads

Road Type	Overall Width	Carriageway Width	Width of Paved Shoulders on either side of Carriageway	Width of Treated Shoulders on either side of Carriageway	Approximate length
Internal Road Type -1	8 m	6	1 m	-	900 m
Internal Road Type -2	6 m	4	1 & 0.5 m	-	100 m
Internal Road Type -3	4 m	2.5	1 m	-	200 m

Layout of Roads and Typical Cross sections are shown in tender drawings enclosed in **Section 8.**

3.2.4 Group 4- MEP Works

3.2.4.1 Electrical Distribution System

The scope includes supply, Installation and commissioning of electrical distribution system from the Substation for further distribution to various load centres as per details given in **Table 3.4**.

Table 3.4 Load Centres for Electrical System

S. No.	Location of Load Centre
1.	IWT Administration Building
2.	Port in call Office
3.	Customs Office Building
4.	Canteen & Rest Rooms
5.	Open Storage areas, Covered Storage Shed
6.	Security Cabins (Guard Rooms)
7.	Berth and Approach Lighting
8.	Substation

9.	Workshop (480 sqm) & Weighbridge building (120 sqm) - Both to be built Later by operator
10.	Raw and Fire water Pumps and Misc.
11.	High Mast Lighting

One DG set 365kVA would be provided to meet the emergency power load requirement of lighting and other utilities.

3.2.4.2 Communication and Public Address System

The contractor shall provide a digital EPABX with a capacity of 50 lines to the various parts of the terminal. It would be connected to public switched telephone network. The scope includes laying of the wires etc. complete.

The system shall include provision of telephone instruments at the identified locations to be decided by employer during implementation stage.

Public address system with talk back facility shall be provided around the terminal area.

3.2.4.3 CCTV

The contractor shall provide CCTV at the strategic locations in the terminal area as below:

- Two camera at terminal entry
- Four cameras at IWT Admin building
- Total six cameras along the boundary wall
- Six cameras at Jetty and approach trestle
- Four cameras at Yard

The monitoring shall be from the control room located in administrative building.

4.0 DESIGN CRITERIA OF TERMINAL WORKS

4.1 Jetty and Trestle

4.1.1 Design Life

The permanent works shall be designed and constructed to give the following design lives:

- Berth - 50 years
- Shore protection works - 50 years
- Fenders, Bollards and ladders - 8 years

Above design lives are defined as a period within which the asset will continue to be serviceable for design loads without collapse

4.1.2 Design Vessel Size

The details of the maximum and minimum design vessel sizes are given below:

Table 4.1: Design Vessel Size

DWT (T)	Length (m)	Beam (m)	Draft (m)
3000	80	15	2.5
250	45	7	1.0

4.1.3 Salient Levels

Finished Deck level has been arrived considering following details are as follows:

High Flood Level (HFL) : +36.65 m

Low Water Level (LWL) : +28.28 m

Formation Level of Onshore Area : +37.50 m

Finished Deck Level : +37.00 m

Design Bed Level : +23.50 m

Scour Level : +3.59 m

4.1.4 Material Specifications

Structural Concrete	M-40
Levelling Concrete	M-15 of 100 mm thick
Reinforcement	Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500
Cement	Ordinary Portland Cement of minimum grade 53 as per IS:8112
Structural Steel	As per IS:2062 (Grade-A) with minimum thickness of 10 mm
Protective coating to structural steel	Minimum DFT of 240 microns after sand blasting to SA 2.5 grade

4.1.5 Minimum Cover

Clear cover to outermost reinforcement will be as mentioned here under in

Pile, Pile Muff	75 mm
Beams	50 mm
Slab	50 mm

4.1.6 Loads

4.1.6.1 Dead Load

The dead loads shall be assessed based upon the volume of the material using the following densities:

- Plain Concrete : 2.35 T/m^3
- R.C.C. : 2.50 T/m^3
- Reinforcement Steel : 7.85 T/m^3
- Saturated Density of Compacted Earth Fill : 1.8 T/m^3
- Bulk Density of Compacted Earth Fill : 0.8 T/m^3
- Water : 1.0 T/m^3

The unit weight of all other materials shall satisfy the requirements of IS: 875.

4.1.6.2 Superimposed Load

Table 4.2: Superimposed Load

S. No.	Load Type	Multi-Modal Jetty
1.	Live Load	3 T/m^2 (or) Single lane of IRC class AA vehicle (or) Loads due to Mobile crane of minimum lifting capacity crane of 15T @20 m radius, whichever is more.

4.1.6.3 Equipment Load

The berth shall be designed for mobile crane for minimum lifting capacity of 15 T @ 20 m radius. Crane loads during operating and Storm conditions shall be considered in conformance with crane manufacturer's recommendations.

4.1.6.4 Wind Load

Wind load on the exposed jetty structural elements is calculated considering wind speed as given below:

- Basic Wind Speed in operating condition : 22 m/s
- Basic Wind Speed in extreme condition : 50 m/s

Wind pressures shall be calculated in accordance with IS: 875 (Part 3).

4.1.6.5 Seismic Load

Seismic loads and design will be as per IS1893 (Part 1) : 2002.

4.1.6.6 Seismic Parameters

Table 4.3: Seismic Parameters

Zone	V
Zone Factor – Z (corresponding to seismic zone V)	0.36
Importance Factor – I	1.0
Response Reduction factor	3.0
Damping Factor	Steel - 2%, RCC – 5%

4.1.6.7 Current Load

The current velocity for design of structure shall be taken as 2 m/s and 5 m/s respectively for operating and extreme conditions. Water current forces shall be determined as per method recommended in Pile Design and Construction Practice by Tomlinson.

4.1.6.8 Berthing Loads

Berthing loads shall be determined in accordance with IS: 4651. For the purpose of calculating the Berthing energy, 2,000 DWT vessels under fully loaded condition is assumed to berth at an angular approach of maximum 10° with an approach velocity of 0.25 m/s. Berthing energy for design vessel size of 2,000 DWT has been calculated as 144 kNm.

Considering the water level variation of the order of 9 m between high flood level and low water level at the site and also the variation in the sizes of vessels to be handled at the jetty, the fendering system is designed such that sufficient contact area between the hull of the vessel and the fender face is ensured at all water levels. It is required to provide a suitable fender system, not only to absorb the design berthing energy of the vessel but also to keep the vessel's hull pressure below the limit of 40 T/m^2. To absorb the design Berthing energy of 144 kNm, it is proposed to provide suitable Arch fenders at each fender block. Fender blocks are provided @ 6.5 m c/c.

4.1.6.9 Mooring Load

Mooring Load shall be calculated based on the design vessel size with an operating speed corresponding to signal no. 7 on Beaufort scale, i.e. wind speed of 65 km/hr (18 m/s). It shall take into account the effect of currents also. In any case the jetty shall be designed for a minimum mooring load of 50 T. Mooring load shall be calculated considering following parameters:

- Normal condition- Wind Speed at 18 m/s & Current speed at 2 m/s
- Extreme Condition- For full Capacity of Bollard
- Current direction shall be taken parallel to jetty

50 T capacity bollards have been provided at 24m c/c and mooring load is applied at bollard location based on the calculations.

It is assumed that mooring loads will act on two bollards simultaneously from each vessel and therefore mooring load of half of the load calculated is considered for analysis. In case of extreme condition, mooring load equivalent to full capacity of provided bollards at single bollard is considered.

4.1.6.10 Temperature & Shrinkage Loads

- Mean Effective Temperature : 27.5 ° C
- Design Range of Effective Temperature Variation : ± 25 ° C
- The Co-efficient of Thermal Expansion for
- Reinforcing Steel and for Normal Weight Concrete : 11.7 x 10-6

Temperature difference shall satisfy the codal provisions mentioned in IRC 6.

4.1.6.11 Shrinkage

For shrinkage strain of $\varepsilon = 0.0002$ & coefficient of thermal expansion of $\alpha = 12x10^{-6}$ /° C, equivalent temperature fall for temperature of $t = \varepsilon/\alpha = 17°C$ shall be considered additionally with temperature fall of 24°C.

4.1.7 Load Combinations

The load combinations shall be in accordance with IS:4561 (Part 4):2014 as presented in **Table 4.4** below:

Table 4.4: ULS Combinations

	LD comb	DL	LL (udl)	EP	CL(op)+ LL (udl)	CL-Non op + LL (udl)	WL op	WL st	Wc st	Wc op	BE op	BE ab	ML op	ML xt	EQ
Normal	1	1.5	1.5	1.2			1			1					
	2	1.5		1.2	1.5		1			1					
	3	1.5	1.5	1.2			1			1.2	1.5				
	4	1.5	1.5	1.2			1			1.2			1.5		
	5	1.5		1.2		1.5	1			1.2	1.5				
	6	1.5		1.2	1.5		1			1.2			1.5		
Extreme	9	1.2	1.2	1			1			1				1	
	10	1.2		1		1.2	1			1				1	
	11	1.2	1.2	1			1			1		1			
	12	1.2		1		1.2	1			1		1			
	13	1.2	1.2	1				1.2	1						
	14	1.2		1		1.2		1.2	1						
Seismic	15	1.5		1											1.5
	16	1.2	1.2	1			1			1					1.2
	17	1.2		1		1.2	1			1					1.2
	18	0.9	0.9	1			1			1					1.5
	19	0.9		1		0.9	1			1					1.5
Reversal	20	1.2	1.2	1			1			1					
	21	1.2		1	1.2		1			1					
	22	0.9	0.9	1			1			1	1.5				
	23	0.9		1		0.9	1			1	1.5				
	24	0.9	0.9	1			1			1			1.5		
	25	0.9		1	0.9		1			1			1.5		
	26	0.9	0.9	1				1.5	1						
	27	0.9		1		0.9		1.5	1						

Table 4.5: SLS Combinations

	LD comb	DL	LL(udl)	EP	CL(op)+ LL (udl)	CL-Non op + LL (udl)	Wind op	Wind st	Cr st	Cr op	BL op	BL ab	ML op	M xt	T	S	EQ
Transient Short term for crack width chk	1	1	1	1			1			1	1						
	2	1	1	1			1			1			1				
	3	1	1	1			1			1							
	4	1		1		1.1	1			1	1						
	5	1		1	1.1		1			1							
	6	1		1	1.1		1			1			1				
Short term for deflection @ expansion jt	7	1	1	1			1			1							1
	8	1		1		1.1	1			1							1
Sustained Long term crack width and deflection check	9	1	0.5	1											1	1	
	10	1		1	0.5										1	1	

Note: 50% Live load shall be considered for seismic case

The loads and their abbreviations are described below:

DL - Dead Load

SIDL - Superimposed Dead load

LL - Uniform live load

WL - Operating wind load

WL(St) - Storm wind load

WC - Wave & Water current load

BL - Berthing load

ML - Mooring load

EQ - Earthquake load

T - Temperature variation

S - Shrinkage

4.1.7.1 Deflection Limits

Deflection for individual members shall be limited to deflection limits as specified in IS 456: 2000, Clause 23.2. However, deflection shall not be checked for Berthing and Mooring load combinations as per clause 8.3.7 of IS 4651:2014 part IV.

4.1.7.2 Crack Width Limits

Crack width for reinforced concrete structures shall be as recommended in Table-3 of IS 4651: Part 4:2014 and presented in **Table 4.6**.

Table 4.6: Allowable Crack Width for Jetty

S. No.	Exposure Zone	Crack Width Limit (mm)	
		Sustained Load	Transient Load
1.	Atmospheric Zone – Zone above HWL	0.2	0.3
2.	Splash Zone – Zone between HWL and LWL	0.1	0.2
3.	Below splash Zone up to Bed level	0.2	0.3
4.	Below Bed level	0.3	0.3

Sustained Load = Dead Load + 50% LL + Earth pressure

Transient Load = Dead Load + Berthing Load + LL + Earth pressure

4.2 Shore Protection, Bund and Site filling

4.2.1 Loads for Shore protection

The following loads shall be considered for the design of Shore protection works

- Current velocity (max) = 5 m/s
- Discharge of 55,000 m^3/s
- Surcharge load of 1.0 T/m^2 (assumed)
- Earth and Water pressure

Scour Depth shall be considered about 29m below HFL i.e. at the level of +7.93m CD.

Soil properties shall be taken from actual geotechnical investigation report.

4.2.2 Loading on Earth Retaining bund and Onshore area

The onshore area shall be capable of supporting superimposed loads of 20 kPa and loads arising from the permanent works under all operating conditions.

4.2.3 Factor of Safety

Overall Slope Stability of Edge structures:

- Factor of Safety > 1.5 for underwater slope Condition.
- Factor of Safety > 1.3 Normal Condition
- Factor of Safety > 1.1 Considering Earthquake.

4.2.4 Settlement Limitation

(i) Residual Settlement of filling shall not exceed the following:

- Site area shall be designed and constructed to accommodate the design loadings, and such greater loads as stated in the Specification, without significant ongoing settlements which may damage or affect the efficiency of operation throughout its design life.
- The Contractor shall make allowance in his design for the effect of the estimated residual settlement (including but not limited to secondary consolidation of compressible strata and creep of fill), but this allowance shall not be greater than 300mm.
- The Contractor shall also demonstrate that his proposed ground improvement method, with his detailed calculations, will achieve a total residual settlement, after completion that shall not exceed 10% of the estimated total ground settlement.
- Total or differential settlement does not result in failure or ineffectiveness of drainage slopes or systems or utility services.

(ii) Immediate Settlement under Foundation Loads

- The immediate settlement under the load shall be less than 25 mm.

(iii) Settlement under earthquake

- Settlement at ground level under contingency level earthquake shall be smaller than 200mm after the seismic event.
- If the tolerances for overall settlement of the final reclamation level are exceeded during the ‘Defects Notification Period’, the Contractor shall undertake corrective actions to the approval of the Engineer to reinstate the paving to the original design levels.
- In addition to the above, the ground improvement shall minimize differential settlement arising from hard points, buried foundations, services or other obstructions and variations in ground condition within the area.

4.2.5 Liquefaction Potential

Liquefaction potential of soils and fills should be assessed. The Factor of safety of liquefaction analysis shall be greater than 1.1.

4.2.6 Compaction

i. Relative Density of underwater shall be greater than 70%.

ii. Compaction of Fill Materials above water: The uppermost zone of fill shall be placed and treated to ensure that the top 1.5m of the fill has an in-situ density not less than 95% of the maximum dry density. The in-situ density of fill throughout the full thickness and lateral extent shall not be less than 90% of the maximum dry density. The values of maximum dry density shall be obtained in accordance with BS 1377: Pt. 4: 1990.

4.2.7 Ground Improvement

The onshore area, particularly the filled areas shall be treated as necessary to provide adequate stability and bearing capacity to withstand the design loadings including seismic loads. The method(s) of ground improvement performance could be either Cone Penetration Testing (CPT) or Standard Penetration Testing (SPT) as per BS:6349 and BS:1377.

The Contractor shall choose the type of ground improvement based on the reclamation material. The ground improvement shall be done as per IS:13094 and BS:6031.

4.3 On-Shore Facilities

4.3.1 Design Life

The permanent works shall be designed and constructed to give the following design lives:

- Terminal Buildings - 50 years
- Access Road - 20 years
- Utilities - 20 years

Above design lives are defined as a period within which the asset will continue to be serviceable for design loads without collapse.

4.3.2 Design Criteria for Buildings and Covered Storage

4.3.2.1 General Design Considerations

4.3.2.1.1 General

The buildings shall be provided with adequate arrangements for plumbing, sanitary, electrical fittings, illumination, water distribution etc.

4.3.2.1.2 Foundations

Type of foundation system shall be decided based on locations and loading arrangement, load intensity and soil strata. Design of foundation at various levels shall be dependent up on the soil profile, which in turn shall be as per recommendation of soil investigation report.

4.3.2.1.3 Grade Slab

All ground floors for Terminal buildings shall be of R.C.C (M-20) with minimum thickness of 150mm over 100 mm thick PCC (M-10) base over well compacted earth.

DG room floor finish shall be 40mm thk including 13mm thk metallic hardener topping as per specification. Floor top shall be laid to slope minimum 1:100 towards floor drain for floor washing.

4.3.2.1.4 Staircase

- Minimum clear width : 0.8m
- Tread width : not less than 250mm
- Riser : not greater than 180mm

Continuous Handrail shall be provided.

4.3.2.1.5 Minimum Cover

Clear cover to any reinforcement shall be as mentioned here under but shall not be less than the diameter of such reinforcement.

Table 4.7: Minimum Cover

Top, bottom & side of footing (if any):	50 mm
Pedestal / column	
- Below ground	50 mm
- Above ground	40 mm
Beams	40 mm
Slab	30 mm
Face of walls & grade beam	50 mm (in contact with soil)
Face of walls not exposed to soil	25 mm (min.) or dia of main bar

4.3.2.1.6 Deflection Limits

Steel structures shall conform to IS 800: 2007, Clause 5.6.1, Table 6. Reinforced concrete structures shall conform to IS 456: 2000, Clause 23.2. Deflection of Pile at deck level shall be restricted to L/350.

4.3.2.1.7 Crack width Limits

Crack width of all the structural elements shall be calculated wherever necessary as per IS: 456-2000.

4.3.2.1.8 Permissible Stresses

Permissible stresses and permissible increase or decrease of stresses shall be in accordance with the relevant IS codes, whichever is applicable.

4.3.2.1.9 Materials

Table 4.8: Material Specifications

Structural Concrete	M-30
Levelling Concrete	M-15 of minimum 100 mm thick
Reinforcement	Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500/Fe 500D
Cement	Ordinary Portland Cement of minimum grade 53 as per IS:12269
Structural Steel	As per IS:2062 (Grade-A) with minimum thickness of 10 mm Or ASTM A-570, Grade 50 having minimum yield strength of 345 MPa shall be used for built up sections with minimum thickness of 10 mm as per IS:2062 (Grade-A) Angle /Rod bracing shall conform to IS codes and having minimum yield strength of 250 MPa.
Protective coating to structural steel	Minimum DFT of 240 micron after sand blasting to SA 2.5 grade.
Rolled steel Section &Plates up to 20mm thick	As per IS:2062 (Grade-A)
Rolled steel plates above 20mm thick	As per IS:2062 (Grade-B) Normalized
Chequered plate	Conform to IS: 3502-1994.
Pipes and hands rail	As per medium grade of IS: 1239.
Cold formed Tube Hollow section (SHS/RHS)	Conform to IS: 4923:1997.
Cold formed Circular Hollow section (CHC)	Conformed to IS: 1161:1998.

4.3.2.1.10 Material Density

Table 4.9: Material Density

Materials	Unit Weight (kN/m^3)
Steel	78.5
Plain Cement Concrete (PCC)	24.0
Reinforced Cement Concrete (RCC)	25.0
Cement Concrete Solid Block Work	20.0
Soil	18.0
Water	10.0
Cement Concrete Screed	24.0

4.3.2.1.11 Factor of Safety

The factor of safety against sliding, Overturning & hydrostatic uplift:

- Sliding : 1.4
- Overturning : 1.4
- Hydro static uplift / Buoyancy : 1.2

(Dead weight of structures shall be considered as 0.9 times of actual and 20°wedge action of soil is considered in restoring the force.)

- Uplift of shallow Foundations : Minimum F.O.S. shall be 2.0

4.3.2.2 Design Loads

4.3.2.2.1 Dead Loads

Dead load comprises of self-weight of all permanent construction, including walls, floors, grading concrete on floors roofs, ceilings, stairways, cable shaft, equipment etc. as applicable to the particular structure. The unit weight of all other materials shall satisfy the requirements of IS: 875.

4.3.2.2.2 Superimposed Loads

Table 4.10 Live Loads on Buildings

Load Description	UDL (kN/m^2)
Machine Loads	As per design

4.3.2.2.3 Live Loads

Live loads shall be as per IS: 875 (Part 2).

Table 4.11: Live Loads

Load Description	UDL (kN/m^2)
Terraces with Access	1.50
Terrace without Access	0.75
Terminal Area	5.0
Staircase/Corridors	5.0
Electrical/Panel room	10.0
Data Storage/UPS /Battery Room	10.0

4.3.2.2.4 Design for Wind Load

- Basic Wind Speed in operating condition : 22 m/s
- Basic Wind Speed in extreme condition : 50 m/s

Wind pressures have been calculated in accordance with IS: 875 (Part 3)

4.3.2.2.5 Design for Seismic Load

Seismic loads and design will be as per IS1893 (Part 1):2002.

Table 4.12: Seismic Parameters

Zone	V
Zone Factor – Z	0.36
Importance Factor – I	1.0
Response Reduction factor	5.0
Damping Factor	Steel - 2%, RCC – 5%

4.3.2.2.6 Equipment Load

The building shall be designed to accommodate anticipated static and dynamic loading from electrical equipment. Where the uniform floor live load adequately accounts for the equipment weight, the weight of such equipment as a dead load need not be considered.

Impact Factor:

- For Manual monorail/Hoist design an impact factor of 1.20 shall be considered in design.
- For Electrical monorail/ Hoist design an impact factor of 1.25 shall be considered in design.

4.3.2.2.7 Temperature Loads

If expansion joints are proposed as per IS800:2007 requirements, no temperature loads shall be considered.

4.3.2.3 Load Combination

The Various loads specified above shall be combined in accordance with CI: 8.0 of IS: 875 (Part- 5)-1987. The individual member of the frame shall be designed for Worst combination of forces Such as bending moment, axial force, shear force and torsion. Permissible stresses for Different load combination shall be taken as per IS 875 (part 5)-1987.

4.3.3 Design Criteria for Roads

4.3.3.1 Geometric Parameters

- Maximum longitudinal grade : 3.0%
- Cross slope : Unidirectional/ Bi-Directional 2.5% for All Roads
- Maximum super elevation : 3%
- Sight Distance : Intermediate sight distance
- Turning Radius at junction : Min. 25 m

- Design Speed : 40 km/hr

4.3.3.2 Design Traffic

- Traffic : 2 MSA

4.3.3.3 Pavement Criteria

- Embankment : Min. Density shall be 1.6 T/cum
- Sub grade : density 1.75 T/cum, CBR as per Soil report
- Granular Subbase : Pavement Design shall be as per IRC: 37
- Granular Base : Pavement Design shall be as per IRC: 37
- Bituminous Surfacing
  - Binder course : Pavement Design shall be as per IRC: 37
  - Wearing course : Pavement Design shall be as per IRC: 37

The culverts, if any, required for the cross-drainage works shall be designed as per the relevant IRC codes.

4.3.4 Design Criteria for Storm Water Drains

The design rainfall intensity for the design of storm water drainage system shall be taken as 50 mm/hr. The drains shall be of Trapezoidal cross section with stone pitching interfiled with cement mortar grout with natural slope towards silt trap and ultimately discharge it to the river. All Indian codal provisions shall be considered while designing the storm water drain system.

The design of the structural components shall be carried out either using STAAD Pro or manually using standardized excel spreadsheets for the loads and their combinations. All designs of RCC structures shall be carried out by limit state method as per IS: 456 cracked section.

4.3.5 Design Criteria for Sewerage System

4.3.5.1 General

The sewerage system at terminal shall comprise of disposal system from buildings and toilet block to septic tank through a network of pipes and manholes and further to the Septic Tank which shall be RCC underground Tank. All Manholes shall be provided with heavy duty ductile iron or cast-iron covers.

4.3.5.2 Design Parameters

Manholes in the sewerage collection system shall be installed. The channels in manholes at junctions and bends shall be smooth with gradual transitions to avoid turbulence and deposition/ Build-up of solids.

Adequate ventilation arrangements shall be provided.

Rate of Infiltration: Infiltration into the sewerage system occurs through defective sewers, manholes, etc. The rate of infiltration into sewers also depends upon the ground water table and permeability of the surrounding soil.

Parameters to be adopted for sewage network design have been listed in **Table 4.13**.

Table 4.13: Parameters adopted for Sewage Network Design

S. No.	Parameters	Value
1.	Minimum outside diameter	200 mm
2.	Minimum Velocity for gravity network at initial peak flow	0.6 m/s
3.	Maximum Velocity for gravity network	3 m/s
4.	Peak Factors based on contributing population:	Peak Factor
	(i) Up to 20,000	3.00
	(ii) 20,000 to 50,000	2.50
	(iii) 50,000 to 7,50,000	2.25
	(iv) More than 7,50,000	2.0
5.	Maximum d/D Ratio	0.7 at peak flow
6.	Design formula	Manning's Formula V= 1/n R^2/3 S^1/2 Where V is velocity in m/sec S= Slope of conduit
7.	Manning's 'n'	As per CPHEEO Manual
8.	Manholes	RCC with removable cover.
9.	Minimum bed slopes	As per CPHEEO Manual
10.	Minimum depth of sewer	As per site condition for minimum cover requirements
11.	Maximum depth of sewer	As per site condition, maximum 4m

4.3.5.3 Typical Manhole Sizing

Manhole sizing shall be based on criteria as given in the **Table 4.14**:

Table 4.14: Manhole Sizing Criteria

S. No.	Range of Depths	Max. pipe dia. (mm)	Manhole Size dia. (mm)
1.	From 0.90 m and up to 1.65 m	300	900

2.	From 1.65 m and up to 2.30 m	600	1200
3.	From 2.30 m and up to 9.0 m	900	1500
4.	From 9.0 m and up to 14.0 m	1200	1800

4.3.5.4 Spacing of Manholes

Spacing of manholes shall be based on criteria as given in the **Table 4.15** below:

Table 4.15: Criteria for Manhole Spacing

S. No.	Sewer Size	Manhole Spacing
1.	Sewer < 600 mm	up to 30 m
2.	Sewer ≥ 600 mm	45 m to 60 m

Further, for inspection, cleaning and testing of sewers, manholes shall be provided at every change of alignment, gradient and diameter. The sewer shall be in a straight line between two manholes.

4.3.5.5 Flushing Manholes

Where self-cleansing velocities are not achieved due to flatness of gradients/less flow, a flushing arrangement shall be incorporated as per IS 4111 and CPHEEO.

4.3.5.6 Loads

4.3.5.6.1 Dead Load

The dead loads shall be assessed based upon the volume of the material using the following densities:

- Plain Concrete : 2.40 T/m^3
- R.C.C. : 2.50 T/m^3
- Reinforcement Steel : 7.85 T/m3Live Load

4.3.5.6.2 Uniform Live load

20 kN/m^2 on Precast Cover slab / Top slab

4.3.5.6.3 Lateral Earth Pressure

Earth Pressure shall be Active earth pressure considering -

- Soil internal friction angle : 30°
- Saturated Density of Compacted Earth Fill : 1.8 T/m^3

4.3.5.6.4 Lateral Surcharge Pressure

A uniform Surcharge of 20 kN/m^2 shall be considered

4.3.5.6.5 Hydrostatic Pressure

Water level for calculating the hydrostatic pressure shall be taken at Ground level.

All Underground Tanks shall be checked for Uplift in empty condition. Minimum factor of safety against uplift shall be 1.2. For calculating Soil friction, the coefficient of Friction shall be taken as Tan ϕ.

4.3.6 Design Criteria for Water Supply System

4.3.6.1 General

The water supply system includes the connecting pipeline from the Municipal water source and collection at the underground water tank and then pumping to the consumption areas by pipelines. All Manholes shall be provided with heavy duty ductile iron or cast-iron covers.

The design of the structural components shall be carried out either using STAAD Pro or manually using standardized excel spreadsheets for the loads and their combinations. All designs of RCC structures shall be carried out by limit state method as per IS: 456 cracked section.

4.3.6.2 Design Parameters

The broad design parameters for water supply system are given below:

- Wastage and leakage in system: 15% of the total theoretical demand.
- Hydraulic design of the pipeline shall be using Hazen-Williams formula.
- All pipelines shall be laid 1.2 m below ground.
- The residual pressure in the pipeline at the terminal point shall be 2 kg/sq.cm.
- Material of all piping shall be ductile iron. All valves in network shall be Resilient Seat mounted Sluice Valve of min. PN 16 rating in potable and treated sewage lines. For fire line the rating of valves shall be one higher than the pipe rating.
- The flow meter shall be provided in the pipeline tapped from the DI pipe and shall be electromagnetic type. All flow meters shall be provided with bypass arrangement with manual operated butterfly valves in the pipeline.
- RCC valve chambers (covered) shall be provided for installation of valve and flow meters along with bypassing, dismantling arrangements, workable space for operations and maintenance shall be provided.

4.3.6.3 Loads

4.3.6.3.1 Dead Load

The dead loads shall be assessed based upon the volume of the material using the following densities:

- Plain Concrete : 2.40 T/m^3
- R.C.C. : 2.50 T/m^3
- Reinforcement Steel : 7.85 T/m^3

4.3.6.3.2 Live Load

Uniform Live load of 20 kN/m^2 on Precast Cover slab / Top slab

4.3.6.3.3 Lateral Earth Pressure

Earth Pressure shall be Active earth pressure considering -

- Soil internal friction angle : 30°
- Saturated Density of Compacted Earth Fill : 1.8 T/m^3

4.3.6.3.4 Lateral Surcharge Pressure

A uniform Surcharge of 20 kN/m^2 shall be considered

4.3.6.3.5 Hydrostatic Pressure

Water level for calculating the hydrostatic pressure shall be taken at Ground level.

All Underground Tanks shall be checked for Uplift in empty condition. Minimum factor of safety against uplift shall be 1.2. For calculating Soil friction, the coefficient of Friction shall be taken as Tan ϕ.

5.0 TECHNICAL SPECIFICATIONS - JETTY AND APPROACH TRESTLE

5.1 General

A high standard of workmanship in all trades will be required. The Contractor shall ensure that only skilled and experienced tradesmen are employed. Where required, the Contractor shall furnish such details of his Temporary Works to the Employer and the Contractor shall satisfy the Employer as to their safety and efficiency. The Employer may direct that Temporary Works, which he considers unsafe or inefficient, shall be removed and replaced in a satisfactory manner.

The Contractor shall provide and maintain survey stations which he may require to carry out the Works. The Contractor shall carry out all the necessary surveys, measurements and setting out of the Works and shall for this purpose engage qualified and competent engineering surveyors.

The Contractor shall furnish all necessary supervision, labour, materials, equipment and tools for Site preparation clearing and all other works. Clearing shall mean to completely demolish remove and dispose with all leads, lifts and descents from the area, bushes, deadfalls, embedded logs, dislodged roots, stumps, snogs, boulders, existing structures and other objectionable materials.

All materials shall be stored at proper places so as to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space must also permit easy inspection, removal and re-storage of the materials. All such materials even though stored in approved godowns/places, must be subjected to acceptance test prior to their immediate use.

The contractor shall plan his construction activities duly considering the weather conditions round the year and available working window in open riverine environment.

5.2 Concrete

5.2.1 Qualified Personnel, Labour & Equipment

A fully qualified and experienced concrete quality control Engineer shall be employed by the Contractor and shall be available on Site at all times when concreting is taking place. Operators for mechanical vibrators and mixers and foreman in charge of placing of concrete shall be fully trained and experienced for their class of work.

The Contractor shall also provide all necessary supervision, labour, materials, equipment and tools to carry out the concreting work as described below.

5.2.2 Type of Concrete Mix

Unless otherwise noted on drawings all lean and reinforced concrete shall be nominal mix and design mix types respectively.

5.2.3 Nominal Mix Concrete

This concrete shall be made (without preliminary tests) by adopting nominal concrete mix with proportions of materials as specified in **Table 5.1**.

Table 5.1: Proportions for Nominal Mix Concrete

Nominal Mix of Concrete (by mass)	Quantity of Water per 50 Kg of cement (max)
1:5:10	60 litres
1:4:8	45 litres
1:3:6	34 litres
Note:	
1. The proportions of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregates becomes larger. Graded coarse aggregates shall be used.	
2. The cement content of the mix shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio, as specified, is not exceeded.	

5.2.4 Design Mix Concrete

The mix shall be designed to produce the grade of concrete having the required characteristic strength and workability not less than appropriate values given in **Table 5.2** and **Table 5.3**.

Table 5.2: Grades of Concrete

Grade Designation	Characteristic Compressive Strength of 15 cm cube at 28 days (N/mm^2)
M15	15
M20	20
M25	25
M30	30
M35	35
M40	40

The characteristic strength is defined as the strength of material, below which not more than five (5) percent of the test results are expected to fall.

As long as the quality of materials does not change, a mix design done earlier, shall be considered adequate for later work. However, in case the quality of materials changes, the Employer may ask for a new design mix.

While designing the mix, the durability requirements as given in IS:456 shall also be taken into account.

5.2.5 Concrete Mix Proportioning

Proportioning, as used in this specification, shall mean the process of determining the proportions of the various ingredients to be used to produce concrete of the required strength, workability, durability and other properties.

The Employer shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Employer shall order fresh trial mixes to be made by the Contractor. No claim to alter the rates of concrete work shall be entertained due to such changes in mix variations. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of start of work. The design mix shall conform to the guidelines of IS:10262.

5.2.5.1 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for grade of concrete shall be selected to give as nearly as practicable the maximum density. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation. The Contractor shall submit to the Employer at least three sets of mix design and corresponding test results after varying the mix proportions and / or grading of aggregate so as to establish the maximum density of any particular grade of concrete.

5.2.5.2 Water-Cement Ratio

Once a mix, including its water-cement ratio, has been determined and approved for use by the Employer, that water-cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted so as to maintain the approved water-cement ratio. Maximum water-cement ratio shall never exceed the values given in IS:456 and IS:4651 for various exposures and sulphate attack conditions from durability considerations.

5.2.5.3 Consistency

The concrete shall have a consistency such that it shall be workable in the required position and when properly vibrated it flows around reinforcing steel, all embedded fixtures etc.

5.2.5.4 Workability

The concrete mix proportion shall be such that the concrete is adequate workability for the placing condition and can be properly compacted with the means available. Use of plasticizer / super-plasticiser of approved make shall be taken recourse to where required for attaining proper workability as specified in **Table 5.3** below. However, prior written approval of the Employer shall be obtained for any such use of plasticiser/super-plasticiser before submitting the proposed design-mix for approval. Where adequate workability is difficult to obtain at maximum permissible water-cement ratio, an increased cement content shall also be alternatively considered while designing the mix proportions.

The suggested ranges of values of workability of concrete measured in accordance with IS: 1199 are indicated in **Table 5.3** below. However, the actual values to be followed shall be established

depending on aggregate sizing, mix proportions, placing conditions, etc and shall be got approved by the Employer.

Table 5.3: Values of Workability

Placing Conditions	Degree of Workability	Values of Workability
Concreting of shallow sections with vibration	Very low	20-10 seconds vee-bee time or 0.75-0.80 compacting factor
Concreting of lightly reinforced sections with vibration	Low	10-5 seconds vee-bee time or 0.80-0.85 compacting factor
Heavily reinforced sections with vibration	Medium	5-2 seconds vee-bee time or 0.89-0.92 compacting factor or 25-75mm slump for 20mm aggregate

5.2.5.5 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Workability of concrete shall be such that concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform and as shown in drawings. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum water-cement ratio conforming to the exposure conditions as given in **Table 5.4**.

Table 5.4: Minimum Cement Content and Maximum Water Cement Ratio for Durability

Exposure	Type of Cement	Plain Concrete		Reinforced Concrete	
		Minimum Cement Content (Kg./m^3)	Maximum Water-Cement Ratio	Minimum Cement Content (Kg./m^3)	Maximum Water-Cement Ratio
Normal	OPC* PPC* PSC*	Nominal mix as shown in **Table 5.1**	0.6	300	0.55
Moderate	OPC* PPC* PSC'	250	0.6	350	0.50
Severe	SSC* PSC* SRC'	310	0.45	400	0.45

Note 1: Severe exposure shall include structures exposed to river or saline water (e.g. tidal rivers, brackish water, estuaries etc.), alternate wetting and drying, freezing whilst wet and subject to heavy condensation or corrosive environment. This shall also include structures exposed to sulphate and/or chloride attack due to presence of these chemicals in Soil and ground water. Total SO_3 content of 0.2% and above in Soil and 300 ppm in ground water shall be considered to constitute severe exposure. Similarly, chloride (as CI) content exceeding 1500 ppm in ground water or soil shall be considered as severe exposure condition.

Note 2: Structures subjected to aggressive environment below the minimum limits expressed in Note-1 above and/or those in industrial/chemical plants atmosphere shall be considered under moderate exposure. Also, any concrete structure in contact with water or retaining water or any other liquid not usually harmful to concrete shall be considered under moderate exposure.

Note 3: All other environmental conditions not covered under Notes-1 & 2 shall be categorised under Normal exposure.

* OPC - Ordinary low heat Portland Cement

* PPC - Portland Pozzolana Cement

* PSC - Portland Slag Cement

* SRC - Sulphate Resistant Cement

* SSC - Super Sulphated Cement

5.2.5.6 Batching

In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass. Where the mass of cement is determined on the basis of mass of cement per bag, a reasonable number of bags shall be weighed periodically to check the net mass. Where the cement is weighed at site and not in bags, it shall be weighed separately from the aggregates. Water shall be either measured by volume in calibrated tanks or weighed. Any solid admixtures that are to be added, shall be measured by mass; liquid and paste admixtures shall be measured by volume or mass. Batching plant, where used, shall conform to IS: 4925. All measuring equipment shall be maintained in a clean serviceable condition, and their accuracy periodically checked.

Except where it can be shown to the satisfaction of the employer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, different sizes being stacked in separate stock piles. The grading of course and fine aggregates shall be checked frequently, the frequency for a given job being determined by the Employer to ensure that the approved grading is maintained.

Under special circumstances, change from weigh batching to appropriate volume batching may be permitted by the employer on specific request from the Contractor. However, in such cases all conversions from mass of ingredients to volume shall be based on actual and appropriate bulk densities physically measured at site and approved by the Employer.

The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in both fine and coarse aggregates. For the determination of moisture content in the aggregates, IS:2386 (Part- III) may be referred to. To allow for the variation in mass of aggregates due to variation in their moisture content, suitable adjustments in the mass of aggregate shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in **Table 5.5**.

Table 5.5: Surface Water Carried by Aggregate

Aggregate	Approximate Quantity of Surface Water	
	Percent by mass	Litre / m^3
Very wet sand	7.5	120
Moderately wet sand	5.0	80
Moist sand	2.5	40
Moist Gravel or Crushed Rock	1.25-2.5	20-40

No substitutions in materials used on the work or alterations in the established proportions, except as permitted shall be made without additional tests to show that the quality and strength of concrete are satisfactory. In case the Contractor proposes any change in the already approved mix design, fresh mix design with supportive laboratory tests shall be submitted to the employer and his approval has to be obtained prior to using the Employer revised mix proportion in the works. However, such proposals for revision shall only be entertained in case of successive failure of test cubes to achieve the required strength.

5.2.5.7 Concrete Mixing

The mixing of concrete shall be strictly carried out in an approved type of mechanical concrete mixer. The mixing shall be continued until there is a uniform distribution of the material and the mass is uniform in colour and consistency. If there is segregation, after unloading from the mixer, the concrete shall be remixed.

5.2.5.8 Mixer

Mixers shall comply with IS: 1791 and shall be maintained in satisfactory operating condition. Mixer drum shall be kept free of hardened concrete and blades shall be replaced when worn down more than ten percent (10%) of their depth. Should any mixer at any time produce unsatisfactory results, leak mortar or cause waste of materials, its use shall be promptly discontinued until it is repaired.

5.2.5.9 Mixing Time

Mixing time shall be as indicated in the following **Table 5.6**. Excessive mixing requiring additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Employer may, however, direct a change in the mixing time, if he considers such a change necessary.

Table 5.6: Mixing Time

Capacity	Minimum
$2m^3$ or less	2 minutes
$3m^3$	2 minutes
$5m^3$	3 minutes

All records and charts for the batching and mixing operations shall be prepared and maintained by the Contractor as per the instructions of the Employer.

5.2.5.10 Hand Mixing

Hand mixing of concrete shall not be permitted. However, for non-critical structures located at far away isolated places, this may be permitted by the Employer as a special case. Ten percent (10%) extra cement shall have to be added to the normal mix when mixed by hand. It shall be carried out on a watertight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. No extra payment shall be made to the Contractor for mixing by hand or for using extra cement due to hand mixing. However, extra cement consumed shall be considered for reconciliation purposes where such concreting is allowed by the Employer.

5.2.5.11 Admixtures

Admixtures in concrete shall be used only with the prior approval of the Employer. Any admixture used for obtaining proper workability or leak-proofness of concrete or repair/rendering works of concrete due to non-conformance to the specifications, shall not be measured and paid for. All costs relating to such usage shall be borne by the Contractor.

5.2.5.12 Grouting

All loose materials, grease, oil, dirt, etc. shall be removed from the concrete surface which is to receive grout. The surface shall be left rough, but not so rough as to interfere with the proper placing of the grout.

The grout for pressure grouting shall be mixed as quickly as possible, consistent with the fluidity requirement using a cement to sand ratio not less than 1:2. Pressure grouting shall be done at a pressure of 2kg/sqcm.

Polymer modified non-shrink grout as approved by the Employer shall be used.

5.2.5.13 Test Cubes

Test cubes shall be made in accordance with IS:516 "Methods of Test for Strength of Concrete".

5.2.5.14 Concrete Testing

All sampling and testing of concrete shall be carried out in accordance with IS:1199 "Method of sampling and analysis of concrete".

5.2.5.15 Transportation of Concrete

The concrete shall be transported from the mixer to its place in the works as rapidly as possible and in such a manner that there shall be no separation or loss of its ingredients. For such purpose, as far as possible, transit mixers shall be used. In no circumstances shall more than half an hour elapse between the time water is added to the mix and the time when the concrete is finally compacted in position. No concrete shall be permitted to be used in the works after initial set has taken place.

5.2.5.16 Deposition of Concrete

The arrangements for depositing concrete shall be subject to the approval of the Engineer. In no case shall concrete be dropped or thrown from a height of more than 2 metres. Concreting beams, slabs and similar members shall be carried out in continuous operation to the full depth of the member and the sequence of placing shall be arranged as to avoid disturbance of partially set concrete. The concrete shall be deposited as close to its final position as practicable in order to prevent segregation.

Freshly laid concrete shall not be wheeled over or otherwise disturbed. When depositing concrete adjacent to a construction joint special care shall be taken not to disturb the dowels or other reinforcing bars projecting from the existing concrete.

In foundations, walls, and columns where the full height is not being poured in one continuous operation the surface of each lift shall be finished horizontal and any laitance removed between the period of initial and final set.

For slip formed wall, concrete shall be placed in horizontal layers approximately 150 to 250 mm in thickness. Not more than one hour should elapse between the placing of successive layers of concrete in any portion of the slipform. This is to ensure that each pour is thoroughly worked into and made homogeneous with the preceding pour.

5.2.5.17 Compaction of Concrete

The Contractor shall agitate the placed concrete thoroughly into place by means of a sufficient number of approved mechanical vibrators of adequate power and having a frequency of not less than 6,000 impulses per minute. The vibrator shall be allowed to sink freely of its own weight until it enters the previous lift. It shall be withdrawn immediately at the same rate and used at a new location. Concrete once vibrated shall not be vibrated again. The Contractor shall ensure that the concrete is thoroughly worked around the reinforcement and against external shutters so that all entrained air is expelled and the concrete surface when exposed, is found good and free from air pockets, honeycombing or other defects. Retamping of concrete or mortar, which has partially hardened, shall not be permitted.

5.2.5.18 Concreting in Inclement Weather

In the event of rainstorm or any other severe conditions arising, concreting shall be stopped, and appropriate temporary stop ends, vee grooves, etc. placed as may be necessary. During wet weather, the concrete shall be adequately protected as soon as put into position.

The Contractor shall always have in readiness approved framed sheeting, tarpaulin, etc. for the protection of newly placed concrete during inclement weather. Should any concrete be damaged due to rainstorms or other weather conditions, the Employer may order the cutting out and replacement of the damaged concrete, all at the expense of the Contractor.

5.2.5.19 Concreting Under Water

Where concrete is to be deposited underwater, the greatest care shall be taken to prevent the cement being washed out. The concrete shall be placed through a tremie pipe with suitable hopper and plunger arrangements. Great care shall be taken to ensure that no segregation of concrete takes place and the method of placing shall be approved by the Employer.

5.2.5.20 Items Embedded in Concrete

Concreting shall not be started unless the electrical conduits, pipes, fixtures etc., wherever required, are laid by the Contractor. The Contractor shall afford all the facilities and maintain co-ordination of work with other Package Contractors if any engaged in electrical, mechanical and such other works.

Before concreting, the Contractor shall provide, fabricate and lay in proper position all metal inserts, anchor bolts, pipes etc., which are required to be embedded in concrete members.

All embedment, inserts including the inserts supplied by equipment contractor shall be fully held and secured in their respective positions to the entire satisfaction of Employer so as to avoid any dislocation or displacement during the concreting operations. The Contractor shall take all possible care during concreting to maintain these embedment/inserts in their exact locations.

5.2.5.21 Construction Joints

The Contractor shall remove shutters as per the design requirements. Any skin of laitance should be removed and the tops of the larger stones exposed by means of brushing and washing.

At horizontal constructions joints, removal of laitance and exposure of the tops of the larger stones shall be accomplished, wherever practicable, by means of washing and brushing shortly after pouring, care being taken to obviate undue erosion of the mortar. After cleaning, excess water shall be removed immediately to limit absorption by the concrete. In cases where the concrete has set but not set hard, the removal of laitance and roughening shall be accomplished by wire brushing and washing, great care being taken not to damage the underlying mass.

Where, either at vertical or horizontal joints, the concrete has set hard any skin or laitance shall be removed and the surface roughened by hammering with an approved power operated "bush hammer" followed by wire brushing to remove all loose particles. When using this procedure, great care shall be taken to avoid breaking off the arises of the joint face and stunning the stones.

Whichever of the above treatments has been given to the exposed surface, foreign matter shall be cleaned off that surface by further wire brushing, if necessary. It shall then be thoroughly washed with clean fresh water and the surplus blown off before depositing fresh concrete. The surface while still moist shall be covered evenly with a layer not less than 4 mm thick of 1:1 cement mortar of medium consistency which shall be vigorously stippled into the surface by means of a suitable stiff brush, the depositing of the fresh concrete following on closely.

It is of the utmost importance that the fresh concrete shall be forced hard on the mortar layer and the set faces. To this end the compacting tools and vibrators, where appropriate shall be worked right upto the old faces and into angles and corners formed between them and the shutters and the damping effect on vibration in such position shall be allowed for.

5.2.5.22 Expansion Joints

The Contractor shall provide all labour, supervision, materials, equipment and tools to carry out the work to the entire satisfaction of the Engineer.

The expansion joints shall be formed at the locations and levels as shown in the drawings and as approved by the Employer.

Instruction of manufacturer of the approved material shall be followed while preparing expansion joints.

5.2.5.23 Screeding

All the surfaces of slabs or other members not required to be shuttered are to be screeded in an approved manner and within a tolerance of plus minus 3 mm of true level and grade. In making such finish care shall be exercised not to work in excess fines to the top. Surface shall be scabbed / cleaned and all laitance removed before screed is placed. Care is to be taken to ensure that the concrete is properly compacted and for this purpose vibrator screed boards or plates will normally be required.

5.2.5.24 Curing

All concrete shall be protected during hardening from the harmful effects of sunshine, moisture and drying winds. All exposed faces of concrete shall be kept continuously moist for a period of 14 days.

In the case of slabs or other pours of large surface area, timber frames covered with two thicknesses of damp hessian shall be placed over the concrete, immediately after pouring. When the concrete has set, the frames shall be removed, and the covering laid directly on the concrete. For 10 days thereafter concrete shall be kept continuously damp by spraying the cover with clean fresh water or by covering it with not less than 25 mm thickness of sand and kept continuously damp or by ponding where practicable.

5.3 Field Tests

5.3.1 Grading Test

Grading test on fine and coarse aggregates shall be carried out as per IS:2386 at intervals specified by the Employer.

The mandatory tests and their frequencies shall be done on sand and stone aggregates as given in **Table 5.7.**

Table 5.7: Mandatory Tests on Sand & Stone Aggregates

S. No.	Material	Test	Field/Lab Test	Minimum Qty. of Material/ Work for Carring out the Test	Frequency of Testing
1	Sand	a) Bulking of Sand	Field	$20m^3$	Every $20m^3$ or part thereof or more frequently as decided by the Employer
		b) Silt content	Field	$20m^3$	-do-
		c) Particle size distribution	Field or Lab as decided by the Employer	$40m^3$	1) Every $40m^3$ of fine aggregate/ sand 2) Evcry $80m^3$ of fine aggregate/sand
2	Stone aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test where required by the Employer or as	As required	For all quantities

S. No.	Material	Test	Field/Lab Test	Minimum Qty. of Material/ Work for Carring out the Test	Frequency of Testing
			specified		
		b) Particle size distribution	Field or lab as required by Employer	45m^3	For every 45m^3 or part thereof as decided by Employer
		Ten precent Fine value	Laboratory	45m^3	Initial test and subsequent test as & when required by Employer.

5.3.2 Vee-Bee Test/Slump Test of Concrete

At least one Vee-Bee Test/Slump Test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in working conditions or if required by the Employer.

5.3.3 Strength Test of Concrete

Samples from fresh concrete shall be taken as per IS:1199 and cubes shall be made, cured and tested at 28 days in accordance with IS:516.

In order to get a relatively quicker idea of the quality of concrete, tests on beams for modulus of rupture at 72±2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values given in **Table 5.8** may be taken for general guidance. In all cases, the 28 days compressive strength specified in **Table 5.2** shall alone be the criterion for acceptance or rejection of the concrete from strength consideration. If, however, from tests carried out in a particular work over a reasonably long period, it has been established to the satisfaction of Employer that a suitable ratio between 28 days compressive strength and the modulus of rupture at 72±2 hours or compressive strength at 7 days may be accepted, the Employer may suitably relax the frequency of 28 days compressive strength specified in **Table 5.9**, provided the expected strength values at the specified early age are consistently met. However, set of test cubes for 28 days strength test shall always be taken and maintained to cater to any contingencies in the event of failure of 7 days strength.

Table 5.8: Test Requirement of Concrete

Grade of Concrete	Compressive strength on 15 cm cubes minimum at 7 days (N/mm^2)	Modulus of Rupture by Beam Test, at minimum	
		72±2 hours (N/mm^2)	7 days (N/mm^2)
M40	27.0	2.5	3.4
M30	20	2.1	3.0

5.3.4 Procedure

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested, that is the sampling should be spread over the entire period of concreting and cover all mixing units.

5.3.5 Frequency of Sampling

The minimum frequency of sampling of concrete shall be in accordance with the following:

Table 5.9: Sampling Frequency

Quantity of concrete in the work in m^3	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 & above	4 plus one additional sample for each additional $50m^3$ or part thereof
Note:At least one sample shall be taken from each shift.	

5.3.6 Test Specimen

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing, or to check the testing error. Additional cubes may also be required for testing cubes cured by accelerated methods as described in IS:9013. The specimen shall be tested as described in IS:516.

5.3.7 Test Strength of Sample

The test strength of the sample shall be the average of the strength of three specimens. The individual variation should not be more than ±15 percent of the average.

5.3.8 Standard Deviation

(i) Standard deviation based on test results:

a) Number of test results: The total number of test results required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts should be made to obtain the 30 test results, as early as possible, when a mix is used for the first time.

b) Standard deviation to be brought up to date: The calculation of the standard deviation shall be brought up to date after every change of mix design and at least once a month.

(ii) Determination of Standard Deviation:

a) Concrete shall be analysed to determine its standard deviation.

b) The standard deviation of concrete shall be calculated using the following formula from the results of individual tests of concrete obtained **Clause 5.3.3**.

Estimated standard deviation(s) = $\sqrt{\frac{\sum \Delta^2}{n-1}}$

Δ = deviation of the indiviaual test strength from the average strength of n samples

n = number of sample test results

c) When significant changes are made in the production of concrete batches (for example changes in the materials used, mix design, equipment or technical control), the standard deviation value shall be separately calculated for such batches of concrete.

(iii) Assumed Standard Deviation: Where sufficient test results for concrete are not available, the value of standard deviation given in **Table 5.10** may be assumed.

Table 5.10: Assumed Standard Deviation

Grade of Concrete	Assumed Standard Deviation (N/mm^2)
M40	6.6
M30	6.0

However, when adequate past records exist and justify to the Employer, a value of standard deviation different from that shown in **Table 5.10**, it shall be permissible to use that value.

5.3.9 Acceptance Criteria

A. The concrete shall be deemed to comply with the strength requirements if:

(a) every sample has a test strength not less than the characteristic value;

or

(b) the strength of one or more samples though less than the characteristic value, is in each case not less than the greater of:

i) the characteristic strength minus 1.35 times the standard deviation;

and

ii) 0.80 times the characteristic strength;

and

iii) the average strength of all the samples is not less than the characteristic strength plus

$\left\{1.65 - \frac{1.65}{\sqrt{\text{no. of samples}}}\right\}$ x the Standard Deviation

B. The concrete shall be deemed not to comply with the strength requirements if:

(a) the strength of any sample is less than the greater of:

(i) the characteristic strength minus 1.35 times the standard deviation;

(ii) 0.80 times the characteristic strength;

or

(b) the average strength of all the samples is less than the characteristic strength plus

$$\left\{1.65 - \frac{3}{\sqrt{\text{no. of samples}}}\right\} \times \text{the Standard Deviation}$$

Concrete which does not meet the strength requirements as specified in **5.3.9 (A)** but has strength greater than that required may, at the discretion of the Employer be accepted as being structurally adequate without further testing.

If the concrete is deemed not to comply pursuant to **5.3.9 (B)**, the structural adequacy of the parts affected shall be investigated as stipulated in **Clause 5.3.10**.

Concrete shall be assessed daily for compliance.

Concrete is liable to be rejected if it is porous or honey-combed; its placing has been interrupted without providing a proper construction joint; the reinforcement has been displaced beyond the tolerances specified; or construction tolerances have not been met.

5.3.10 Inspection and testing of Structures

5.3.10.1 Inspection

Immediately after stripping the formwork, all concrete shall be carefully inspected and defective work or small defects, if any, shall either be removed or made good before concrete has thoroughly hardened.

5.3.10.2 Testing of Structures or Parts of Structures

In case the results of work test cubes do not comply with the specified strength requirements or there is reasonable doubt regarding the strength of concrete used, either due to poor workmanship or materials, the Employer may instruct the Contractor to perform additional tests as Employer feel necessary and/or load test as specified in **Clause 5.3.10.3** to ascertain the quality of concrete. These tests shall also be required to be carried out in the event the Employer is doubtful regarding the adequacy of strength of the structure due to suspected overloading during construction, premature removal and nonconformance to specification of formwork, improper curing or any other reason. The number and type of tests to be carried out shall be determined by the Employer whose decision shall be final and binding on the Contractor. All such costs will be to the account of Contractor.

5.3.10.3 Load Test

Load test, where directed by the Employer, shall be carried out as soon as possible after expiry of 28 days from the time of placing of concrete. The structure shall be subjected to a load equal to full dead load of the structure (which shall include Self Weight of Structural members plus weight of finishes) plus 1.25 times the imposed load (for which the structure has been designed) for a period of 24 hours and then the imposed load shall be removed. The deflection due to imposed load only shall be recorded. If within 24 hours of removal of the imposed load the structure does not recover at

least 75 percent of the deflection under imposed load, the test shall be repeated after a lapse of 72 hours. If the recovery is less than 80 percent, the structure shall be deemed to be unacceptable.

If the maximum deflection in mm, shown during 24 hours under load is less than 40 L^2/D, where L is the effective span in meters and D the overall depth of the section in mm, it is not necessary for the recovery to be measured and the recovery provision as given above shall not apply.

The Employer shall be the final authority for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Employer shall be final and binding on the Contractor. In case the results of the tests are unsatisfactory, the Employer may instruct the Contractor to demolish and reconstruct the structure.

5.3.10.4 Finishing of Concrete

On striking the form work, all surface defects such as bulges, ridges and honey-combing etc. observed shall be brought to the notice of the Employer. The Employer may at his discretion allow rectification by necessary chipping and packing or grouting with concrete or cement mortar. However,if honey-combing or sagging are of such extent as being undesirable, the Employer may reject the work totally and his decision shall be binding. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as from the formwork except that honey-combed surface shall be made good as specified above.

5.3.10.5 Repair and Replacement of Unsatisfactory Concrete

Repair shall be made as soon as possible after the forms are removed and before the concrete becomes too hard with prior permission from the Employer. Stone pockets, segregation patches and damaged areas shall be chipped out and the edges undercut slightly to form a key. All loose material shall be washed out before patching. No excess water shall be left in the cavity, but the concrete shall be damp. A good bond between the patch and parent concrete shall be obtained by sprinkling dry cement on the wet surface or by throwing mortar with force on to the wetted concrete, or by brush in a coat of thick cement grout of about 1:1 (1 cement: 1 Sand) just before applying the patching material. Before this has dried, the remainder of the patch shall be filled with mortar or concrete, depending on the extent of the repair.

Cement concrete/mortar used in repair of exposed surfaces shall be made with cement from the same source as that used in concrete and blended with sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. The proportions of ingredients shall be same as those used in parent concrete. The mortar shall be as dry as possible and well compacted into the cavity. All filling shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the filling has been cured and dried.

For larger repairs to hardened concrete, necessary formwork bearing tightly at the edges of the cavity shall be provided. Concrete shall be chipped out to a depth of at least 100mm and preferably 150mm. Mortar shall be scrubbed into all surfaces with a wire brush before placing the concrete. Damaged reinforcement shall be adequately spliced with new steel so as to maintain the original strength. Additional reinforcement, if required in the patch, shall be provided as per the instructions of Employer.

In case in the opinion of the Employer defects in the concrete is excessive or beyond repair, the Contractor shall either redo the structure or take other remedial measures as instructed by the Employer. The decision of the Employer shall be final and binding to all in this respect.

Approved epoxy formulation for bonding fresh concrete used for repairs with already hardened concrete shall be used by the Contractor. Epoxy shall be applied in strict accordance with manufacturer's specification and instructions.

All repair works due to non-conformance or non-adherence to specification, shall be carried out.

5.3.10.6 Curing of Patched Work

Immediately after patching is completed, the patched area shall be covered with an approved non-staining water saturated material, which shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the patched area shall be kept continuously wet by a fine spray or sprinkling for not less than 10 days.

5.3.10.7 Faulty Work

Concrete defective from any cause whatsoever, shall, if so directed by the Employer, be rectified or be cut out and the work reconstructed all at the Contractor's cost including cost of plant, material, labour, etc. all complete. Concrete thus cut out shall not be used again. No reconstruction or repairs to faulty work shall be done without the permission of the Employer, and in such a manner as he shall direct.

5.4 Form Work

5.4.1 General

Forms for concrete shall be of plywood conforming to IS:6461 or steel or as directed by the Employer and shall give smooth and even surface after removal thereof.

If it is desired by the Employer, the Contractor shall prepare, before commencement of actual work, design and drawings for formwork and get them approved by the Employer.

Form work and its supports shall maintain their correct position and be to correct shape and profile so that the final concrete structure is within the limits of dimensional tolerances specified below, unless required otherwise, for functional/aesthetic reasons. The decision of the Employer shall be final and binding in this regard.

(a) Deviation from specified dimensions – 6 mm to + 12 mm of cross section of beams.

(b) Deviation in length (major dimension of single unit)

upto 3 m		± 6 mm
3 m to 4.5 m		± 9 mm
4.5 m to 6 m		± 12 mm
additional deviation for every	subsequent 6m	± 6 mm

(c) Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam or slab edge.

upto 3 m	6 mm
3 m to 6 m	9 mm
6 m to 12 m	12 mm
additional for every subsequent 6 m,	6 mm

(d) Deviation in squareness shall be measured taking the longer of two adjacent sides as the base line.

The shorter side shall not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions exceeds 6mm. For this purpose, any error due to lack of straightness shall be ignored. Squareness shall be checked with respect to the straight lines that are most nearly parallel with the features being checked. When the nominal angle is other than 90 degree, the included angle between check lines shall be varied accordingly.

(e) Deviation in twist shall be within a limit such that any corner shall not be more than the limit given below from the plane containing other three corners:

upto 600 mm wide and upto 6 m in length	- 6 mm
over 600 mm wide and for any length	- 12 mm

(f) Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6mm.

5.4.2 Form Requirement

The formwork shall be true, rigid and adequately braced both horizontally as well as diagonally. The forms shall have smooth and even surface and be sufficiently strong to carry, without deformation, the dead weight of the green concrete working load, wind load and also the side pressure exerted by the green concrete. As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used. Projected part of nail shall not be bent or twisted for easy withdrawal.

Where through tie rods are required to be put to hold the formwork and maintain accurate dimension, they shall always be inserted through a precast concrete block (of same mix proportion as is to be used for concreting) with a through hole of bigger diameter. The precast block shall tightly fit against in inner faces of formwork. The holes left after the withdrawal of tie rods shall be fully grouted with cement-sand mortar of same proportion as that used for concrete. However, use of such precast block shall in no case impair the desired appearance or durability of the structure.

Tie wires shall be permitted only upon approval of the Employer and shall be cut off flush with the face of the concrete or counter sunk, filled and finished in the manner specified in Section 5.3.10.4.

Form joints shall not permit any leakage. The formwork shall be strong enough to withstand the effect of vibrations practically without any deflection, bulging, distortion or loosening of its components.

All vertical forms may be designed and constructed for the following minimum pressure. The pressures listed in **Table 5.11** are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

Table 5.11: Minimum Design Pressure for Vertical Formwork

Rate of pour in meter/hour	Pressure in kN/m^2	
	at 10° (in Celsius)	at 24° (in Celsius)
0.6	36.0	29.0
0.9	40	32.0
1.2	44	35.0

All horizontal forms shall be designed and constructed to withstand the dead load of the green concrete, reinforcement, equipment, material, embedment and a minimum live load of 2.0 kN/sqm.

5.4.3 Inspection of Forms

Before concrete is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly cleaned, properly treated and free from foreign material. The complete form work shall be inspected and approved by the Employer before the reinforcement bars are placed in position. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the work shall be stopped until the defects have been corrected as per the instructions of the Employer.

5.4.4 Treatment of Forms

The surfaces of forms that would come in contact with concrete shall be well treated with approved non- staining release agents such as soft soap, oil, emulsions etc. Care shall be taken that such releasing agents are kept out of contact with the reinforcement.

5.4.5 Chamfers and Fillets

All corners and angles shall be formed with 45 degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfer and fillets, unless otherwise detailed or specified shall be 25x25mm.For heavier work chamfers or fillets shall be 50x50mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

5.4.6 Reuse of Forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired and retreated, before resetting. Formwork shall not be reused, if declared unfit or un-serviceable by the Employer.

5.4.7 Removal of Forms / Stripping Time

In the determination of time for removal of forms, consideration shall be given to the location and character of the structures, the weather and other conditions including the setting and curing of the concrete and material used in the mix.

Forms and their supports shall not be removed without the approval of the Employer. The formwork shall be removed without shock and methods of form removal likely to cause over stressing or damage to the concrete shall not be adopted. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In normal circumstances when average air temperature exceeds 16 degree Celsius during the period under consideration after pouring of concrete, forms may generally be removed after expiry of following periods, subject to the approval by the employer:

(a) Vertical	:	24 to 48 hours for faces of all structural Members.
(b) Slabs	:	3 days.
(c) Beam Soffits	:	7 days.
(d) Cantilever Construction	:	Formwork shall remain till structures for counteracting or bearing down have been erected & have attained sufficient strength (minimum 14 days).

Note: Where the shape of the element is such that the formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

5.4.8 Staging / Scaffolding

Staging/Scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. The Contractor shall get it reviewed by Employer before commencement of work. While designing and during erection of scaffolding/staging, the following measures shall be considered:

(a) Sufficient sills or under pinning's in addition to base plates shall be provided particularly where scaffolding is erected on soft grounds.

(b) Adjustable bases to compensate for uneven ground shall be used.

(c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

(d) Horizontal braces shall be provided to prevent the scaffolding / staging from rocking.

(e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

(f) The scaffolding / staging shall be checked at every stage for plumb line.

(g) Wherever the scaffolding / staging is found to be out of plumb line it shall be dismantled and re-erected afresh, and effort shall not be made to bring it in line with a physical force.

(h) All nuts and bolts shall be properly tightened, and care shall be taken that all clamps/couplings are firmly tightened to avoid slippage.

(i) Erection work of a scaffolding/staging under no circumstances shall be left totally to semi-skilled or skilled workmen and shall be carried out under the supervision of a technically qualified civil Engineer of the Contractor.

For smaller works or works in remote areas, wooden ballies may be permitted for scaffolding / staging by the Employer at his sole discretion. The Contractor must ensure the safety and suitability of such works as described above.

5.5 Exposed Concrete Work

5.5.1 Form Work

Other things remaining same as per **Clause 5.4**, formwork shall be of high quality. The forms shall be butting with each other in straight lines, the corners of the boards being truly at right angles. The joints between the forms shall cross in the two directions at right angles. The size of forms shall be so selected as to exactly match with the pattern of forms impression on the concrete face. Maximum care shall be taken to make the formwork watertight. Burnt oil shall not be used for treatment of forms. The Contractor may be permitted reuse of forms brought new on the work for exposed concrete work as specified below.

Such reuses shall be permitted only if forms are properly cared for, stored, repaired and treated after each use.

(a) Plywood Forms 6 Reuses (Max.)

(b) Steel Forms 10 Reuses (Max.)

The Employer may, at his absolute discretion, order removal of any forms considered unfit for use in the work irrespective of the number of uses specified above.

5.5.2 Finishing

Repairing to exposed concrete work shall be avoided. Rendering and plastering shall not be done. Minor repairing, if unavoidable shall be done as specified in Section 0 with prior approval of the Employer.

5.6 Reinforcement

5.6.1 General

Reinforcement shall be cut, bent to shape and dimensions as shown in the bar bending schedules/drawings.

5.6.2 Straightening, Cutting and Bending

Procedure for cutting and bending shall be as given in IS:2502. In case bars are supplied in coils,they shall be smoothly straightened without any kinks.

Cold twisted deformed bars shall be bent cold. Bars larger than 25mm in size (except cold twisted deformed bars) may be bent hot at cherry red heat to a temperature not exceeding 850° Celsius as per the instructions of the Employer. The bars shall be allowed to cool gradually without quenching. Bars shall be bent in a slow and regular movement to avoid fractures. Bars which develop cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time is radius of the bend less than 4 times bar diameter for plain mild steel or 6 times bar diameter for high strength deformed bars. Care shall also be taken when bending back bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

5.6.3 Placing and Fixing

All reinforcement shall be cleaned to ensure freedom from loose mill scale, loose rust, oil, grease or any other harmful material before placing them in position. Reinforcement shall not be surrounded by concrete unless it is free from all such harmful materials.

All reinforcement shall be fixed in the correct position and shall be properly supported to ensure that displacement will not occur when the concrete is placed and compacted.

The reinforcement bars shall be tied at every intersection by two strands of 16 SWG black soft annealed binding wire. Crossing bars shall not be tack welded for assembly of reinforcement. The reinforcement bars shall be kept in position by using the following methods:

(a) In case of beam and slab construction, precast cover blocks (having the same cement sand contents as the concrete which shall be placed) of size 40 x 40 mm and thickness equal to the specified covers shall be placed firmly in between the bars and forms so as to secure and maintain the specified covers over the reinforcement.

(b) When reinforcement bars are placed in two or more layers in beams, the vertical distance between the horizontal bars shall be maintained by introducing spacer bars at 1 to 1.2m centre to centre.

(c) In case of pile caps having two or multi layers of reinforcement, the vertical distance between the horizontal bars shall be maintained by introducing suitable chairs, spacers, etc.

(d) Exposed portions of reinforcement bars shall not be subjected to impact or rough handling and workmen will not be permitted to climb on extending bars until the concrete has attained sufficient strength so that no movement of the bars in the concrete is possible.

5.6.4 Splicing / Overlapping

Only bars of full length shall be used. But where this cannot be done, overlapping of bars shall be done as directed by the Employer. Where practicable, the overlapping bars shall not touch each other, but these shall be kept apart by 25mm or 1.25 times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be tied with two strands of 16 SWG black soft annealed binding wire. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.

5.6.5 Welded Joints

Welding of reinforcing bars shall not be permitted without the written permission of the Employer. Where welding is permitted, it shall be in accordance with the recommendations of IS:2751 and IS:9417. Welded joints shall be located at suitable staggered positions. Tests shall be made as directed by the Employer to prove that the joints are of the full strength of the bars. Maximum one welded joint shall be allowed per bar.

5.6.6 Mechanical Connections

The mechanical splices in reinforcement by means of couplers, clamps etc. shall be used {as per manufacturer's specifications) with the written approval of the Employer. However, tests shall be

made as directed by Employer to prove that such connections are of the full strength of the bars on trial joints.

5.6.7 Tolerances

Unless otherwise directed by the Employer, reinforcement shall be placed within the following tolerances:

(a) For effective depth 200mm or less ± 10mm

(b) For effective depth more than 200mm ±15mm

The cover shall in no case be reduced by more than one third of specified cover or 5mm, whichever is less.

5.6.8 Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Employer.

5.6.9 Cover

Cover to reinforcement shall be as per standard codes or as directed by the Employer.

5.6.10 Depositing Concrete

No concrete shall be deposited until all concrete and reinforcement have been inspected and approved by the Engineer. There shall be in attendance on each concreting gang a competent steel fixer who shall ensure that the reinforcement and other embedded fittings are kept in position before placing and compacting of the concrete.

5.7 Precast Concrete

5.7.1 General

The requirement of the clauses relating to concrete and reinforcement shall be observed in the case of precast concrete work so far as they are applicable, as well as the following requirements relating to the precast concrete work, in particular.

5.7.2 Precasting Yard

The precast units shall be cast on, or their shutters supported from a suitably prepared level unyielding paved area.

5.7.3 Shutters

A shutter shall be strongly constructed, closely jointed, smooth and shall be such as to ensure true sharp arris and a perfect surface. Shutters are to be so designed that they can be taken apart and reassembled readily.

5.7.4 Casting Tolerance

The casting tolerances, unless otherwise ordered or directed, shall be within 3 mm of true dimensions.

5.7.5 Striking Shutters

The method and time after casting of units of striking side shutters shall be subject to approval of the Engineer. In the event of any damage resulting from premature removal of shutters or from any other cause, the unit or units concerned shall be liable to rejection and to replacement by the Contractor at his own cost.

5.7.6 Lifting and Stacking

Lifting and stacking of precast units shall be undertaken without causing shock, vibration or undue stress to or in the units. Precast units shall not be lifted, transported or used in the works until they are sufficiently matured; the crushing test on the test cubes which are to be kept with the precast units shall be used to assess the maturity of the units. Lifting methods shall be defined as per the requirements of the design and the Contractor shall satisfy the Engineer that the methods he proposes for lifting, transporting and setting precast units shall not overstress or damage the units in any way. In the event of overstress or damage due to whatever cause, the unit or units concerned shall be liable to rejection and if so rejected shall be immediately broken up and removed from the Site. The Contractor shall replace such rejected units at his own cost.

5.7.7 Marking

The Contractor shall ensure that all precast units are properly marked in clean and legible manner with the reference number and the date of casting, which information shall be clearly visible where the units are stacked. Reinforced precast members shall be clearly marked to indicate the top face.

5.7.8 Precasting Records

Full and accurate records are to be maintained of all precast work. Every unit shall have a reference number. Date of casting, date of removal from bed and date and position of placing shall be recorded together with corresponding test cube reference number.

5.8 Bored Piles

5.8.1 General

The Contractor shall furnish materials, labour and equipment necessary to drill or bore and install bored piles in accordance with the following sections.

5.8.2 Standard

Construction and testing of bored piles shall be carried out in accordance with the relevant sections of IS:2911 (Part I) "Code of Practice for Design and Construction of Pile Foundations".

5.8.3 Method of Construction

The Contractor must furnish to the Employer, before commencing work, a detailed method of construction he intends to adopt for piling work together with the programme of construction.

5.8.4 Boring

Boring shall generally be carried out by recommended procedure as set out in IS:2911 by either rotary or percussion equipment, grabbing equipment or by reverse or direct mud circulation method. If the soil is found to be unstable, the boring tools should be such that suction effects are minimised. Walls of boreholes shall be stabilised by using casing/liners with or without drilling fluid depending upon the soil conditions. In soils liable to flow the bottom of the casing/liners should be kept ahead of the boring in all cases to prevent the entry of soil into the bore, so preventing the formation of cavities and settlements in the adjoining ground. Continuous pumping shall not be used for excavating inside the boreholes. While below sub-soil water level, precaution shall be taken so that no boiling of the bottom of the hole occurs due to the difference in hydrostatic head.

Where stabilisation of the sides of the borehole is effected by the use of drilling fluids, the fluid level shall be maintained at a level not less than 1.5 m above the level of the sub-soil water or high water level as the case may be and the hole shall then always be kept almost full with it till the concreting is completed.

The specific gravity and composition of the fluid shall be such as to suit the requirements of the ground conditions and to maintain the fine materials from the boring in suspension.

Boring of any pile must be completed in one continuous operation without interruption. In case such interruptions are unavoidable, steps shall be taken to prevent the collapse of sides of the borehole.

Boring in rock shall be carried out either by chiselling or by any other approved method. The bottom of the borehole shall be cleaned off by air lifting all the spills and sediments so that the bases of piles shall be free from loose materials. The piles shall be anchored into hard rock with minimum 1.0 m socketing. Rock in which the rate of penetration of the chisel of weight 3 tonnes is less than 20 cms per hour of continuous chiseling will only be deemed to be hard rock. The drop of the chisel for this purpose shall not be less than 60 cm. In case of lesser weight of chisel the drop of the chisel shall be correspondingly increased proportionately to obtain the equal energy of fall and the number of blows on an average not less than 20 per minute.

Bailer samples shall be collected invariably at rock touch level and founding level and at any other intermediate level as directed by the Engineer. Notwithstanding the confirmation of hard strata to the rate of penetration specification above, the final decision about the founding strata shall however be subject to verification of physical samples of rock as judged of the Engineer about the acceptance of the founding strata shall be final and binding.

The Contractor shall be responsible for the prompt removal from the Site of all spoil due to the boring upto a distance of 1 km and at places specified by the Employer. The cost of such disposal shall be deemed to have been included in the price.

Foundation elevation of each pile will be individually approved by the Employer on the basis of the Employer satisfying himself, from observations and all data.

5.8.5 Drilling Fluid

Bentonite used in the Works shall be of the best quality. Sodium based bentonite shall be used in preparing bentonite slurry. The bentonite used in the work shall satisfy the following requirements.

- The liquid limit of bentonite shall be more than 300% and less than 450%.
- Sand content of the bentonite powder shall not be greater than 450%.

- The swelling index shall be at least 2 times its dry volume.
- The PH value of the bentonite suspension shall be less than 11.5.
- Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the bentonite solutions should be about 1.12.
- The marsh viscosity when tested by marsh cone should be about 37 seconds.
- Bentonite shall be mixed thoroughly with clean fresh water to make a suspension, which will maintain the stability of the pile excavation for the period, necessary to place concrete and complete construction. The fluid used shall be such as to form a suspension, which remains stable under the saline conditions likely to be encountered at the Site.
- Control tests shall be carried out on the bentonite suspension using suitable apparatus. The frequency of testing the drilling fluid and the method and procedure of sampling shall be as directed by the Engineer. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed.
- The measuring device shall be calibrated to read to within 0.005 g/ml. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite supplied to the pile boring.

5.8.6 Formation of Pile

The concrete to be placed under water or drilling fluid shall be placed by tremie unless otherwise approved and shall not be discharged freely into the water or drilling fluid. Before placing concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the boring and the Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the pipe of the tremie, has not accumulated in the bottom of the hole.

A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.25, the placing of concrete shall not proceed. In this event, the Contractor shall modify or replace the bentonite as directed by the Engineer.

All equipment, material and operations employed in the formation of the piles shall be such as to ensure that the piles are and remain of full cross-section and shall be capable of carrying the specified test load 28 days after concreting.

The concrete shall be properly graded and well compacted without excess water, admixture of soil or other extraneous matter. The concrete shall be placed through a tremie pipe of 20 to 25 cm in dia with a suitable hopper. The tremie pipes joints shall be air-tight and hopper capacity shall be such that it produces a build-up of at least 2m concrete in the pile. Great care shall be taken in the placement of the first pour using a suitable pig in the pour or a PVC plunger so that the concrete does not come in contact with water. The first pour is eventually brought up through successive pour of concrete and overflow at the end of concreting. The tremie pipe must extend down to the bottom of the borehole at the start and may be withdrawn in sections as the level of the concrete rises in the boreholes, but its discharge end shall at all times be immersed in the concrete to a minimum depth of one metre. Placing of concrete shall be continuous and the tremie pipe shall be held concentric in the hole. Special care shall be taken regarding compaction of concrete in the top section of the pile.

At all stages of work every precaution shall be taken to prevent the formation of voids in the concrete caused by the faulty consolidation or pockets of air trapped within it. The volume of concrete placed shall be checked against calculated volume of pile at the time of placing. Any shortfall in actual consumption of concrete in pile shall not be more than 5% of the theoretical volume.

Any excess consumption of concrete above the theoretical volume shall be borne by the Contractor at his cost.

All piles shall be adequately braced by temporary bracings by the Contractor at his own cost to the satisfaction of the Engineer till the deck is completed. The responsibility of the safety of the permanent works, however, shall rest with the Contractor.

5.8.7 Reinforcement

Reinforcement shall be mild steel bars conforming to IS:432, or tor steel bars conforming to IS:1786.

Any reinforcement used shall be made up into stiff cages sufficiently well wired or welded to withstand handling without any distortion or damage. The bars shall be so placed as not to impede the placing of the concrete. They shall be placed correctly in position and be supported away from the sides of the pile shaft by means of spacer blocks to assume concentric alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the piles without any distortion or displacement. Care shall be taken to preserve the correct cover and alignment of the reinforcement throughout the whole operation of placing the concrete.

Normal lap between reinforcement cages shall be as per I. S. Specifications. The main reinforcing steel shall project for a length sufficient to develop bond above the cut-off level of the pile. The clear concrete cover to main reinforcement shall be 75 mm and suitable spacer blocks shall be provided at intervals not exceeding 2 metres and wired to the main reinforcement.

5.8.8 MS Liner / Casing

For Jetty Piles, permanent mild steel liner shall be provided for all piles from cut off level upto the required level depends on the soil conditions and/or as approved by the Employer. The minimum length should be provided 5m below the river bed level.

5.8.9 Control of Alignment

The pile shall be cast as accurately as possible to the vertical. Any pile deviating from its proper alignment to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile ties shall, at the discretion of the Employer, be replaced or supplemented by additional piles at no extra cost.

5.8.10 Recording of Data

During Construction of pile, the following data shall be recorded along with any other data as directed by the Engineer. These data shall be submitted to the Engineer in triplicate on completion of construction of each pile as and when required by the Engineer.

(a) Date of starting and completion of the pile.

(b) Sequence of installation of piles.

(c) Dimensions of the pile, reinforcement details and mark of the pile.

(d) Details of mild steel liner provided along with mark of the pile.

(e) Depth bored and founding level along with a bore log indicating nature of stratum.

(f) Time taken for penetration of every 15cm during last 1m depth before founding level.

(g) Method of cleaning bottom of hole at founding level before concreting.

(h) Time taken for concreting.

(i) Cut off level / working level / RL of top of concrete.

(j) Actual Cement bag consumption, including theoretical consumption, slump of concrete.

(k) Any other relevant important observation.

5.8.11 Volume Check

The volume of concrete placed shall be observed in the initially cast piles and the average figure obtained shall be used to check whether there is undue deviation in concrete consumption for the subsequent piles. If actual quantity is found to be considerably less, special investigation shall be conducted, and appropriate measures taken.

5.8.12 Defective Piles

Piles, which have been declared defective by the Employer, shall either be removed or left in position as per decision of the Employer. If left in place, the cost of any modifications required in the pile/pile caps shall be borne by the Contractor in addition to the cost of construction of any replacement piles. If removed, all costs related to this shall be borne by the Contractor.

5.8.13 Finishing Pile Heads

The top of the piles shall be brought up above the finished level to permit all laitance and weak concrete to be removed and to ensure that it can be properly keyed into the cap. Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete and bonded into the old.

5.8.14 Load Tests

5.8.14.1 Vertical Load Test

The test shall be carried out by applying a series of loads on the test pile. The load shall be preferably applied by means of hydraulic jacks reacting against a symmetrically erected loaded platform which shall be preloaded to not less than 1½ times the design load carrying capacity of the pile. The hydraulic jack shall be of adequate capacity and shall have a pressure gauge and remote control pump.

The Contractor shall arrange all the necessary equipment and kentledge with platform at his own expense well in advance of the load test. Detailed proposal together with a sketch for the load test arrangement shall be furnished by the Contractor to the Engineer for the latter's checking and approval.

The pile to be tested shall be chipped and dressed to a well-levelled surface. It is important that reinforcing bars of the pile do not project beyond the top surface of the level pile top.

A round plate of suitable thickness and always greater than the diameter of the pile that is to be tested, shall be placed over a fine layer of sand spread over the top of the pile.

A jack or two jacks, depending on the capacity of the jacks and the ultimate test load shall be inserted between the gap formed by the top of the plate resting on the pile and the lower flange of the main R.S.Js of the loaded platform. The jacks should preferably be connected and operated by one pump.

The Contractor shall submit certificates showing the correctness of the calibration of the pressure gauges and the jacks before use. All jacks shall be fitted with locking devices.

Another plate of suitable thickness shall be placed over the ram of the jack, which is later raised by operating the hydraulic pump so that the plate on the top of the ram butts against the bottom flange of the main R. S. Js of the platform.

Readings of settlement and rebound shall be recorded with the help of four dial gauges of 0.02 mm sensitivity and resting on diametrically opposite ends of the pile cap.

The dial gauges shall be fixed to a datum bar whose ends rest upon non-movable supports. The supports should be at least 5 x d away clear from the pile where "d" is the diameter of the pile. Readings on the dial gauges are to be observed immediately before and after application of loads and immediately before and after release of loads.

The test load shall be applied in equal increments of about 1/5 of the design load until the test load is reached.

Each stage of loading and unloading shall be maintained until the rate of movement of the pile top is not more than 0.02 mm per hour. Unloading shall be done as under:

1. Test load to design load
2. Design load to 50% of the design load
3. 50% to 25% of the design load
4. 25% to complete unloading.

The rebound reading for each decrement shall be noted. The final rebounding shall be recorded 24 hours after the entire load is released. The safe carrying capacity of the pile shall be estimated in accordance with IS:2911.

5.8.14.2 Lateral Load Test on Piles

Two test piles shall be installed to the required depth and spacing as specified by the Engineer. A hydraulic jack of adequate capacity shall be inserted in between them to apply the lateral load at the approximate cut-off level of the pile. Thrust pieces shall be inserted on either end of the jack to make up the gap. Lateral deflections shall be measured at the thrust level by means of dial gauges fixed to immovable supports.

The loading shall be applied in one half tonne increments till the rate of deflection reduces to 0.02 mm/hour and a load deflection curve shall be plotted.

The loading shall be continued till the deflection of the pile top reaches the estimated value or the estimated safe load whichever is earlier.

When the full test load is applied it shall be kept on for 24 hours with observations made every hour and then released in 3 stages.

5.8.14.3 Plant and Equipment

All temporary work, plant, equipment, kentledge for supplying the load and all necessary instruments for measurement of loads, deflection, etc. shall be provided by the Contractor. The equipment provided shall be capable of slowly applying and maintaining the required test loads to within an accuracy of 0.02 mm. The Contractor shall submit for approval of the Engineer his detailed proposal for carrying out the load test.

5.8.14.4 Test Piles

Vertical load tests shall be carried out on the specially constructed test piles.

In addition to vertical load tests, the Contractor shall carry out horizontal load test on bored piles specially constructed for the purpose. Maximum test loads shall be as determined by the Engineer according to I. S. Specifications considering the design horizontal loads.

5.8.14.5 Cost of Delay

The Contractor shall be deemed to have allowed in the construction programme the time required for testing of piles. No claim shall be entertained for any delay due to the testing programme.

5.8.14.6 Records

The Contractor shall assist the Engineer in keeping the following records of the tests:

(a) Make and specification of jack pressure gauge and dial gauges;

(b) Calibration of pressure and dial gauges;

(c) Design load of pile, description of location and identification marks of pile.

The readings for settlement and rebound shall be entered in the following form:

Time	Load	Dial	Settlement	Dial	Settlement	Mean set	Remarks
1	2	3	4	5	6	7	8

5.8.14.7 Interpretation of Test Results

The pile shall be deemed to be acceptable under the following conditions:

(a) Total settlement under the test load does not exceed 12 mm, plus allowance for normal elastic deformation;

(b) The increase in settlement between two consecutive increments of loading does not exceed 6 mm plus allowance for elastic deformation.

The elastic deformation is defined as shortening of the pile within the elastic limit of the materials forming the ingredients.

5.8.14.8 Integrity Testing

Non-destructive integrity testing of bored piles, as decided by the Employer, shall be conducted using the low strain sonic diagnostic system consisting of hammer, low `g' accelerometer with amplifier, pile integrity tester, portable computer system, graphics printer, etc. all complete. The test shall be conducted by qualified and experienced specialists in this field. Employer's decision shall be final regarding acceptance of piles passing integrity test but of questionable workmanship.

5.9 Earthwork

5.9.1 Drainage and Dewatering

The Contractor shall plan and carry out all stages of the Works in a manner that avoids erosion, ponding, softening, saturation, contamination and sedimentation of the Site and surrounding areas. The Contractor shall provide all necessary control measures, which may include:

(i) Construction of temporary drains;

(ii) Pumping and/or dewatering of excavations;

(iii) Diversion of concentrated flows to points where they can pass through the Works without damage;

(iv) Construction and maintenance of silt traps;

(v) Staging of earthworks; and

(vi) Progressive restoration of disturbed areas throughout the project.

Any area which becomes damaged as a result of the effects of water shall be repaired by the Contractor. The Contractor shall arrange for the rapid dispersal of water collected/ accumulated on the earthwork or completed formation during construction or on the existing roadway or which enters the earthwork or any other item of work from any source, and where practicable, the water shall be discharged into the permanent outfall of the drainage system or as directed by Engineer. The Contractor shall provide, where necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a sufficient minimum cross fall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

Care shall be taken to discharge the drained water so as not to cause damage to the works. If any such damage is caused due to any negligence on the part of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore it to original condition or compensate the damage at his own cost.

Where cofferdams are required, these shall be carried to adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for facilitating construction to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping equipment's etc., inside the enclosed area.

At the discretion of the Contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the excavation area.

The works involved in keeping the earthwork or any other item of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the same.

5.9.2 Protection of Finished Earthworks

The Contractor shall protect finished earthworks of reclaimed areas from construction or other vehicular traffic, weather and erosion and keep them free of rubbish and debris and repair and re-establish grades in settled, eroded and rutted areas to the specified tolerances.

Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, the Contractor shall scarify the surface, reshape and compact to the required density in accordance with these specifications prior to further construction.

Construction traffic and other vehicular traffic shall not traverse or bear on the cut formation, prepared surface of the filling or finished subgrade unless permitted by the Engineer. Any damage arising out of such use shall be made good by the Contractor at his own expense.

5.9.3 Safety of Excavations

All excavations shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accidents and all other measures as may be nominated in his approved Health and Safety Management Plan. The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures. For safety precautions, guidance may be taken from IS: 3764.

5.9.4 Earthworks Materials

The Contractor shall be responsible for his assumptions made in relation to the nature and types of materials as encountered in excavations or imported, and the bulking and compaction characteristics of all such materials which are to be incorporated into the works.

The material to be used for work shall not have more than 20% by weight of particles smaller than 75 microns. The material shall be free from organic and deleterious constitutes. The fill material and subgrade shall have excellent drainage characteristics.

Source of suitable material shall be identified by the contractor. Cost of transportation and placement of suitable fill material shall be included in the item rate. No additional cost will be paid for transportation and placement of suitable fill material.

5.9.5 Compaction

Prior to the commencement of works the Contractor shall sufficiently describe the proposed methods of compaction (equipment, number of passes and achieved MDD). The methods and verification of the compaction shall be agreed by the Engineer.

All material placed as a fill material to make up ground levels, shall be compacted to achieve dry density as specified in specification by means of mechanical vibratory roller or tendon roller. The required number of passes, roller weight, roller speed, frequency, amplitude of vibration shall be decided based on the trial compaction and to meet the required MDD as per these specifications. If the required compaction is not achieved with the above mentioned number of passes, then number of passes shall be increased till the final compaction is achieved. Care shall be taken to see that the

compaction equipment does not hit or come too close to any structural member so as to cause any damage to them or excessive pressure against the structure.

Table 5.12: Heavy compaction for various fill materials

Type of work/material	Maximum Dry Density IS: 2720 Part 8 - Heavy Compaction
Fill Material	95%
Subgrade Material	98%

Levels shall be taken along the grid lines by the Contractor before Improvement commences, at intervals during the Improvement process as instructed by the Engineer and on completion.

5.9.6 Performance Criteria

Following completion of the cutting and filling of the ground surface, after to the commencement of compaction, the Contractor shall undertake CBR testing at the final grade level to ensure that the material can satisfy the relevant design CBR requirements specified by Engineer.

The CBR testing shall be carried out in accordance with IS: 2720 Part 16 on remoulded specimens compacted to the same relative density specified for the foundation. The Contractor shall submit the test results to the Engineer for approval prior to the commencement of any subsequent compaction or filling activities. The Testing and Acceptance Criteria of the compacted soil is given in **Table 5.13**:**.**

Table 5.13: Testing and acceptance criteria

Test	Frequency
Field density test by sand replacement method	• 1 test for every 1000 Sqm of each compacted area. • In areas where the degree of compaction is doubtful
Laboratory CBR test	• 1 test for every 3000 cum on the top 500 mm of the compacted layer • The bulk sample shall be collected preferably from the road area.

Filling: 95% MDD

Subgrade Material: 98% MDD

5.10 Steel Work

5.10.1 Fabrication

The Contractor shall prepare detailed drawings giving complete information necessary for the fabrication of the steel works. All information should be clearly given and the Drawings shall be in conformity with the best modern practice. A marking diagram allotting distinct identification marks to each separate piece of steel work shall be prepared in sufficient detail to ensure convenient assembly and erection. Symbols for welding used on the Drawings shall be in accordance with IS:813 "Scheme of Symbols for Welding".

The Contractor shall prepare comprehensive bill of material sheets for each shop Drawing giving therein all the items shown on the Drawings together with their weights, mark numbers, cutting lengths, etc.

All fabrication shall be in accordance with IS:800 "Code of Practice for use of Structural Steel in General Building Construction".

5.10.2 Welding

Metal arc process shall be used for welding in all cases, unless otherwise specified. The welding procedure shall be in accordance with the requirements of IS:816 "Code of Practice for Use of Metal Arc Welding for General Constructions in Mild Steel". The symbols for welding as shown on the Drawings will be interpreted in accordance with IS:813.

Electrodes used for hand welding or for automatic welding machine shall conform to IS:814 "Covered Electrodes for Metal Arc Welding of Structural Steel".

5.10.3 Galvanising

Galvanising where specified shall be of the best quality conforming to IS:2629 "Recommended Practice for Hot-Dip Galvanising of iron & Steel". All galvanising to be 125 microns thick.

5.11 Painting

5.11.1 Items to be Painted

All structural steel work and metals including handrails, brackets & exposed surfaces of steel inserts shall be painted except if otherwise specified.

5.11.2 Standard

The operations, workmanship, schedules and equipment for painting shall generally comply with the requirements of IS:1477 (Parts I & II) "Code of Practice for Painting of Ferrous Metals in Buildings" except in so far as this Specification modifies it.

5.11.3 General Requirements

All surfaces shall be thoroughly cleaned of all foreign matters adhering to the steel surface to Swedish Standard specification Sa $2^{1}/_{2}$ by means of blasting with sand. Use of scraper wire brush and pig hammer is acceptable wherever blasting with sand is not possible due to lack of access. All painting shall be carried out by brushing. Spray and roller application of paint shall not be allowed without the written permission of the Engineer.

Painting shall generally be done immediately after cleaning. The cleaned surface shall not be allowed to stand overnight before painting. Where galvanised surfaces are to be painted, they shall be cleaned and washed with a solution of copper sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Employer.

5.11.4 Schedule

All steelwork unless specified otherwise, shall be painted as per the following schedule:

(a) Two coats of epoxy base zinc rich primer (92% zinc on dry film) shall be applied. The dry film thickness of two coats shall be 60 microns minimum.

(b) After the application of primer, all surfaces shall receive two coats of coal tar epoxy or any other high build epoxy compatible with the primer. The finish paint shall be applied to establish an endurable protection of the prime coat. It shall be resistant to atmospheric heat, reflect heat and rays and withstand mechanical stresses without crumbling. The total dry film thickness for these 2 coats shall be 200 microns minimum. the colours for the finishing coats shall be as approved by the Engineer.

(c) Total dry film thickness for the system shall be 260 microns minimum.

(d) For steel work intended to be painted only at Site, a primary coat of Red Oxide Zinc Chromate shall be given at the shop before despatch.

5.12 Fixtures and Fittings

5.12.1 Steel Ladders

Ladders shall be provided on the berth face either in grooves without protruding outside the berth face at as per the size, length and locations specified in the drawings.

5.12.2 Materials

All steel parts shall be as per steel grade St 37-2, DIN 17100 or equivalent and approved by Employer.

5.12.3 Welding

All Welding and welding material shall confirm to the best recommended practices as per AWS D1.1. Fabrication shop should be approved for its fabrication facilities as per international standards like ISO 3834 or equivalent.

5.12.4 Painting

Ladder shall be sand blast cleaned as per SA 2.5 and will be hot dipped galvanized as per ISO 1461. DFT: 90 Micron Minimum.

5.12.5 Inspection

Dimension report and Material test certificates for Physical and chemical properties shall be provided along with supply of material.

All weld shall be checked by NDT Methods

Testing shall be witnessed by any reputed Third-party Inspection Agency.

5.13 Marine Timbering

5.13.1 General

Timber used for marine works in edge, coping, etc. shall be of full size and lengths or as instructed by the Employer. Timber shall be chamfered or radiused as required. Where timbers are to be bolted to concrete or steelwork, or where timber are liable to come into contact with ship/vessel sides, bolt holes shall be recessed.

5.13.2 Timber for Edge Strips

Timber shall be constructed of second grade hard wood, thoroughly seasoned.

5.13.3 Assembly

Individual members shall be assembled in a jig and firmly fixed together by bolts or bracket plates using approved type of shear connectors. Faces of timber to be jointed together shall be flush and notching of timbers, scarfing or the use of packing pieces will not be permitted.

5.13.4 Bolting

All bolts shall fit tightly when driven home. If the holes are too large, the Contractor shall at his own expense provide bolts of the size that will tightly fit the holes. Oversize bolts may only be fitted with the approval of the Engineer. Bolt holes shall be drilled from one direction only. Bolt holes shall run truly parallel to the edge of the timber unless otherwise specified.

5.13.5 Fitting and Fixing

Fittings and fixing shall be as required in relevant I. S. Specifications. All countersunk holes shall be well filled with an approved mastic compound.

5.13.6 Treatment

The timber is to be subjected to the treatment of copper-chrome-arsenic preservative by vacuum pressure impregnation in accordance with IS:401-1982 "Code of Practice for Preservation of Timber". The absorption of the preservative into timber shall be 40 kg/cum.

5.14 Bollards

5.14.1 General

The Contractor shall supply and install bollards to piers in accordance with the details shown on the Drawings.

Bollards shall be of the types and rated load capacities shown on the Drawings.

Bollards shall be proprietary units manufactured by a specialist marine bollard and mooring equipment manufacturer.

5.14.2 Codes and Standards

For manufacturing and testing of cast steel bollards the codes specified in **Section 6A- Volume-II** shall be followed.

5.14.3 Materials and Classification

Bollards shall be manufactured from cast steel complying with the requirements of IS 1030.

The casting shall conform to IS 1030. The mechanical properties of it shall be:

Tensile strength	: 540 MPa (min.)
Elongation	: 15% (Gauge length 4JA)
Yield strength	: 50% of min. tensile strength
Angle of bend	: 60% (min.)

The limit for sulphur and phosphorous in the steel when analysed shall be as follows:

Sulphur	: 0.05% max.
Phosphorous	: 0.5% max.

5.14.4 Design Life

Design working life of Bollards shall be 8 years.

5.14.5 Design Requirements

Load capacities shown on the Drawings indicate the minimum safe working load capacity or rated load capacity of the bollard and shall be applicable to loading angles within 180 degrees of the jetty cope line alignment in the horizontal plane and within the range -10 degrees to +70 degrees from horizontal in the vertical plane.

5.14.6 Protective Coatings

Bollards shall be painted in accordance with the requirements of these specifications. Coatings may be either applied by the manufacturer or can be applied by the Contractor's specialist protective coating subcontractor but in either case shall fully conform to the requirements of IS:1477 (Part I & II) "Code of Practice for Painting of Ferrous Metals in Buildings".

The surface, before painting, shall be cleaned of all rust, scale, dirt and other foreign matter with wire brushes, steel wool, scrappers, sand paper etc. The surface shall then be wiped finally with mineral turpentine, which shall then be removed of grease etc. The surface then shall be allowed to dry.

Schedule:

1. One coat of Organic Zinc Rich Primer (thickness, 60m DFT).
2. Strip coat on each weld joint and edge of structure by surface tolerant Epoxy

– 75m DFT by Brush – One Coat

3. Two coats of High Build Abrasive Epoxy (DFT 100m for each coat)
4. Total System Thickness = 250m DFT without Strip Coat
5. Strip coat and one coat of high build epoxy should be immediately followed by primer. It is not permitted to keep organic Zinc Rich Primer exposed to atmosphere for long time.

5.14.7 Hold-down Bolts and Anchorage Details

Cast in anchorage and hold-down bolt details shall be strictly in accordance with the requirements of the manufacturer.

All anchor bolts, nuts and washers shall be of stainless steel conforming to AISI 304 or equivalent.

All fittings including bolts, nuts, washers shall be tested and certified in accordance with the relevant materials standards. All relevant materials tests results, and certificates shall be supplied with the hold down bolts and anchorage accessories and shall be submitted to the Engineer for approval prior to the installation of the hold down bolts.

The Contractor shall install the hold down bolts strictly in accordance with the manufacturer's specific requirements for each type of bollard. A temporary template shall be used at the top of the bolts to prevent movement or dislocation during concreting.

The exposed ends of the bolts shall be coated with an approved petrolatum paste and wrapping tape upon completion of the bollard installation and tightening of the bolts to prevent corrosion and facilitate the future removal of the bollard if necessary.

5.14.8 Grouting of Baseplates

The Contractor shall install each unit in accordance with the supplier's specific requirements for each type of bollard. The clear gap between the underside of the baseplate and the top surface of the concrete deck shall be as specified by the bollard unit manufacturer.

Following installation and levelling of each bollard unit and tightening of the hold down bolts, the Contractor shall grout the baseplates so as to completely fill the void between the underside of the baseplate and the top surface of the concrete deck.

The grout shall be an approved free flowing, high strength cementitious grout, Fosroc "Conbextra HF" or equivalent.

The grout shall be shrinkage compensated by way of volumetric expansion of the grout in the plastic state as well as formulated to compensate for longer term expansion in the hardened state. The compressive strength of the grout must exceed 60MPa at 28 days. The storage, handling, placement and curing of the grout shall be strictly in accordance with the manufacturer's instructions.

5.15 Specifications for Casting

5.15.1 Method of Casting

The steel for the casting can be made from open hearth, electric, duplex, acid Bessemer, basic oxygen (L.D.) or a combination of these processes.

Castings manufactured from steel made by Bessemer processes will not be accepted. The steel shall conform in quality, strength, hardness etc. to IS 1030.

The casting shall be made under strictly controlled condition to ensure chemical composition, soundness, uniformity, correct grain size to develop shock resistance properties and to avoid any blow-holes.

5.15.2 Moulding and Moulding Tolerances

The casting shall be accurately moulded in accordance with the drawing. The dimensional tolerance that can be allowed for all important dimensions shall be ± 1.6 mm. The thickness of casting shall in no instance be greater than or less than 1.6 mm.

The castings shall be sound, clean and free from sand. They shall be free from distortion, blowholes, twists and other injurious defects. They shall be properly flattened and dressed.

5.15.3 Heat Treatment

All casting shall be supplied in the heat treated condition which shall be carried out at suitable temperature to give the mechanical properties as specified. The casting shall thoroughly be annealed to refine the crystalline structure throughout the casting by heating to a uniform temperature not less than the normalizing temperature and allowing to cool slowly from maximum temperature in a uniform manner or alternatively normalizing by heating in a similar manner and allowing it to cool in air away from draughts.

In no case it shall be allowed to conduct heat treatment process for more than two times on the same casting.

The Contractor shall furnish, the method of heat treatment and all relevant records.

5.15.4 Marking Procedure

Each casting shall be legibly marked with

- Number or identification mark by which it can be traced to the melt from which it was made, and
- The manufacturer’s initial and trade mark
- The capacity of the bollard

5.15.5 Defects and rectification

If the casting is found defective during the course of any subsequent preparation or machining, it shall be rejected even if it has been found satisfactory during earlier testing, if any.

No casting shall be repaired or welded without the prior permission of the Employer or his representative. When repairs that might have been so sanctioned are completed, the concerned casting shall be again presented for inspection.

When welding is carried out, the welding technique and the preparation of the casting for repairs shall be accordance with IS 5530.

5.15.6 Inspection

The Employer shall have free access to the works of the manufacturer at all reasonable times during the manufacture of the castings. He shall be at liberty to inspect the manufacture at all stages and to reject any casting or material that is unsound and does not otherwise conform to the terms of this specification.

5.16 Testing

5.16.1 Test Sample

All test samples shall be cast in the presence of the Employer or his representatives and shall be tested in his presence.

The test samples shall be cast separately from the casting. The test sampling shall be cast from moulds of the same material, which is used for casting and shall be poured at the same time and from the same melt as the casting they represent.

The samples shall be treated along with the casting they represent.

The test samples shall be provided to the extent of 2% of the number of casting from each melt but in no case less than two samples per melt. When a casting is made from more than one melt, at least four tensile tests and four bend tests shall be made from samples situated as far apart as possible in the casting. Some of the test samples shall be taken as near the top and others from as near the bottom of the casting as is practicable.

The test samples shall be stamped in presence of the Employer so as to identify the casting to which they relate.

5.17 Type of Test

5.17.1 Tensile Test

The tensile test shall be carried out in accordance with IS 1608. The minimum tensile strength and elongation shall be as given earlier in this specification

5.17.2 Bend Test

The bend test shall be carried out in accordance with IS 1599. This test piece shall be capable of being bent without fracture to the angle specified earlier in this specification. It should be bent round a former having a radius of 25 mm.

5.17.3 Non-destructive Tests

The following non-destructive tests at Cross-sections decided by the Employer shall be carried out to ensure that the castings are in every aspect sound, free from cracks, hot tears, shrinkage cavities and other defects.

(a) Ultrasonic flaw detector test as per IS 3664 for checking the thickness of the castings and to detect the defects in the casting

(b) Magnetic particle test

(c) Ringing test

The Employer shall indicate the location to be examined on the casting and the stage of manufacture at which such examinations are to be made.

The technique, inspection and interpretation of results shall be laid down and agreed between the Employer and the Contractor before the manufacture is commenced.

5.17.4 Test by Chemical Analysis

Chemical analysis test shall be conducted to ascertain the percentages of sulphur and phosphorous content in the material of which the casting is going to be made.

The Contractor shall supply a certificate of chemical analysis of such cast when required to do so by the Employer.

The Employer shall have the option to take the test sample and subject it to complete analysis by a metallurgist appointed by the Employer at the cost of the Contractor.

5.17.5 Testing Facilities

The Contractor shall supply the casting required for testing free of charge and shall at his own cost furnish and prepare the necessary test pieces and supply labour and appliances for conducting all tests at his own premises in accordance with this specification. If such facilities are not available at the place of manufacture for conducting the prescribed tests, the Contractor shall bear the cost of transportation for the test pieces or casting and for carrying out the tests at a place approved by the Employer.

5.17.6 Test Certificate & Acceptance Criteria

The Contractor shall supply a test certificate giving the results of all tests mentioned in this specification, batch wise, stating that the material complies with requirements as specified by the Employer.

5.17.7 Re-Test

If any of the test piece fails to pass any of the mechanical tests specified under tensile test and bend test, two further samples which represent that particular casting or castings shall be selected and tested in the same manner. The Contractor shall have the option, if he so desires, to re-heat-treat (not more than twice) the casting before the two further samples are accepted. Should either of these tests fails, the casting represented shall be liable for rejection.

5.17.8 Submittal Requirements

The Contractor shall submit full details of the proposed bollard/Quick Release Hooks (QRH) to the Engineer for approval prior to the procurement of these items including but not limited to the following;

(a) Details of the manufacturer and supplier of the unit including details of the manufacturers quality control system, evidence of project experience and statement regarding the suitability of the product in this application and it's conformance to the requirements of the Specification;

(b) Shop drawings showing the general arrangement and principal dimensions of the item including the hold down bolt layout and anchorage arrangement;

(c) Scale sketches demonstrating that the proposed hold down bolt arrangement can be installed without compromising the requisite concrete reinforcement at the installation location, including illustration of any proposals for localised displacement of reinforcement as may be required.

(d) Specifications detailing the features of the unit, the manufacturing or fabrication process, the materials used, requirements for installation and use and all relevant design or manufacturing standards or regulations;

(e) Detailed calculations and analysis demonstrating the structural capacity of the unit and the hold down bolts with reference to the specified safe working load and the requisite factors of safety; and

(f) Where the units are proposed to be supplied coated by the manufacturer, all details pertaining to the proposed coatings.

5.18 Fenders

5.18.1 General

This specification covers the general requirements of the fenders to be used for main fendering on berths and jetties as well as protective fendering. Energy absorption capacity of the fender shall be as stipulated in Structural Design Basis.

The fender shall be selected by the Contractor to suit the structural arrangement of the fender facia. Only products with satisfactory proven track record shall be accepted. Where reference to any code or specification is made, the same shall be taken as the latest revision (with all amendments issued there to) on the notified date of submission of the proposal.

5.18.2 Physical Properties of Rubber

The rubber material used for the fender shall satisfy the following physical requirements based on the standards established by ASTM D-2000 or its equivalent.

The material used for the rubber fender shall be natural or synthetic rubber of high quality having sufficient resilience, resistance to oxidation, ozone, sunlight, and shall have anti-ageing weather and wear resistant properties to meet all normal service conditions. The material shall be homogenous and shall not have any defects, impurities, pores, cracks, warpage or blisters that could affect fender

performance. Colour shall be as per Manufacturer's Data Sheet. Compound requirements shall be as specified in **Table 5.14.**

Table 5.14 Rubber material specifications and standards

Property		Unit	Criteria	Testing Standard and Condition
Before Ageing	Tensile Strength	Kg/cm^2	Min 160	ASTM D412 Die C
	Elongation	%	Max 350	
	Hardness	Deg	Max 77	ASTM D2240 Shore A Durometer
After Ageing	Change in Tensile Strength	%	Not less than 80% of original	70 Deg C × 96 hrs ageing through air heating ASTM D 573 Die C
	Change in Elongation	%	Not less than 80% of original	
	Hardness	Deg	Original value + 8 Deg max	
Compression Set		%	Max 30	ASTM D 395
Ozone exposure		%	Quality retention rating min 85%	ASTM D 1171 Method A
Resistance to outdoor ageing		%	Quality retention rating min 85%	ASTM D 1171
Water resistance		%	Vol change Max 10%	ASTM D 471 70 hrs at 100Deg C
Sea Water resistance		%	Vol change Max 10%	ASTM D 471 70 hrs at 100Deg C

5.18.3 Method of Manufacture

Manufacture of fenders shall be by the extrusion process. In case moulded or otherwise manufactured rubber fenders are to be considered as a substitute, these shall require the prior approval of the Employer.

There shall be no cracks or breaks in the body of the fender. Necessary chamfers must be provided to clean up the back rind.

5.18.4 Load Deflection Characteristics

The load deflection and energy deflection curves for the selected fender shall be furnished along with the proposal clearly specifying the rated/maximum deflection as well as correction factors to account for angular berthing. The selected fender shall meet the Berthing Energy absorption criteria specified in the Structural Design Basis.

5.19 Accessories

5.19.1 Chains, Shackles, Bolts, Accessories

1. Chains shall be of grade SBC490 as per JIS G3105 or equivalent (galvanized) and will be provided in order to fulfil following requirements:

    - To prevent the fender assembly from sagging under its own weight after installation on fender facia.
    - To restrain outward movement at the top of the fender panel
    - To support shear strength, if necessary
    - Minimum chain size will be 25 mm
    - Yield strengths shall not be less than 1.25 times the average breaking strength of the chain.
    - Weight chains will be furnished with tensioning devices which will allow proper tensioning of the chains after installation. Also a weak link shall be provided in order to prevent anchor damage in case of dangerous berth conditions.

2. Shackles shall conform to ASTM A575 Gr 1025/JIS G4051.U anchors shall conform to ASTM A276 type 304 or 316.

3. Anchor bolts, washers, flanges and sleeve shall be of stainless steel conforming to AISI 403 grade 304 or 316/ASTM A276 type 304 or 316. Anchor bar and anchor plate shall be mild steel conforming to ASTM A36. Yield strength shall not be less than 1 25 times the average breaking strength of the bolts. Minimum 8 anchor bolt assemblies shall be provided per rubber fender unit.

Note: All mild steel/carbon steel components shall be hot dipped galvanized with minimum thickness of 900 g/sqm in accordance with ASTM A153.

5.19.2 Frontal Frame

The steel frontal frame shall be a proprietary type as provided by the fender manufacturer and demonstrated by him as being adequate to carry the applied loads. The same shall be purpose designed steel frame with stresses and constructional details in accordance with the recommendation of BS 6349 part 4.

The frame shall be fixed to the fender using a minimum of 8 Nos bolts of minimum diameter 63 mm. Bolts shall conform to ASTM A-36 and shall be hot dipped galvanized as specified. The frontal frame and accessories shall be sized to limit the hull pressure to specified limits for full tidal/vessel range (laden/light). Positive tolerance on reaction as applicable shall be considered while evaluating the hull pressure. The top and bottom edges and both sides of the frontal frame as well as four corners shall be chamfered 100mm in width so that damage to vessel's hull as well as peeling off of the paint on the vessel's hull by sharp edges of the frame is avoided. For calculating the hull pressure, the area of above chamfered edges and corners shall not be considered. A set of suitably designed tension chains to hold back the fendering frame for low point of impact shall be provided A set of shear chains shall be provided for each fender unit.

5.19.3 Frontal Pads

Frontal pads having proper and integrated arrangements with the fenders shall be provided. The pads shall be made of ultra-high molecular weight polyethylene having low friction coefficient to avoid sparks during berthing. It shall have the following physical properties in accordance with ASTM standards:

Density	0.92 - 1.05 g/cm^3
Tensile strength(min)	200 kg/cm^2
Compression strength (min.)	300 kg/ cm^2
Friction coefficient (max.)	0.2
Elongation (min.)	500 %
Bending Strength	140 - 210 kg/cm^2
Thickness (min.)	30 mm

Frontal pads shall be fixed to the frontal steel plate by bolts (minimum 20mm diameter), washers 3mm thick and nuts conforming to ASTM A307/IS 1364 and these shall be hot dipped galvanized in accordance with ASTM A153 and replaceable even if the pads are damaged.

The design of fendering system including design of fender frontal frame and accessories shall be submitted to The Employer for review. Approval of purchase order shall be sought after the review of the designs and drawings of the fendering system and incorporation of the Employer's comments.

5.19.4 Inspection and Testing

Test certificates from recognized testing laboratories for all tests specified for each batch of rubber compound for fender and raw material for frontal pad proposed to be used in the manufacture shall be provided by the Contractor/Fender Manufacturer, for the approval of the Employer.

The fender system may be inspected by the Employer or his representative during manufacture or after manufacture or both. The Contractor/Fender Manufacturer shall extend all facilities at no extra cost for such inspection.

Contractor/Fender Manufacturer shall also perform load-deflection and load-energy absorption testing at 0 degree and 10 degree berthing angle and upto maximum permitted deflection of fender, for each fender being supplied. The Contractor/Fender Manufacturer shall furnish the load and energy absorption versus deflection curve for each fender. The tested fender unit will be accepted as part of the supply only if it conforms to the specifications/specific requirements.Data and Information.

The bidder shall furnish the following details for approval:

1. Complete manufacturing details of all components and fixtures.
2. Manufacturing and test certificates of fenders and all connected fixtures.
3. Rated energy absorption capacity, Max. reaction force and forces on chains.

5.19.5 Manufacturer's Certificate

The contractor shall submit to the Engineer-in-charge Certificate by the manufacturer for the fender giving the following details:

- Manufacturer's name, trademark or other means of identification.
- Type and quantity supplied.
- Linear dimensions of each fender noting deviation from the nominal dimensions.
- Quality of rubber used with test results for requirements outlined in **Table 5.14**.
- Method of manufacture.
- Certified load deflection and energy deflection characteristics.

Six copies of the maintenance manual shall be submitted before despatch of fenders.

5.19.6 Site Acceptance Test

Contractor/Fender Manufacturer shall provide site acceptance test procedure for the fender system in order to verify proper delivery and installation. Damaged fender or accessories will be rejected and replaced at no extra time or cost implication to the Employer.

5.19.7 Commissioning

Contractor/Fender Manufacturer shall provide Commissioning assistance to the Employer.

5.19.8 Warranty

The Contractor/Fender Manufacturer shall warranty the complete fendering system for 24 months or more after the facility is put into service, for any kinds of manufacturing defects or deviations from specified performance not withstanding testing and inspection carried out as per section.

5.19.9 Handrail Posts and Handrails

Handrail posts and handrailing shall be fabricated from medium class stainless Steel Tubes conforming to ASTM A312, ASME SA312 (SS 316 grade).

5.19.10 Drain Holes

For jetty, the Contractor shall provide drain holes in the deck to drain surface water as shown in the drawings. Drain holes shall be by PVC pipes through the deck.

5.19.11 Edge Angles

Galvanised iron edge angles shall be provided as shown in the drawings. Hot dip galvanization in factory shall be carried out to achieve a commercial coating of not less than 600 g of zinc per square meter and painting of the same shall be done conform to the requirements specified for Protective Coating of Structural Steelwork in section B1105.

5.20 PVC Water Stops at Expansion Joints

5.20.1 Materials

The water-stop should be fabricated from a plastic compound, the basic resin of which shall be polyvinyl chloride. The compound shall contain additional resins, plasticizers, inhibitors or other materials such that when the material is compounded, it shall meet the requirements given in this Specification.

5.20.2 Test Requirements

PVC water-stops shall meet the requirements specified in **Table 5.15** given below. The colour of water-stops shall be black or white.

Table 5.15 Test Requirements for PVC Water-Stops

S. No.	Characteristic	Requirements	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Tensile strength, Min	13.8 Mpa	IS 8543 (Part 4/Sec 1)
ii)	Elongation, Min	285%	IS 8543 (Part 4/Sec 1)
iii)	Hardness (Shore A), Min	65	1S 13360 (Part 5/Sec 11)
iv)	Water absorption, percent by mass, Max	0.6	Annex A of IS 15058 standard
v)	Cold bend temperature at which samples does not crack, Min	-25°C	Annex G of IS 9766
vi)	Accelerated extraction test: a) Tensile strength, Min b) Elongation, Min	 10.3 Mpa 280%	Annex B of IS 15058 standard
vii)	Stability in effects of alkalies test: a) Weight increase at 7 days, percent by mass, Max b) Weight decrease at 7 days, percent by mass, Max c) Change in hardness at 7 days (Shore A) d) Weight increase at 28 days, Max e) Weight decrease at 28 days, Max f) Dimension change	 0.25 0.10 ±5 0.40% 0.30% ±1%	Annex C of IS 15058 standard

5.20.3 Shape and Dimensions

The cross-section of PVC water-stops shall be as per drawing. The permissible to tolerance on width shall be as follows: and thickness.

Width	± 10 mm
Thickness	+ 2 mm
Thickness	- 0

5.20.4 Packing

The water-stop shall be packed in coil form, the inside diameter of which shall not be less than 300 mm.

5.20.5 Marking

The water-stops shall be marked with the following information:

(a) Size of the water-stops;

(b) Name of manufacturer or trade-mark, if any; and

(c) Month and year of manufacture.

5.20.6 BIS Certification Marking

The PVC water-stops may also be marked with the Standard Mark.

The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

5.21 Geotextile Material

5.21.1 General

All geotextiles shall be manufactured by and purchased/obtained from a reputable manufacturer(s) and ISO 9001: Compliant. The manufacturer(s) shall have ample experience in the 'fabrication of the type of geotextile specified.

Before ordering any quantity of geotextile, the Contractor shall submit samples, and test reports from an approved independent testing laboratory accredited in accordance to ISO 17025 and certified by GAI-LAP certification. The test reports from laboratories without accreditation are not acceptable.

The Geotextile shall be supplied in Roll. Each Roll shall be wrapped using good quality wrapper. A packing label pasted on the roll and also at the inner face of the core of the roll.

The packing label shall necessarily indicate

- Manufacturer's name,

- Type of geotextile (Product code and Product grade)
- Manufacturing date.
- Roll No. & Lot no.

No geotextiles shall be used in the Works which were manufactured more than one year prior to arrival on Site.

5.21.2 Standards

The standards specified in **Section 6 of Volume-II** for geotextiles shall apply.

5.21.3 Properties

The Geotextile shall be 100% Polypropylene Continuous filament needle punched Non-woven Geotextile complying to the following technical specifications as in **Table 5.16**.

Table 5.16 Geotextile specifications

Technical Parameters	Test Method	Unit	Value	Range
Tensile strength	ISO 10319	kN/m	>22	Minimum
Tensile Elongation	ISO 10319	%	>50	Minimum
Performance Energy*	Calculated	kN/m	7.20	Minimum
Effective Opening Size	ISO 12956	mm	0.09	Maximum
Vertical water flow	ISO 11058	lit/m^2/sec	55.00	Minimum
Horizontal water flow in place @ 20kpa	ISO 12958	lit/m^2/sec	16.00	Minimum
Thickness	ISO 9863	mm	>2.80	Minimum

* Performance Energy indicates the ability of the geotextile to absorb construction stress.

* Performance Energy = 0.5*(Energy(MD) X Energy(CD))

Energy(MD) = 0.5*(Tensile strength(MD) X Elongation(MD))

Energy(CD) = 0.5*(Tensile strength(CD) X Elongation(CD))

The geotextile shall not be exposed more than 1 week to Sun-light. In case of higher exposures are needed, it should be covered temporarily with a 90gsm tarpaulin cloth till it is permanently covered.

5.21.4 Seaming and Overlapping

The Geotextile shall be cut in to panels of (Full Width) x Length. The length may be equal to the slope length + anchorage lengths both at the toe & top of anchorage. Under no circumstances, overlap is allowed in transverse direction on the slope.

Overlaps are allowed in longitudinal direction by means of having a 500mm joint without stitching or 100mm joints by stitching using a portable stitching machine and it shall be with a prayer seam (double stitch).

The yarns used for stitching may comply to :

- Mass characteristic : min. 220 tex (=gr/1,000 m length)
- Diameter : min. 0.4 micron
- Tensile strength : min. 140 N
- Elongation at break : max. 20 per cent

5.21.5 Anchoring Scheme

The geotextile needs to be anchored both at the top and toe by means of an anchor trench of size 0.6m x 0.6m. The length of the anchorage shall be in the form of “L” which means 1.2m at each anchorage point.

The anchor trench shall be excavated and be backfilled after geotextile is placed. The backfilling is done by placing the excavated spoils for 200mm thickness and compacting them by using a hand rammer.

5.21.6 Testing of Geotextile

Manufacturer shall submit one test report / Lot from an ISO 17025 accredited laboratory.

Engineer will conduct random sampling at site and send one sample/5000sqm for tests at an accredited laboratory for all the parameters to ISO 17025 accredited laboratory in India/Overseas.

At least one sample (out of all samples collected in the project) shall be sent to international reputed laboratory such as TRI, USA to check all parameters including UV resistance.

Notwithstanding the submission of reports to the effect that the geotextile conforms to the Specification, the Engineer shall at all times be entitled to have additional samples of geotextile tested if he suspects that the geotextile does not conform to the Specification.

The Engineer shall only select samples from ends of rolls or from geotextile which has already been cut.

5.21.7 Transportation, Storage and Handling

All geotextiles shall be transported, handled and stored fully in accordance with the manufacturer's recommendations and shall arrive on Site in their original wrappings. Products susceptible to UV degradation shall be wrapped to prevent UV exposure until immediately prior to usage. Unused portions shall be re-wrapped until usage.

Geotextiles arriving on the site in containers shall be unpacked and stored until usage in locations or in a manner well sheltered from the sun. Sufficient ventilation under the shelter shall be provided so as to minimise the effects of high temperature thermos-oxidation.

5.21.8 Laying of Geotextile

The surface on which geotextiles are placed shall be relatively smooth, free of obstructions, depressions and soft pockets. Depressions shall be filled with compacted material as directed by the

Engineer. Placing of the geotextile shall not start until underlying slope has been approved by the Engineer.

The geotextile shall be placed loosely without wrinkles or folds with the warp running normal to the shoreline. The geotextile will be laid in one piece over the required depth. Lapped joints will not be permitted. Joining of geotextile strips shall be achieved by stitching.

No joints in the geotextile are allowed perpendicular to the shore. All seams (if used} must face upwards from the river bottom to allow for inspection and repair. A surplus of minimum 10mm of geotextile shall be provided at the seams to allow movement.

Holding the geotextile in position shall be by ballasting with the filter rock. Pinning with steel pins or wooden pegs will not be allowed. No cover layer shall be placed on top of the geotextile without approval by the Engineer.

From the time the textile is removed from storage for incorporation into the works, until it is placed and covered by the first gravel layer shown on the drawing, the total period shall not exceed 7 days. No geotextiles shall be placed in the Works which cannot be covered with protective elements the same day.

Filter fabric shall be laid on prepared surfaces in accordance with the manufacturer's recommendations. The Geotextile shall be laid and installed in the positions and to the line and levels described on the drawings. Material which will be in contact with the Geotextile shall not have uneven surface which are likely to damage the Geotextile during installation or in service. Construction plant / equipment must not operate directly on the Geotextile. On sloping surfaces, the fabric shall be laid with its longitudinal axis down the slope.

5.21.9 Specifications Not Covered

Specifications for materials and workmanship not covered in this Section shall be referred from the specifications of materials and workmanship covered in other sections of **Volume -II** as appropriate, subject to the approval of the Employer whose decision shall be final and binding on the contractor.

The specifications for any materials and workmanship not fully specified in any sections of **Volume-II** shall be carried out as per relevant IS Specifications and in absence thereof shall be as per the best standard practice as approved by the Employer.

6.0 TECHNICAL SPECIFICATIONS - ONSHORE FACILITIES

6.1 Materials

6.1.1 General

The Contractor shall be responsible for furnishing all materials required for execution of the Works. The Contractor shall submit the source and method of execution for the Employer's review before any execution. All materials used in the construction of permanent works required under this Contract shall be of 1st class quality as specified herein and comply with the latest IS Codes or equivalent. The material shall be tested before bringing it to the site.

This specification establishes and defines the requirements of various materials to be used in Civil and Structural works.

Whenever any reference to IS Codes is made, the same shall be taken as the latest revision (with all amendments issued thereto) as on the date of submission of the Tender.

Apart from the IS Codes mentioned in particular in various clauses of this specification, all other relevant codes related to specific job under consideration regarding quality, tests, testing and/or inspection procedures shall be applicable. Reference to some of the codes in various clauses of this specification does not limit or restrict the scope of applicability of other referred or relevant codes.

In case of any variation/contradiction between the provision of IS Codes and this specification, the provision given in this specification shall be followed, unless the Employer agrees/consents to follow IS codes or other proposal of the Contractor as provided in the Contract.

All materials shall be of standard quality and shall be procured from renowned sources/manufacturers approved by the Employer. It shall be the responsibility of the Contractor, to get all materials/manufacturers approved by the Employer prior to procurement and placement of order.

Wherever brand is not mentioned, Contractor can choose a brand complying with the tender specifications however mentioning the brand considered in the Bid submission for the approval of the Employer if required.

Whenever called for by the Employer, all tests of the materials as specified by the relevant IS Codes shall be carried out by the Contractor in an approved laboratory and test reports duly authenticated by the laboratory, shall be submitted to the Employer for his approval. If so desired by the Employer, tests shall be conducted in the presence of the Employer or his authorised nominee.

Quality and acceptability of materials not covered under this specification shall be governed by the relevant IS Codes. In case IS code is not available for the particular material, other codes e.g. B.S. or DIN or API/ASTM etc. shall be considered. The decision of Employer in this regard shall be final and binding on the Contractor.

Whenever asked for, the Contractor shall submit representative samples of materials to the Employer for his inspection and approval. Approval of any samples does not necessarily exempt the Contractor from submitting necessary test reports for the approved material, as per the specification/relevant IS Codes.

The Contractor shall submit manufacturer's test reports on quality and suitability of any material procured from them and their recommendation on storage, application, workmanship etc. for the intended use. Submission of manufacturer's test reports does not restrict the Employer from asking fresh test results from an approved laboratory of the actual material supplied from an approved manufacturer/source at any stage of execution of work.

All costs relating to or arising out of the tests and submission of test reports and or samples to the Employer for his approval till the date of issuance of Performance Certificate shall be borne by the Contractor.

Materials for approval shall be separately stored and marked, as directed by the Employer and shall not be used in the Works till these are approved.

All rejected materials shall be immediately removed from the site by the Contractor at his own cost.

6.1.2 Water

Water used in construction for all civil & structural works shall be clean and free from injurious amount of oil, acids, alkalies, organic matters or other harmful substances, which may be deleterious to concrete, masonry or steel. The pH value of water sample shall be not less than 6. Potable water shall be considered satisfactory.

Tests on water samples shall be carried out in accordance with IS:3025 and they shall fulfil all the guidelines and requirements given in IS:456.

The Employer may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall not have average 28 days compressive strength lower than 90% of the strength of concrete prepared with distilled water.

The Employer may require the Contractor to get the water tested from an approved laboratory before starting the construction work and in case the water contains any oil/organic matter or an excess of acid, alkalies or any injurious amount of salts etc., beyond the permissible maximum limits given in IS:456, the Employer may refuse to permit its use. In case there is any change in source of water, water samples shall be tested again to meet the specified requirements.

Water shall be stored in tin barrels, steel tanks or water tight reservoirs made with bricks/stone or reinforced concrete. Brick/stone masonry reservoirs shall have RCC base slab and shall be plastered inside, with 1 part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be of sufficient capacity to meet the water requirements, at any stage of construction.

Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for preparation of cement mortar, concrete as well as for curing of plain/reinforced concrete and masonry works. Sea water shall not be used for hydrotesting and checking the leakage of liquid retaining structures also.

6.2 Aggregate

6.2.1 General

Coarse and fine aggregates for civil and structural Works shall conform in all respects to IS:383 (Specification for coarse and fine aggregates from natural sources for concrete). Aggregates shall be obtained from an approved source known to produce the same satisfactorily. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or a combination thereof. These shall be chemically inert, hard, strong, dense durable, clean and free from veins, adherent

coatings, injurious amount of alkalies, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, sea shells etc.

Source and type of aggregates shall be got approved by the Employer prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, the Employer subject to the Contract may accept the proposal to change. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Employer. Aggregates, which may chemically act with alkalies of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Employer, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.

The maximum quantities of deleterious materials in the aggregates as determined in accordance with IS:2386 – Part II (Methods of Test for aggregates for concrete), shall not exceed the limits defined in IS:383. No special test is required to prove the absence of such deleterious matters if the aggregates are from a known source with satisfactory prior data on the properties of concrete made with them. In case of newly developed quarry sites, the Contractor shall submit necessary test results as per IS:383 and IS:2386 to the Employer prior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS:2430.

Coarse and fine aggregates shall be batched separately. All-in-aggregates shall be used only where specifically permitted by the Employer.

Separate sieve analysis and grading curves shall be prepared by the Contractor for any/all batches of coarse and fine aggregates, and submitted to the Employer, whenever asked for, to ensure conformity with those submitted along with the mix design.

Whenever required by the Employer, the aggregates (coarse/fine) shall be washed and/or sieved by the Contractor before use in the works to obtain clean and graded aggregate at no extra cost to the Employer.

Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

6.2.2 Coarse Aggregates

Coarse aggregates are the aggregates, which are retained on 4.75mm IS Sieve. It shall have a specific gravity not less than 2.6 (saturated surface dry basis).

These may be obtained from crushed or uncrushed gravel or stone as per **clause 6.2.1** and may be supplied as single sized or graded. The grading of the aggregates shall be as per IS:383 or as required by the mix design, to obtain densest possible concrete. For this purpose, the Contractor shall submit to the Employer at least three sets of mix design and test results, each with different gradings of coarse aggregates, proposed to be used. The Employer may allow “All-in-aggregates” to be used provided they satisfy the requirements of IS:383.

6.2.3 Fine Aggregates

Fine aggregates are the aggregates which pass through 4.75mm IS sieve but not more than ten percent (10%) pass through 150 micron IS sieve. These shall comply with the requirements of grading zones I, II, III and IV of IS:383. Fine aggregates conforming to grade zone IV shall not be used for reinforced concrete works.

Fine aggregates shall consist of material resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies, or crushed stone sand or gravel sand. Sand from sea shore, creeks or river banks affected by tides, dredged sand shall not be used for filling or concrete works.

6.2.4 Sampling and Testing

Storage of all types of aggregates at site of work shall be at Contractor's expense and risk and shall be stored as specified in IS:4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.

Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.

Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for at least 24 hours. The Contractor shall obtain prior approval of the Employer for the use of such aggregates and shall adjust the water content in accordance with IS:2386 to achieve the desired mix. In the absence of test results, and to allow variation in mass of aggregates and water content on account of moisture content, the Contractor can make suitable adjustment in the masses as per IS:456, for preparation of nominal mix concrete only.

6.3 Sand

6.3.1 Sand for Masonry Mortars

The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified in IS:2116.

The sand shall not contain any harmful impurities such as iron pyrites, alkalies, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shells in such form or in such quantities as to affect adversely the hardening, strength or durability of the concrete.

Unless found satisfactory as a result of further tests as may be specified by the Employer, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand, when tested in accordance with IS:2386, shall not be more than 5% by mass in natural sand, or crushed gravel sand or crushed stone sand. For organic impurities, when determined in accordance with IS:2386, colour of the liquid shall be lighter than that indicated by the standard solution specified in IS:2386.

6.3.2 Grading of Sand

The particle size grading of sand shall be within the limits as specified in **Table 6.1** below:

Table 6.1: Grading of Sand

IS Sieve Designation	Percentage	Method
IS:460 (Part I)	Passing by Mass	
4.75mm	100	IS:2386 (Part I)
2.36 mm	90-100	-do-

IS Sieve Designation	Percentage	Method
1.18 mm	70-100	-do-
600 micron	40-100	-do-
300 micron	5-70	-do-
150 micron	0-15	-do-

In case of a sand whose grading falls outside the specified limits due to excess or deficiency of coarse of fine particles, this shall be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable sizes of natural sand particles or crushed stone screenings which are by themselves unsuitable. Based on test results and in the light of practical experience with the use of local materials, the Employer subject to the Contract may accept the proposal for change in grading of sand. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

6.3.3 Sampling and Testing

The method of sampling shall be in accordance with IS:2430. The amount of material required for each test shall be as specified in relevant parts of IS:2386. Any test which the Employer may require in connection with this shall be carried out in accordance with the relevant parts of IS:2386.

If further confirmation as to the satisfactory nature of the material is required, compressive test on cement mortar cubes (1:6) may be made in accordance with IS:2250 using the supplied material in place of standard sand and the strength value so obtained shall be compared with that of another mortar made with a sand of acceptable and comparable quality.

6.3.4 Sand for Filling

Sand for filling shall meet the requirements of IS:383 and shall be natural sand, hard, strong, free from any organic and deleterious materials. Any sand proposed for filling, shall be used only after it is approved by the Employer. Sand obtained from sea shore, creeks or river banks affected by tides shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below grading zone-III as per IS-383 shall be allowed for filling.

6.3.5 Cement

Cement to be used, for civil and structural works, shall be as per the relevant IS codes for Cement provided in **Section 2 of Volume-II**. For plain and reinforced concrete works minimum 43 grade ordinary Portland cement shall be used.

6.3.6 Storage at Site

The storage of cement at the site of work shall be at Contractor’s expense and risk and shall meet the requirements of IS:4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner as to permit easy access for proper inspection and also to prevent determination due to moisture.

All approved cement shall be arranged in batches with type, brand and date of receipt flagged on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received from the manufacturer. The Contractor shall maintain a register, on day to day basis, giving the details of the receipt/consumption, source of supply and type of cement etc. The register shall always be accessible to the Employer for verification.

6.3.7 Tests After Delivery

Each consignment of cement procured by the Contractor, shall, after delivery at Site and at the discretion of the Employer, be subjected to any or all of the tests and analyses, required by the relevant Indian Standard Codes.

6.3.8 Rejection

The Employer may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant IS Codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective shall not be used and shall be promptly removed from the site by the Contractor.

6.4 Steel

6.4.1 General

All steel bars, sections, plates and other miscellaneous steel materials, etc. shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings. The materials, construction specifications such as dimensions, shape, weight, tolerances, testing, etc. for all materials covered under this section, shall conform to respective IS Standards for reinforcement bars listed in **Section 2 of Volume-II.**

6.4.2 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works shall be Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500, conforming to IS:1786. Reinforcement steel shall be purchased only from primary suppliers and that purchased from secondary suppliers shall not be accepted.

6.4.3 Structural Steel

Structural steel to be used for general structural purposes shall be of grade A conforming to IS:2062.

Structural steel sections shall conform to IS specifications listed in **Section 2 of Volume-II.**

6.4.4 Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the IS specifications listed in **Section 2 of Volume-II.**

6.4.5 Anchor Bolts

Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant IS Codes mentioned in **Section 2 of Volume-II.**

6.4.6 Storage

The storage of all materials at site of work shall be at the Contractor's expense and risk and shall be done as per the requirements given in IS:4082. The Contractor shall maintain the proper records of receipt/consumption. The records shall always be accessible to the Employer for verification.

The reinforcement bars, structural steel sections and other miscellaneous steel materials etc., shall be stored in such a way as to avoid and prevent deterioration, corrosion, bending, twisting and wrapping.

6.4.7 Tests after Delivery

Materials procured by the Contractor, shall, after delivery at site and at the discretion of Employer, be subjected to any or all of the tests, required by the relevant IS Codes. The Contractor shall carry out and bear the cost of such tests. The Contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense.

6.4.8 Rejection

The Employer may reject at his direction any material, notwithstanding the manufacturer's certificate, failing to meet the requirements of relevant IS Codes for testing of materials. He may similarly reject any material, which has deteriorated or corroded etc., due to improper storage, handling or transport. Defective materials shall not be used and has to be removed from the site by the Contractor at his own expense.

6.5 Bricks

6.5.1 General

Bricks for masonry works shall conform to IS:1077–Specification for common burnt clay building bricks and shall be of class 5.0 (with minimum compressive strength of 5.0N/mm^2). Specific requirement for any other class of bricks shall be as shown in drawings or as described in the Contract for a particular site or type of work. Physical requirement, quality, dimensions, tolerances etc. of common burnt clay building bricks shall conform to the requirements of IS:1077.

Bricks shall be hand-moulded or machine moulded and shall be made from suitable soils. The bricks shall have smooth rectangular faces with sharp corners and shall be well burnt, sound, hard, tough and uniform in colour. These shall be free from cracks, chips, flaws, stone or humps of any kind.

6.5.2 Tests After Delivery

The Contractor shall make samples of each type of brick as directed by the Employer as per the requirements of IS: 5454 and tests shall be carried out as per IS: 3495. The cost for carrying out any or all the tests shall be borne by the Contractor. The bricks, when tested, as per IS: 3495 shall have a minimum average compressive strength, as given in the Code, for a particular class of brick. Water absorption shall not be more than 20% by its dry weight, when soaked in cold water for 24 hours.

Brick samples so approved shall be deposited with the Employer. All subsequent deliveries shall be upto the standards of the approved samples.

6.5.3 Stacking of Bricks

Bricks shall be stored at site as per the requirements given in IS:4082 and shall not be dumped at site. They shall be unloaded from trucks to a place on a levelled surface near to the work site. They shall be stacked in regular tiers even as they are unloaded, to minimise breakages and defacement of bricks. The supply of bricks shall be so arranged that as far as possible, at least two days' requirements of bricks are available at site at any time. Bricks, of different class, shall be stacked separately.

6.5.4 Local Bricks

Where shown on drawings, locally available bricks of non-modular size (230 mm x 115 mm x 75 mm) in place of bricks of modular size (190 mm x 90 mm x 90 mm) can be used in case the bricks satisfy the other requirements of IS: 1077.

6.6 Stones

6.6.1 General

All stones used for masonry works shall conform to the requirements of IS Codes specified in **Section 2 of Volume-II.**

6.6.2 Quality of Stones

Stones shall be of approved quality, hard, dense, strong, sound, durable, clean and uniform in colour. They shall also be free from veins, adherent coatings, injurious amount of alkalies, vegetable matters and other deleterious substances such as iron pyrites, coal, lignite, mica, sea shell, etc. Unless otherwise approved, stones from one single quarry shall be used for any one work. The strength of stones should be adequate to carry the imposed load and shall meet all the requirements of IS:1905, taking into account the appropriate crushing strength of stone and type of the mortar used. The percentage of water absorption, when tested in accordance with IS:1124, shall not exceed 5 percent.

Stones normally used, shall be small enough to be lifted and placed by hand. The length of the stone shall not exceed 3 times the height. Width of stone on base shall not be less than 150 mm and in no case exceed 3/4th thickness of the wall. Height of the stone shall not be more than 300 mm.

6.6.3 Unloading/Stacking

The stones shall be unloaded from the trucks to a site near to the place of work as defined in IS:4082 and shall be stacked on a firm ground having adequate stop for drainage. The supply of stones shall be so arranged that as far as possible, at least two day's requirements of stone are available at site of at any time.

6.7 Admixtures

6.7.1 General

All concrete admixtures shall in general comply with the Indian standards listed in **Section 2 of Volume-II** unless otherwise stipulated in this specification.

Generally, admixtures shall have ISI certification marks. However, even in case of BIS certified admixtures, Employer may require the Contractor to carry out and submit any or all the tests (as specified in relevant IS Codes), from approved laboratories, over and above the manufacturer's test certificate, before giving his final approval.

In case, admixtures certified by BIS are not available, the Contractor shall submit to the Employer the type and/or proprietary brand of the admixture from only reputed manufacturers along with necessary test certificates from recognised and approved laboratories or any other document directed by the Employer for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Employer for his selection. In case, both the names are rejected, the Contractor shall submit a fresh list of two manufacturers for approval by the Employer.

The Employer may direct the Contractor to submit test results as required by IS:2645 or IS:9103 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.

In case of non-availability of any IS code for testing and acceptability criteria, relevant British, American or German Code shall be applicable in the order of preference.

Prior approval of the Employer shall be obtained while using water reducing admixtures in the concrete (PCC/RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless prior approval taken from the Employer. Once approved, utmost care shall be taken at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/mortar so produced.

The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates together with any other materials to be actually used in the works as per the direction of Employer. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved laboratory to show their interaction and compatibility. Any/all tests specified in IS Codes shall be carried out only with the type of material and mix design, to be actually used in the work site.

No admixture shall impair the durability of the concrete nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement. Use of admixtures shall not reduce the dry density of concrete. Once the proportion of admixture has been established, strict check shall be maintained not to alter the proportions of ingredients and water cement ratio of the Design Mix during execution.

The chloride contents in admixtures shall not exceed 2% by mass of the admixture or 0.03% by mass of the cement.

Admixtures which do not meet the requirements stipulated in this specification shall be rejected and shall not be used.

6.7.2 Water Proofing Compounds

The permeability of the specimen with the admixture shall be less than half of the permeability with similar specimen without the use of these compounds. These compounds shall be used in such proportion as recommended by manufacturer but in no case it shall exceed 3% by weight of cement.

The initial setting time of the cement with the use of these compounds shall not be less than 30 minutes and final setting time shall not be more than 10 hours. Test shall be carried out in accordance with IS:4031.

Compressive strength of specimen at 3 days shall not be less than 270 kg/sq.cm. nor 90% of the 3 days compressive strength of mortar cubes prepared with same cement and sand only, whichever is higher. Similarly, compressive strength at 7 days shall not be less than 370 kg/sq.cm. nor less than 90% of the 7 days compressive strength prepared with the same cement and sand only, whichever is higher. The test to determine the compressive strength shall conform to IS:4031.

6.7.3 Water Bars (Water Stops)

PVC water bars shall be used in reinforced concrete construction of liquid retaining structures or any other structure to safeguard them from hydrostatic pressure and water leakage and any relative movement between two parts of the structure due to thermal loading shrinkage or differential movement of foundations. These shall be pre-formed and shall provide a permanent water tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. This shall be able to withstand a water head of at least 12 metres.

Performance requirements of PVC water bars shall meet the requirements of IS:12200. These shall be of approved make and of ribbed/serrated/plane type with a bulb at the centre. The thickness shall not be less than 5 mm and width less than 150 mm. The joining of the water bars shall be carried out by vulcanising strictly as per the manufacturer’s specifications. Lapped joints shall not be allowed under any circumstances.

6.7.4 Bitumen/Bituminous Materials

Bitumen to be used for various types of work shall meet all the requirements of relevant IS Codes as per **Section 2 of Volume-II.**

The type and grade shall be as shown on the drawings or as directed by Employer. Tests and acceptable criteria shall be as per relevant IS Codes.

6.7.5 PVC Pipes

PVC Pipes shall conform to the requirements of IS:4985.

6.7.6 Wood/Timber

Timber required to be used for formwork shall be fairly dry before use. It should maintain its shape during the use and even when it comes into contact with moisture from the concrete. Storage of Wood/Timber shall be as per the requirements of IS:4082.

For proper identification and selection of suitable timber for formwork, relevant codes shall be referred from **Section 2 of Volume-II.**

6.8 Paint

6.8.1 General

All paints shall be of an approved quality and shall be obtained from only those suppliers and makers who have been in the market for a period of not less than 5 years. All paints shall conform to the appropriate Indian Standards for ready mixed paints where applicable. All paints, undercoats, primers and finishing paint shall be supplied in sealed container. The Engineer may, if he so wishes, take samples for analysis at the Contractor's expense.

Wood preservative shall be of chemical type comprising copper-chrome-arsenic composition conforming to IS 401-1967.

All paints shall be stored in cool and dry conditions and clear of other stores to the satisfaction of the Engineer.

6.8.2 Painting

All structural steel work and metals including handrails, brackets & exposed surfaces of steel inserts shall be painted except if otherwise specified.

The operations, workmanship, schedules and equipment for painting shall generally comply with the requirements of IS:1477 (Parts I & II) "Code of Practice for Painting of Ferrous Metals in Buildings" except in so far as this Specification modifies it.

All surfaces shall be thoroughly cleaned of all foreign matters adhering to the steel surface to Swedish Standard specification Sa 2 1/2 by means of blasting with sand. Use of scraper wire brush and pig hammer is acceptable wherever blasting with sand is not possible due to lack of access. All painting shall be carried out by brushing. Spray and roller application of paint shall not be allowed without the written permission of the Employer.

Painting shall generally be done immediately after cleaning. The cleaned surface shall not be allowed to stand overnight before painting. Where galvanised surfaces are to be painted, they shall be cleaned and washed with a solution of copper sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Engineer.

All steelwork unless specified otherwise, shall be painted as per the following schedule:

(a) Two coats of epoxy base zinc rich primer (92% zinc on dry film) shall be applied. The dry film thickness of two coats shall be 60 microns minimum.

(b) After the application of primer, all surfaces shall receive two coats of coal tar epoxy or any other high build epoxy compatible with the primer. The finish paint shall be applied to establish an endurable protection of the prime coat. It shall be resistant to atmospheric heat, reflect heat and rays and withstand mechanical stresses without crumbling. The total dry film thickness for these 2 coats shall be 200 microns minimum. The colours for the finishing coats shall be as approved by the Engineer.

(c) Total dry film thickness for the system shall be 260 microns minimum.

(d) For steel work intended to be painted only at Site, a primary coat of Red Oxide Zinc Chromate shall be given at the shop before dispatch.

6.8.3 Polysulphide Sealants

All Polysulphide Sealants shall conform to IS:12118 and be of approved made. Test conditions and requirements shall be as given in the above referred IS code.

6.9 Plain and Reinforced Concrete Works

6.9.1 General

The section of the specifications includes requirements for furnishing and placing all plain and reinforced cement concrete including form work, reinforcement and incidental works required for the completion of this Contract and herein specified.

This specification establishes the materials, mixing, placing, curing, etc. of all types of cast-in-situ and precast concrete used in rigid pavement, crown wall underground and over ground structures, floors etc. Any special requirements as shown shall supersede over the provisions of this specifications.

Apart from this specification, construction of concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS:456 and other relevant codes mentioned therein.

In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern.

6.9.2 Materials

Materials for concrete viz cement, sand, coarse aggregate, water, etc. shall be as described in under specification of ‘Materials’.

Materials for all reinforcements, embedment, inserts, water bars, etc. shall conform to specification of ‘Materials’.

6.9.3 Grades of Concrete

Unless otherwise noted, the grades of concrete shall generally be as per **Table 6.2.**

Table 6.2: Grade of Concrete

Grade Designation	Characteristic Compressive Strength of 15 cm cube at 28 days (N/mm^2)
M15	15
M20	20
M25	25
M30	30
M35	35
M40	40

The characteristic strength is defined as the strength of material, below which not more than five (5) percent of the test results are expected to fall.

6.9.4 Type of Concrete Mix

Unless otherwise noted all lean and reinforced concrete shall be nominal mix and design mix types respectively.

6.9.5 Nominal Mix Concrete

The concrete shall be made (without preliminary tests) by adopting nominal concrete mix with proportions of materials as specified in **Table 6.3**: .

Table 6.3: Proportions for Nominal mix Concrete

Nominal mix of Concrete (by mass)	Quantity of Water per 50 Kg of Cement (max) / Litres
1:5:10	60
1:4:8	45
1:3:6	34
Note:	
1. The proportions of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregates becomes larger. Graded coarse aggregates shall be used.	
2. The cement content of the mix shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio, as specified, is not exceeded.	

6.9.6 Design Mix Concrete

AS per clause 5.2.4.

The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values given in **Table 6.2** above.

As long as the quality of materials does not change, a mix design done earlier shall be considered adequate for later work. However, in case the quality of materials changes, the Employer may ask for a new design mix.

While designing the mix, the durability requirements as given in IS:456 shall also be taken into account.

6.9.7 Concrete Mix Proportioning

AS per clause 5.2.4.

Proportioning, as used in this specification, shall mean the process of determining the proportions of the various ingredients to be used to produce concrete of the required strength, workability, durability and other properties.

The Employer shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Employer shall order fresh trial mixes to be made by the Contractor. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix

designs shall be established well ahead of start of work. The design mix shall conform to the guidelines of IS:10262.

6.9.8 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for grade of concrete shall be selected to give as nearly as practicable the maximum density. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation. The Contractor shall submit to the Employer at least three sets of mix design and corresponding test results after varying the mix proportions and / or grading of aggregate so as to establish the maximum density of any particular grade of concrete.

6.9.9 Water-Cement Ratio

Once a mix, including its water-cement ratio, has been determined and approved for use by the Employer, that water-cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted so as to maintain the approved water-cement ratio. Maximum water-cement ratio shall never exceed the values given in IS:456 and IS:4651 for various exposures and sulphate attack conditions from durability considerations.

6.9.10 Consistency

The concrete shall have a consistency such that it shall be workable in the required position and when properly vibrated it flows around reinforcing steel, all embedded fixtures, etc.

6.9.11 Workability

The concrete mix proportion shall be such that the concrete is of adequate workability for the placing condition and can be properly compacted with the means available. Use of plasticiser / super-plasticiser of approved make shall be taken recourse to where required for attaining proper workability as specified in **Table 6.4** below. However, prior written approval of the Employer shall be obtained for any such use of plasticiser / super-plasticiser before submitting the proposed design-mix for approval. Where adequate workability is difficult to obtain at maximum permissible water-cement ratio, increased cement content shall also be alternatively considered while designing the mix proportions.

The suggested ranges of values of workability of concrete measured in accordance with IS: 1199 are indicated in **Table 6.4** below. However, the actual values to be followed shall be established depending on aggregate sizing, mix proportions, placing conditions, etc. and shall be got approved by the Employer.

Table 6.4: Values of Workability

Placing Conditions	Degree of Workability	Values of Workability
Concreting of shallow sections with vibration	Very low	20-10 seconds vee-bee time or 0.75-0.80 compacting factor
Concreting of lightly reinforced sections with vibration	Low	10-5 seconds vee-bee time or 0.80-0.85 compacting factor
Heavily reinforced sections with vibration	Medium	5-2 seconds vee-bee time or 0.89-0.92 compacting factor or 25-75mm slump for 20mm aggregate

6.9.12 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Workability of concrete shall be such that concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform and as per standard codes. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum water-cement ratio conforming to the exposure conditions as given in **Table 6.5.**

Table 6.5: Minimum Cement Content and Maximum Water Cement Ratio for Durability

Exposure	Type of Cement	Plain Concrete		Reinforced Concrete	
		Minimum Cement Content (Kg/m^3)	Maximum Water-Cement Ratio	Minimum Cement Content (Kg/m^3)	Maximum Water-Cement Ratio
Normal	OPC* PPC* PSC*	Nominal mix	0.6	300	0.55
Moderate	OPC* PPC* PSC'	250	0.6	350	0.50
Severe	SSC* PSC* SRC'	310	0.45	400	0.45

Note:

1: *Severe exposure shall include structures exposed to sea or saline water (e.g. tidal rivers, brackish water, estuaries etc.), alternate wetting and drying, freezing whilst wet and subject to heavy condensation or corrosive environment. This shall also include structures exposed to sulphate and/or chloride attack due to presence of these chemicals in Soil and ground water. Total SO3 content of 0.2% and above in Soil and 300 ppm in ground water shall be considered to constitute severe exposure. Similarly, chloride (as CI) content exceeding 1500 ppm in ground water or soil shall be considered as severe exposure condition.*

2: *Structures subjected to aggressive environment below the minimum limits expressed in Note-1 above and/or those in industrial/chemical plants atmosphere shall be considered under moderate exposure. Also, any concrete structure in contact with water or retaining water or any other liquid not usually harmful to concrete shall be considered under moderate exposure.*

3: *All other environmental conditions not covered under Notes-1&2 shall be categorised under Normal exposure.*

** OPC - Ordinary low heat Portland Cement*

** PPC - Portland Pozzolana Cement*

** PSC - Portland Slag Cement*

** SRC - Sulphate Resistant Cement*

** SSC - Super Sulphated Cement*

6.9.13 Batching

In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass. Where the mass of cement is determined on the basis of mass of cement per bag, a reasonable number of bags shall be weighed periodically to check the net mass. Where the cement is weighed at site and not in bags, it shall be weighed separately from the aggregates. Water shall be either measured by volume in calibrated tanks or weighed. Any solid admixtures that are to be added shall be measured by mass; liquid and paste admixtures shall be measured by volume or mass. Batching plant, where used, shall conform to IS:4925. All measuring equipment shall be maintained in a clean serviceable condition, and their accuracy periodically checked.

Except where it can be shown to the satisfaction of the Employer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, different sizes being stacked in separate stock piles. The grading of coarse and fine aggregates shall be checked frequently, the frequency for a given job being determined by the Employer to ensure that the approved grading is maintained.

Under special circumstances, change from weigh batching to appropriate volume batching may be permitted by Employer on specific request from the Contractor. However, in such cases all conversions from mass of ingredients to volume shall be based on actual and appropriate bulk densities physically measured at site and approved by the Employer.

The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in both fine and coarse aggregates. For the determination of moisture content in the aggregates, IS:2386 (Part-111) may be referred to. To allow for the variation in mass of aggregates due to variation in their moisture content, suitable adjustments in the mass of aggregate shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in **Table 6.6.**

Table 6.6: Surface Water Carried by Aggregate

Aggregate	Approximate Quantity of Surface	
	Percent by mass	Litre / m^3
Very wet sand	7.5	120
Moderately wet sand	5.0	80
Moist sand	2.5	40
Moist Gravel or Crushed Rock	1.25-2.5	20-40

No substitutions in materials used on the work or alterations in the established proportions, except as permitted shall be made without additional tests to show that the quality and strength of concrete are satisfactory. In case the Contractor proposes any change in the already approved mix design, fresh mix design with supportive laboratory tests shall be submitted to the Employer and his approval has to be obtained prior to using the revised mix proportion in the works. However, such proposals for revision shall only be entertained in case of successive failure of test cubes to achieve the required strength.

6.9.14 Concrete Mixing

The mixing of concrete shall be strictly carried out in an approved type of mechanical concrete mixer. The mixing shall be continued until there is a uniform distribution of the material and the mass is

uniform in colour and consistency. If there is segregation, after unloading from the mixer, the concrete shall be remixed.

6.9.15 Mixer

Mixers shall comply with IS: 1791 and shall be maintained in satisfactory operating condition. Mixer drum shall be kept free of hardened concrete and blades shall be replaced when worn down more than ten percent (10%) of their depth. Should any mixer at any time produce unsatisfactory results, leak mortar or cause waste of materials, its use shall be promptly discontinued until it is repaired.

6.9.16 Mixing Time

Mixing time shall be as indicated in the following **Table 6.7**. Excessive mixing requiring additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Employer may, however, direct a change in the mixing time, if he considers such a change necessary.

Table 6.7: Mixing Time

Capacity of mixer	Minimum Mixing time
$2m^3$ or less	1½ minutes
$3m^3$	2½ minutes
$5m^3$	3 minutes

All records and charts for the batching and mixing operations shall be prepared and maintained by the Contractor as per the instructions of the Employer.

6.9.17 Hand Mixing

Hand mixing of concrete shall not be permitted. However, for non-critical structures located' at far away isolated places, this may be permitted by the Employer as a special case. Ten percent (10%) extra cement shall have to be added to the normal mix when mixed by hand. It shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. No extra payment shall be made to the Contractor for mixing by hand or for using extra cement due to hand mixing. However, extra cement consumed shall be considered for reconciliation purposes where such concreting is allowed by the Employer.

6.9.18 Admixtures

Admixtures in concrete shall be used only with the prior approval of the Employer. Any admixture used for obtaining proper workability or leak-proofness of concrete or repair/rendering works of concrete due to non-conformance to the specifications, shall not be measured and paid for.

6.9.19 Transportation, Placing and Compaction

The entire concrete placing programme including transportation arrangements, deployment of equipment, lay out, proposed procedures and methods, shall be submitted to the Employer 24 hours prior to concreting, for approval. No concreting shall be placed until his approval has been received. Approval of the Employer for pouring concrete shall be taken as 'conveyed', when the concrete pour card is signed by him.

6.9.20 Chuting

The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall be permitted only on written authorization from the Employer. In case an inferior quality of concrete is produced by the use of such conveyors, the Employer may order discontinuance of their use and the substitution of a satisfactory method of placing the concrete. Open troughs and chutes shall be equipped with baffles and be in short lengths to avoid segregation. Chutes shall be designed so that the concrete is, to some extent, remixed at the lower end by passing down through a runnel shaped pipe or drop chute. Alternatively, they shall discharge into a storage hopper from which the concrete shall be transported to the point of placing by wheel barrows or other means. Where drop chutes are used, a sufficient number of these must be provided, so that the concrete discharged from the chute is not required to flow laterally more than 1.0 metre. Where a drop chute is swung from the vertical, the bottom two sections must be maintained in a vertical position to avoid segregation. The addition of water at any point in the system of transportation, to facilitate the movement of concrete shall not be permitted. All chutes, troughs and pipes, shall be kept clean and free from coatings of hardened concrete by thoroughly flushing them with water after each run; water used for flushing shall be discharged clear of the structure. Concrete shall not be normally permitted to fall freely from a height of more than 1.5 metre nor to strike the forms at an angle. However, a deviation from this normal practice may be allowed provided proper precaution is taken, while placing concrete into the forms to avoid segregation, to the satisfaction of the Employer.

6.9.21 Vibrators

Concrete shall be compacted with mechanical vibrating equipment supplemented, if necessary to obtain consolidation, by hand spreading, rodding and tamping. The vibrators shall be of immersion type with operational frequency ranging between 8,000 and 12,000 vibrations per minute. All vibrators shall comply with IS:2505. Screed board concrete vibrators or concreting vibrating tables or form vibrators conforming to IS:2506, 2514 and 4656, respectively, shall be used where specifically required and directed by Employer.

Immersion type vibrators shall be inserted in a vertical position at intervals of about 600mm, depending upon the mix, the equipment used, and experience on work. The vibrators shall be withdrawn slowly. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to transport concrete inside the forms. Over vibration or under vibration shall not be permitted as both are harmful. Hand tamping in some cases may be allowed subject to the approval of the Employer.

In placing concrete in layers which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, bonding and moulding of the concrete between the succeeding batches.

The vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

Care shall be taken to prevent contact of vibrators against all embedded reinforcing steel or inserts. Vibrators shall not be allowed to come in contact with forms.

The use of form vibrators shall not be permitted for compaction of in-situ concrete without specific authorization of the Employer.

The use of surface vibrators of screed board type shall not be permitted for consolidation of concrete under ordinary conditions. However, for thin slabs (of thickness less than 200mm) surface vibration by such vibrators may be permitted, upon approval of the Employer.

Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators shall be carefully planned to ensure efficient compaction and to avoid surface blemishes.

6.9.22 Transportation

All concrete shall be conveyed from the mixer to the place of final deposit as rapidly as possible in suitable buckets, dumpers, containers or conveyors, which shall be mortar leak tight. Care shall be taken to prevent the segregation or loss of the ingredients and maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted. All equipment used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, dumpers and other equipment shall be thoroughly cleaned after each use.

6.9.23 Placing and Compaction

Before placing concrete, all surfaces upon which or against which concrete is to be placed shall be well compacted and free from standing water, mud or debris. The surface of absorptive soil (against which concrete is to be placed) shall be moistened thoroughly so that moisture is not drawn from the freshly placed concrete.

Concrete shall not be placed until the formwork, the placement of reinforcing steel, embedded parts, pockets etc. have been inspected and approved by the Employer. Any accumulated water on the surface of the bedding layer shall be removed by suitable means before start of placement. No concrete shall be placed on a water-covered surface.

Concrete shall be discharged by vertical drop only and the drop height shall not normally exceed 1.5m throughout all stages of delivery until the concrete comes to rest in forms. For continuous concreting operation windows of suitable size shall be kept in the formwork or chutes shall be used to avoid segregation of concrete.

Concrete shall be deposited as near as practicable in its final position to avoid rehandling. Concrete shall be placed in successive horizontal layers. The bucket loads, or other units of deposit, shall be placed progressively along the face of the layer with such over-lap as will facilitate spreading the layer of uniform depth and texture with a minimum of hand shoveling. Any tendency to segregation shall be corrected by shoveling coarse aggregates into mortar rather than mortar on the coarse aggregates. Such a tendency for segregation shall be corrected by redesign of mix, change in process or other means, as directed by the Employer.

All struts, stays and braces (serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations) shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These shall not be buried in the concrete. Concrete shall be thoroughly compacted with vibrators and fully worked around the reinforcement, embedded fixtures and into corners of formwork before setting commences and shall not be subsequently disturbed. Methods of placing shall be such as to preclude segregation. The formation of stone-pockets or mortar bondage in corners and against face forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding as directed by the Employer. Care shall be taken to avoid displacement of reinforcement and embedded inserts or movement of formwork.

Unless otherwise approved, concrete shall be placed in single operation to the full thickness of foundation rafts, slabs, beams and similar members. Concrete shall be placed continuously until

completion of the part of the work between approved construction joints or as directed by the Employer.

The method of placing and compaction employed in any particular section of the work shall be to the entire satisfaction of the Employer.

During hot weather (atmospheric temperature above 40 degree Celsius) or cold weather (atmospheric temperature below 5 degree Celsius), the concreting shall be done as per the procedure set out in IS:7861.

Concrete that has set standing and becomes stiffened shall not be used in the work.

6.9.24 Items Embedded in Concrete

Concreting shall not be started unless the electrical conduits, pipes, fixtures etc., wherever required, are laid by the concerned agency. The Contractor shall afford all the facilities and maintain co-ordination of work with other agencies engaged in electrical and such other works as directed by the Employer.

Before concreting, the Contractor shall provide, fabricate and lay in proper position all metal inserts, anchor bolts, pipes etc. (which are required to be embedded in concrete members) as per relevant drawings and directions of Employer.

All embedment, inserts etc. shall be fully held and secured in their respective positions by the concerned agencies to the entire satisfaction of Employer so as to avoid any dislocation or displacement during the concreting operations. The Contractor shall take all possible care during concreting to maintain these embedment/inserts in their exact locations.

6.9.25 Construction Joints

Construction joints shall be provided in position as described in the drawings or as directed by the Employer. Such joints shall be kept to the minimum. These shall be straight and at right angles to the direction of main reinforcement.

When the work has to be resumed on a surface, which has hardened, such surface shall be cleared of any foreign materials and roughened to expose the tips of the coarse aggregate. It shall then be swept clean and thoroughly washed and wetted before any new concrete is poured. Any set mortar or concrete sticking to the exposed reinforcing rods in and around such joints shall be thoroughly removed. The reinforcements shall be wire brushed and washed just before pouring any cement slurry or mortar. For vertical joints neat cement slurry shall be applied on the surface before it is dry. For horizontal joints the surface shall be covered with a layer of mortar about 10 to 15mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing new concrete.

Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgment of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots; work thereafter shall proceed in normal way.

6.9.26 Separation Joint

Separation joint shall be obtained by using an approved alkathene sheet stuck on the surface against which concrete shall be placed. Adequate care shall be taken to cause no damage to the sheet.

6.9.27 Expansion Joints/Isolation Joint

Expansion/Isolation joints in structures shall be formed in the positions and to the required shapes. Isolation joints shall be provided around all equipment foundations, columns, pedestals, trenches, etc. on grade.

6.9.28 Water Stops

PVC water stops as per specifications under 'Materials' shall be accurately cut, fitted and integrally joined as per manufacturer's specifications to provide a continuous, watertight diaphragm at all points.

The water stops shall be located and embedded at expansion/contraction/construction joints.

Adequate provision shall be made for the support and protection of water stops during the progress of the work. Damaged water stops shall be replaced and/or repaired *as* directed.

6.9.29 Protection of Freshly Laid Concrete

Newly placed concrete shall be protected, by approved means, from rain, sun and wind.

6.9.30 Curing

Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers etc. A layer of sacking, canvas, hessian, or other approved material,which will hold moisture for long periods and prevent loss of moisture from the concrete,shall be used as covering. Type of covering which would stain, disfigure, or damage the concrete, during and after the curing period,shall not be used. Only approved covering shall be used for curing.

Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete, except that high early strength concrete shall be so maintained for at least the first 3 days.

The Contractor shall have all equipment and materials required for curing on band and ready to use before concrete is placed.

For curing the concrete in pavements, the ponding method of curing is preferred after the expiry of first 24 hours during which (i.e. first 24 hours) the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Employer. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Employer. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or

brushing as soon as possible after the concrete has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Employer may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to future finishes.

6.10 Field Tests

As per clause 5.3.

6.10.1 Grading Test

Grading test on fine and coarse aggregates shall be carried out as per IS:2386 at intervals specified by the Employer.

The mandatory tests and their frequencies shall be done on sand and stone aggregates as given in **Table 6.8.**

Table 6.8: Mandatory Tests on Sand & Stone Aggregates

S. No.	Material	Test	Field/Lab Test	Minimum Qty. of Material/ Work for Carrying out the Test	Frequency of Testing
1	Sand	(a) Bulking of Sand	Field	20m^3	Every 20 m^3 or part thereof or more frequently as decided by the Employer
		(b) Silt content	Field	20m^3	-DO-
		(c) Particle size distribution	Field or Lab as decided by the Employer	40 m^3	1) Every 40 m^3 of fine aggregate/ sand required in RCC works only 2) Every 80 m^3 of fine aggregate/sand required for other items
2	Store aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test where required by the Employer or as specified	As required by Engineer	For all quantities

S. No.	Material	Test	Field/Lab Test	Minimum Qty. of Material/ Work for Carrying out the Test	Frequency of Testing
		b) Particle size distribution	Field or lab as required by Employer	45 m^3	For every 45 m^3 or part thereof as decided by Employer
		Ten percent Fine value	Laboratory	45 m^3	Initial test and subsequent test as & when required by Employer.

6.10.2 Vee-Bee Test/Slump Test of Concrete

At least one Vee-Bee Test/Slump Test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in working conditions or if required by the Employer.

6.10.3 Strength Test of Concrete

Samples from fresh concrete shall be taken as per IS: 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS:516.

In order to get a relatively quicker idea of the quality of concrete, optional tests on beams for modulus of rupture at 72±2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values given in **Table 6.9** may be taken for general guidance in the case of concrete made with ordinary Portland cement. In all cases, the 28 days compressive strength specified in **Table 6.2** shall alone be the criterion for acceptance or rejection of the concrete from strength consideration. If, however, from tests carried out in a particular work over a reasonably long period, it has been established to the satisfaction of Employer that a suitable ratio between 28 days compressive strength and the modulus of rupture at 72±2 hours or compressive strength at 7 days may be accepted, the Employer may suitably relax the frequency of 28 days compressive strength specified in **Clause 6.9.3,** provided the expected strength values at the specified early age are consistently met. However, set of test cubes for 28 days strength test shall always be taken and maintained to cater to any contingencies in the event of failure of 7 days strength.

Table 6.9: Test Requirement of Concrete

Grade of Concrete	Compressive strength on 15 cm cubes minimum at 7 days (N/mm^2)	Modulus of Rupture by Beam Test, at minimum	
		72±2 hours (N/mm^2)	7 days (N/mm^2)
M15	10.0	1.5	2.1
M20	13.5	1.7	2.4

M25	17.0	1.9	2.7
M30	20.0	2.1	3.0
M35	23.5	2.3	3.2
M40	27.0	2.5	3.4

6.10.4 Procedure

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested, that is the sampling should be spread over the entire period of concreting and cover all mixing units.

6.10.5 Frequency of Sampling

The minimum frequency of sampling of concrete for each grade shall be in accordance with the following:

Table 6.10: Sampling

Quantity of Concrete in the Work in m^3	Number of Samples
1-5	1
6-15	2
16-30	3
31-50	4
51 & above	4 plus one additional sample for each additional $50m^3$ or part thereof
Note: At least one sample shall be taken from each shift.	

6.10.6 Test Specimen

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing, or to check the testing error. Additional cubes may also be required for testing cubes cured by accelerated methods as described in IS:9013. The specimen shall be tested as described in IS:516.

6.10.7 Test Strength of Sample

The test strength of the sample shall be the average of the strength of three specimens. The individual variation should not be more than ±15 percent of the average.

6.10.8 Standard Deviation

i) Standard deviation based on test results:

a) Number of test results: The total number of test results required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts should be made to obtain the 30 test results, as early as possible, when a mix is used for the first time.

b) Standard deviation to be brought up to date: The calculation of the standard deviation shall be brought up to date after every change of mix design and at least once a month.

ii) Determination of Standard Deviation:

a) Concrete of each grade shall be analysed separately to determine its standard deviation.

b) The standard deviation of concrete of a given grade shall be calculated using the following formula from the results of individual tests of concrete obtained as specified in **6.10.7.**

$$\text{Estimated standard deviation(s)} = \sqrt{\frac{\sum \Delta^2}{n - 1}}$$

Δ = d eviation of the individual test strength from the average strength of n samples

n = number of sample test resultsc) When significant changes are made in the production of concrete | batches (for example changes in the materials used, mix design, equipment or technical control), the standard deviation value shall be separately calculated for such batches of concrete.

iii) Assumed Standard Deviation:

Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in **Table 6.11** may be assumed.

Table 6.11: Assumed Standard Deviation

Grade of Concrete	Assumed Standard Deviation (N/mm^2)
M 15	3.5
M 20	4.6
M 25	5.3
M 30	6.0
M 35	6.3
M 40	6.6

However, when adequate past records for a similar grade exist and justify to the Employer, a value of standard deviation different from that shown in **Table 6.11**, it shall be permissible to use that value.

6.10.9 Acceptance Criteria

The acceptance criteria for concrete shall be as per IS456:2000. Concrete shall be assessed daily for compliance.

Concrete is liable to be rejected if it is porous or honey-combed; its placing has been interrupted without providing a proper construction joint; the reinforcement has been displaced beyond the tolerances specified; or construction tolerances have not been met.

6.11 Inspection and Testing of Structures

As per clause 5.3.10

6.11.1 Inspection

Immediately after stripping the formwork, all concrete shall be carefully inspected and defective work or small defects, if any, shall either be removed or made good before concrete has thoroughly hardened.

6.11.2 Testing of Structures or Parts of Structures

In case the results of work test cubes do not comply with the specified strength requirements or there is reasonable doubt regarding the strength of concrete used, either due to poor workmanship or materials the Employer may instruct the Contractor to perform additional tests as Employer feel necessary and/or load test as specified in **Clause 6.11.3** to ascertain the quality of concrete. These tests shall also be required to be carried out in the event the Employer is doubtful regarding the adequacy of strength of the structure due to suspected overloading during construction, premature removal and nonconformance to specification of formwork, improper curing or any other reason. The number and type of tests to be carried out shall be determined by the Employer whose decision shall be final and binding on the Contractor.

6.11.3 Load Test

Load test, where directed by the Employer, shall be carried out as soon as possible after expiry of 28 days from the time of placing of concrete. The structure shall be subjected to a load equal to full dead load of the structure (which shall include Self Weight of Structural members plus weight of finishes) plus 1.25 times the imposed load (for which the structure has been designed) for a period of 24 hours and then the imposed load shall be removed. The deflection due to imposed load only shall be recorded. If within 24 hours of removal of the imposed load the structure does not recover at least 75percent of the deflection under imposed load, the test shall be repeated after a lapse of 72 hours. If the recovery is less than 80percent, the structure shall be deemed to be unacceptable.

If the maximum deflection in mm, shown during 24 hours under load is less than 40 L^2/D, where L is the effective span in meters and D the overall depth of the section in mm, it is not necessary for the recovery to be measured and the recovery provision as given above shall not apply.

The Employer shall be the final authority for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Employer shall be final and binding on the Contractor. In case the results of the tests are unsatisfactory, the Employer may instruct the Contractor to demolish and reconstruct the structure.

6.11.4 Finishing of Concrete

On striking the form work, all surface defects such as bulges, ridges and honey-combing etc. observed shall be brought to the notice of the Employer. The Employer may at his discretion allow rectification by necessary chipping and packing or grouting with concrete or cement mortar. However,if honey-combing or sagging are of such extent as being undesirable, the Employer may reject the work totally and his decision shall be binding. No extra payment shall be made for rectifying these defects, demolishing and reconstructing the structure. However, quantity of cement actually used for this purpose may be considered for reconciliation of materials. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as from the formwork except that honey-combed surface shall be made good as specified above.

6.11.5 Repair and Replacement of Unsatisfactory Concrete

Repair shall be made as soon as possible after the forms are removed and before the concrete becomes too hard with prior permission from the Employer, in writing. Stone pockets, segregation patches and damaged areas shall be chipped out and the edges undercut slightly to form a key. All loose material shall be washed out before patching. No excess water shall be left in the cavity, but the

concrete shall be damp. A good bond between the patch and parent concrete shall be obtained by sprinkling dry cement on the wet surface or by throwing mortar with force on to the wetted concrete, or by brush in a coat of thick cement grout of about 1:1 (1 cement: 1 Sand) just before applying the patching material. Before this has dried, the remainder of the patch shall be filled with mortar or concrete, depending on the extent of the repair.

Cement concrete/mortar used in repair of exposed surfaces shall be made with cement from the same source as that used in concrete and blended with sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. The proportions of ingredients shall be same as those used in parent concrete. The mortar shall be as dry as possible and well compacted into the cavity. All filling shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the filling has been cured and dried.

For larger repairs to hardened concrete, necessary formwork bearing tightly at the edges of the cavity shall be provided. Concrete shall be chipped out to a depth of at least 100mm and preferably 150mm. Mortar shall be scrubbed into all surfaces with a wire brush before placing the concrete. Damaged reinforcement shall be adequately spliced with new steel so as to maintain the original strength. Additional reinforcement, if required in the patch, shall be provided as per the instructions of Employer.

In case in the opinion of the Employer defects in the concrete is excessive or beyond repair, the Contractor shall either redo the structure or take other remedial measures as instructed by the Employer. The decision of the Employer shall be final and binding to all in this respect.

Approved epoxy formulation for bonding fresh concrete used for repairs with already hardened concrete shall be used by the Contractor if asked by the Employer. Epoxy shall be applied in strict accordance with manufacturer’s specification and instructions.

All repair works due to non-conformance or non-adherence to specification, shall be carried out.

6.11.6 Curing of Patched Work

Immediately after patching is completed, the patched area shall be covered with an approved non-staining water saturated material, which shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the patched area shall be kept continuously wet by a fine spray or sprinkling for not less than 10 days.

6.11.7 Cement Wash

If instructed by the Employer, the Contractor shall provide one coat of cement wash over the exposed concrete surfaces of foundations, beams, columns, walls, lintels, soffit of slabs etc. which are not plastered and appearance-wise not upto acceptable standard, as per the sole direction of Employer due to bad workmanship, defective shuttering, honey-combing and other repair works subsequently undertaken by the Contractor. No extra amount shall be paid to the Contractor on this account. However, cement used by the Contractor for providing the cement wash shall be taken into account for material reconciliation purposes.

6.12 Form Work

6.12.1 General

Forms for concrete shall be of plywood conforming to IS:6461 or steel or as directed by the Employer and shall give smooth and even surface after removal thereof.

If it is desired by the Employer, the Contractor shall prepare, before commencement of actual work, design and drawings for formwork and get them approved by the Employer.

Form work and its supports shall maintain their correct position and be to correct shape and profile so that the final concrete structure is within the limits of dimensional tolerances specified below, unless required otherwise, for functional/aesthetic reasons. The decision of the Employer shall be final and binding in this regard.

Deviation from specified dimensions - 6mm to +12mm of cross section of columns and beams.

Deviation from dimensions of footings (see Note below)

i.	Dimensions in plan	:	-12mm to +50mm
ii.	Eccentricity	:	0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
iii.	Thickness	:	±0.05 times the specified thickness.

Note: Tolerances apply to Cast-in-situ concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

Deviation in length (major dimension of single unit)

(i)	upto 3 m	:	± 6mm
(ii)	3 m to 4.5 m	:	± 9mm
(iii)	4.5 m to 6 m	:	± 12mm
Additional deviation for every subsequent 6m		:	± 6mm

Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam, column or slab edge.

(i)	upto 3 m	:	6mm
(ii)	3 m to 6 m	:	9mm
(iii)	6 m to 12 m	:	12mm
Additional for every subsequent 6m.		:	6mm

Deviation in squareness shall be measured taking the longer of two adjacent sides as the base line.

The shorter side shall not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions exceeds 6mm. For this purpose, any error due to lack of straightness shall be ignored. Squareness shall be checked with respect to the straight lines that are most nearly parallel with the features being checked. When the nominal angle is other than 90 degree, the included angle between check lines shall be varied accordingly.

Deviation in twist shall be within a limit such that any corner shall not be more than the limit given below from the plane containing other three corners:

upto 600mm wide and upto 6m in length - 6mm

over 600mm wide and for any length - 12mm

Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6mm.

6.12.2 Form Requirement

As per clause 5.4.2

The formwork shall be true, rigid and adequately braced both horizontally as well as diagonally. The forms shall have smooth and even surface and be sufficiently strong to carry, without deformation, the dead weight of the green concrete working load, wind load and also the side pressure exerted by the green concrete. As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used. Projected part of nail shall not be bent or twisted for easy withdrawal.

Where through tie rods are required to be put to hold the formwork and maintain accurate dimension, they shall always be inserted through a precast concrete block (of same mix proportion as is to be used for concreting) with a through hole of bigger diameter. The precast block shall tightly fit against in inner faces of formwork. The holes left after the withdrawal of tie rods shall be fully grouted with cement-sand mortar of same proportion as that used for concrete. However, use of such precast block shall in no case impair the desired appearance or durability of the structure. No such tie rods shall be used in any liquid retaining or basement structure.

Tie wires shall be permitted only upon approval of the Employer and shall be cut off flush with the face of the concrete or counter sunk, filled and finished in the manner specified in **Clause 6.11.4**

Form joints shall not permit any leakage. The formwork shall be strong enough to withstand the effect of vibrations practically without any deflection, bulging, distortion or loosening of its components.

Forms for beams and slabs (span more than 6.0m) shall have camber of 1 in 500 so as to offset the deflection and assume correct shape and line after deposition of concrete. For cantilevers, the camber at free end shall be 1/100th of the projected length. Where architectural considerations and adjunctive work are critical, smaller form cambers shall be adopted as decided by the Employer.

All vertical wall forms may be designed and constructed for the following minimum pressure. The pressures listed in **Table 6.12** are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

Table 6.12: Minimum Design Pressure for Wall Formwork

Rate of pour in meter/hour	Pressure in kN/m^2	
	at 10° (in Celsius)	at 24° (in Celsius)
0.6	36.0	29.0
0.9	40.0	32.0
1.2	44.0	35.0

All horizontal forms shall be designed and constructed to withstand the dead load of the green concrete, reinforcement, equipment, material, embedment and a minimum live load of 2.0 kN/Sqm.

6.12.3 Inspection of Forms

As per clause 5.4.3

Temporary openings shall be provided at the base of column and wall forms and other places necessary to facilitate cleaning and inspection. Before concrete is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly cleaned, properly treated and free from foreign material. The complete form work shall be inspected and approved by the Employer before the reinforcement bars are placed in position. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the work shall be stopped until the defects have been corrected as per the instructions of the Employer.

6.12.4 Treatment of Forms

As per clause 5.4.4

The surfaces of forms that would come in contact with concrete shall be well treated with approved non- staining release agents such as soft soap, oil, emulsions etc. Care shall be taken that such releasing agents are kept out of contact with the reinforcement.

6.12.5 Chamfers and Fillets

As per clause 5.4.5

All comers and angles shall be formed with 45 degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfer and fillets, unless otherwise detailed or specified shall be 25x25mm. For heavier work chamfers or fillets shall be 50x50mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

6.12.6 Reuse of Forms

As per clause 5.4.6

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired and retreated, before resetting. Formwork shall not be reused, if declared unfit or un-serviceable by the Employer.

6.12.7 Removal of Forms / Stripping Time

In the determination of time for removal of forms, consideration shall be given to the location and character of the structures, the weather and other conditions including the setting and curing of the concrete and material used in the mix.

Forms and their supports shall not be removed without the approval of the Employer. The formwork shall be removed without shock and methods of form removal likely to cause over stressing or damage to the concrete shall not be adopted. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In normal circumstances when average air temperature exceeds 16 degree Celsius during the period under consideration after pouring of concrete and where ordinary Portland cement is used, forms may generally be removed after expiry of following periods.

(a)	Walls, columns and vertical	:	24 to 48 hours as may faces of all structural members be decided by the Employer
(b)	Slabs (props left under)	:	3 days.
(c)	Beam Soffits (props left under)	:	7 days.

(d) Removal of props under slabs:

- Spanning upto 4.5m. : 7 days.
- Spanning over 4.5m. : 14 days.

(e) Removal of props under beams and arches:

- Spanning upto 6m. : 14 days.
- Spanning over 6m and upto 9m. : 21 days.
- Spanning over 9m. : 28 days.

(f) Cantilever Construction : Formwork shall remain till structures for counter acting or bearing down have been erected & have attained sufficient strength (minimum 14 days).

Notes:

1. For rapid hardening cement, 3/7 of the above mentioned periods shall be considered subject to a minimum of 24 hours.
2. For other cements, the stripping time recommended for ordinary Portland cement shall be suitably modified as per the instructions of the Employer.
3. The number of props left under, their sizes, supporting arrangement, and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.
4. Where the shape of the element is such that the formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

6.12.8 Staging / Scaffolding

As per clause 5.4.7

Staging / Scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. The Contractor shall get it reviewed by Employer before commencement of work. While designing and during erection of scaffolding/staging, the following measures shall be considered:

(a) Sufficient sills or under pinnings in addition to base plates shall be provided particularly where scaffolding are erected on soft grounds.

(b) Adjustable bases to compensate for uneven ground shall be used.

(c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

(d) Horizontal braces shall be provided to prevent the scaffolding / staging from rocking.

(e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

(f) The scaffolding / staging shall be checked at every stage for plumb line.

(g) Wherever the scaffolding / staging is found to be out of plumb line it shall be dismantled and re-erected afresh and effort shall not be made to bring it in line with a physical force.

(h) All nuts and bolts shall be properly tightened and care shall be taken that all clamps/couplings are firmly tightened to avoid slippage

(i) Erection work of a scaffolding/staging under no circumstances shall be left totally to semi-skilled or skilled workmen and shall be carried out under the supervision of a technically qualified civil Engineer of the Contractor.

For smaller works or works in remote areas, wooden ballies may be permitted for scaffolding / staging by the Employer at his sole discretion. The Contractor must ensure the safety and suitability of such works as described above.

6.13 Exposed Concrete Work

As per clause 5.5

6.13.1 Form Work

Other things remaining same as per **Clause 6.12**, formwork shall be of high quality. Care shall be taken to arrange the forms so that the joints between forms correspond with the pattern indicated in the Contractor's drawings. The forms shall be butting with each other in straight lines, the comers of the boards being truly at right angles. The joints between the forms shall cross in the two directions at right angles. The size of forms shall be so selected as to exactly match with the pattern of forms impression on the concrete face indicated in the Contractor's drawings. Maximum care shall be taken to make the formwork watertight. Burnt oil shall not be used for treatment of forms. The Contractor shall be permitted reuse of forms brought new on the work for exposed concrete work as specified below.

Such reuses shall be permitted only if forms are properly cared for, stored, repaired and treated after each use.

(a) Plywood Forms 6 Reuses (Max.)

(b) Steel Forms 10 Reuses (Max.)

However, in case of steel formwork higher number of reuses could be permitted as long as casting tolerance levels are within acceptable limits.

The Employer may, at his absolute discretion, order removal of any forms considered unfit for use in the work irrespective of the number of uses specified above.

6.13.2 Finishing

Repairing to exposed concrete work shall be avoided. Rendering and plastering shall not be done.Minor repairing, if unavoidable shall be done as specified in **Clause 6.11.5** with the written permission of the Employer.

6.14 Reinforcement

As per Clause 5.6

6.14.1 General

Reinforcement shall be cut,bent to shape and dimensions as shown in the Contractor's bar bending schedules/drawings. In normal course the bar bending schedule of selected structures/structural parts shall be supplied to the Contractor.

6.14.2 Straightening, Cutting and Bending

Procedure for cutting and bending shall be as given in IS:2502.In case bars are supplied in coils,they shall be smoothly straightened without any kinks.

Cold twisted deformed bars shall be bent cold.Bars larger than 25mm in size (except cold twisted deformed bars) may be bent hot at cherry red heat to a temperature not exceeding 850° Celsius as per the instructions of the Employer. The bars shall be allowed to cool gradually without quenching.

Bars shall be bent in a slow and regular movement to avoid fractures. Bars which develop cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position,care should be taken to ensure that at no time is radius of the bend less than 4 times bar diameter for plain mild steel or 6 times bar diameter for high strength deformed bars.Care shall also be taken when bending back bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

6.14.3 Placing and Fixing

All reinforcement shall be cleaned to ensure freedom from loose mill scale, loose rust, oil, grease or any other harmful material before placing them in position. Reinforcement shall not be surrounded by concrete unless it is free from all such materials.

All reinforcement shall be fixed in the correct position and shall be properly supported to ensure that displacement will not occur when the concrete is placed and compacted.

The reinforcement bars shall be tied at every intersection by two strands of 16 SWG black soft annealed binding wire. Crossing bars shall not be tack welded for assembly of reinforcement. The reinforcement bars shall be kept in position by using the following methods:

(a) In case of beam and slab construction, precast cover blocks (having the same cement sand contents as the concrete which shall be placed) of size 40 x 40 mm and thickness equal to the specified covers shall be placed firmly in between the bars and forms so as to secure and maintain the specified covers over the reinforcement.

(b) When reinforcement bars are placed in two or more layers in beams, the vertical distance between the horizontal bars shall be maintained by introducing spacer bars at 1 to 1.2m centre to centre.

(c) In case of thick rafts& pile caps having two or multi layers of reinforcement, the vertical distance between the horizontal bars shall be maintained by introducing suitable chairs, spacers, etc.

(d) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them. The templates shall be removed after the concreting has been done below it.

(e) Exposed portions of reinforcement bars shall not be subjected to impact or rough handling and workmen will not be permitted to climb on extending bars until the concrete has attained sufficient strength so that no movement of the bars in the concrete is possible.

6.14.4 Splicing / Overlapping

Only bars of full length shall be used. But where this cannot be done, overlapping of bars shall be done as directed by the Employer. Where practicable, the overlapping bars shall not touch each other, but these shall be kept apart by 25mm or 1.25 times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be tied with two strands of 16 SWG black soft annealed binding wire. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.

6.14.5 Welded Joints

Welding of reinforcing bars shall not be permitted without the written permission of the Employer. Where welding is permitted, it shall be in accordance with the recommendations of IS:2751 and IS:9417. Welded joints shall be located at suitable staggered positions. Tests shall be made as directed by the Employer to prove that the joints are of the full strength of the bars. Maximum one welded joint shall be allowed per bar.

6.14.6 Mechanical Connections

The mechanical splices in reinforcement by means of couplers, clamps etc. shall be used {as per manufacturer's specifications) with the written approval of the Employer. However, tests shall be made as directed by Employer to prove that such connections are of the full strength of the bars on trial joints.

6.14.7 Tolerances

Unless otherwise directed by the Employer, reinforcement shall be placed within the following tolerances:

(a) For effective depth 200mm or less : ± 10mm

(b) For effective depth more than 200mm : ±15mm

The cover shall in no case be reduced by more than one third of specified cover or 5mm, whichever is less.

6.14.8 Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Employer.

6.14.9 Cover

Cover to reinforcement shall be as per standard codes / as directed by the Employer.

6.14.10 Precast Concrete

Specifications contained in above regarding concrete, formwork and reinforcement shall apply in addition to the specification given as under. The Contractor shall get the precasting bed approved by the Employer.

Necessary lifting hooks of suitable (but not less than 12mm dia) diameter M.S. rounds shall be provided for handling.

Unless otherwise specified, the exposed surfaces of precast members shall be integrally finished smooth. For precast slabs or planks, the top surface shall be finished with 1:3 (1 cement: 3 sand) cement mortar. Surface used as walkways shall be given a non-skid finish.

The precast concrete units shall be marked clearly on top surface with the letter "T" for identification of surfaces at the time of erection and shall be stored properly until required for erection. The precast units shall be handled and erected by methods approved by the Employer to protect them from damage.

The Contractor shall take all necessary precautions for safe handling during the course of erection. The Contractor shall replace all such units, which are damaged during the course of erection.

6.14.11 Concrete Underwater

Where concrete is to be deposited underwater, the greatest care shall be taken to prevent the cement being washed out. The concrete shall be placed through a tremie pipe with suitable hopper and plunger arrangements. Great care shall be taken to ensure that no segregation of concrete takes place and the Employer shall approve the method of placing.

The discharge end of the tremie tube shall plugged at the start of the work so as to minimise the entry of water into the tube and it shall be entirely sealed at all times and kept full of concrete upto the bottom of hopper. Concreting operations once commenced are to be completed in full without break otherwise the structure shall be considered as rejected.

6.14.12 Underground Concrete Work

All reinforced concrete work below ground level or other filled areas shall be protected from the aggressive action of salts and other chemicals contained in all types of earth and rocks, ground water or other materials as follows:

Except where otherwise agreed by the Employer, the underside of all concrete foundations, beams, slabs, ducts, manholes, shall have a layer of at least 75 mm of blinding concrete of an approved mix using sulphate resistant cement. The top face to be finished to take the polythene sheeting material.

A layer of polythene sheeting material shall be laid prior to concreting under the foundations, beams, slabs, ducts, manholes, etc. and carried up the sides of such members to ground level or other level as defined by the Employer. Laps in the polythene sheeting material shall not be less than 300 mm and securely taped as specified.

Care shall be taken to avoid puncturing or tearing the sheeting and should this occur the puncture or tear shall be repaired to the satisfaction of the Employer or the sheeting replaced.

The surfaces of concrete exposed after the removal of form including top faces of buried members shall be painted with one coat of primer (Bituminous solvent) and two coat of Bituminous (blended together with non-asbestos reinforcing fabric and solvent) applied as manufacturer’s instructions and to the satisfaction of the Employer.

The external surfaces of manholes, cable pits and service pits shall be coated with two coats of a rubber reinforced bitumen emulsion, brush applied. The coatings shall be applied strictly in accordance with the manufacturer’s instructions.

6.14.13 Concreting in Inclement Weather

In the event of rainstorm or any other severe conditions arising, concreting shall be stopped and appropriate temporary stop ends, vee grooves, etc. placed as may be necessary. During wet weather, the concrete shall be adequately protected as soon as put into position.

The Contractor shall always have in readiness approved framed sheeting, tarpaulin etc. for the protection of newly placed concrete during inclement weather. Shall any concrete be damaged due to rainstorms or other weather conditions, the Employer may order the cutting out and replacement of the damaged concrete.

6.14.14 Grouting

The base plates of all the steel structures shall be grouted to thickness as shown on the relevant structural drawings of Contractor, after the alignment and approval of the Employer. The grout shall consist of either

(a) 1:2 (1 Cement: 2 Sand) mortar for operating platforms (not supporting Equipment), pipe supports upto 2.5m in height (above concrete top), cross-over, staircases and ladders. or

(b) Free flow non shrink Grout (Pre-mix type) of compressive strength not less than 40/mm^2 for all structures other than those covered in (a) above, as per the instructions / recommendations of the manufacturer.

6.14.15 Continuous Concreting

Continuous concreting shall be done in a single operation as per the requirements of IS:456 and IS:2974. It shall be ensured that **clause 6.9.23** of these specifications is not violated in case of continuous concreting. Sufficient "Windows" shall be left in the formwork for walls, columns and other thin sections of significant height for pouring& compaction of concrete and inspection. The concrete to be placed in a manner that will prevent segregation and accumulation of hardened concrete on the formwork or reinforcement above the level of the placed concrete. These windows shall be fixed tight once the level of concrete reaches their levels.

6.15 Pile Foundation

6.15.1 General

This section of specification includes requirement for furnishing and placing/installation of reinforced concrete bored cast in-situ piles.

6.16 Bored cast in-situ Piles

6.16.1 General

Piles may be of any type as may be designed by the Contractor for the works or any part thereof. However concrete bored cast in-situ pile types are described in brief.

The Contractor shall furnish materials, labour and equipment necessary to drill or bore and install bored piles in accordance with this specification.

Unless specified the grade of concrete shall be minimum M40 conforming to IS:10262. The cement content for piling work shall be minimum 400 kg/m^3 and maximum water cement ratio shall be 0.45.

The properties of cement, reinforcement and fine/coarse aggregates to be used for piles construction shall be in accordance with the specifications under 'Materials'.

For piles temporary casing upto its required levels shall be provided.

Construction of bored piles shall be carried out in accordance with the relevant sections of IS:2911 (Part I/sec 2) and only routine pile load test shall be conducted as per IS:2911 (Part 4) except where otherwise specified, described or directed by the Employer.

6.16.2 Programme and Method of Construction

The Contractor must furnish to the Employer, before commencing work, a detailed method of construction he intends to adopt for piling work together with the programme of construction.

6.16.3 Boring

Boring shall generally be carried out by recommended procedure as set out in IS:2911 by either rotary or percussion equipment, grabbing equipment or by reverse or direct mud circulation method. If the soil is found to be unstable, the boring tools should be such that suction effects are minimized. Walls of boreholes shall be stabilized by using removable bottom casings with or without drilling fluid depending upon the soil conditions. In soils liable to flow, the bottom casing should be kept ahead of the boring in all cases to prevent the entry of soil into the bore, so preventing the formation of cavities and settlements in the adjoining ground. Continuous pumping shall not be used for excavating inside the boreholes. While below sub-soil water level, precaution shall be taken so that no boiling of the bottom of the hole occurs due to the difference in hydrostatic head. The size of cutting tool shall not be less than the diameter of pile by more than 75 mm.

Where stabilization of the sides of the boreholes is effected by the use of drilling fluids, the fluid level shall be maintained at a level not less than 1.5 M above the level of the sub-soil water or high water level as the case may be and the hole shall then always be kept almost full with it till the concreting is completed.

The specific gravity and composition of the fluid shall be such as to suit the requirements of the ground conditions and to maintain the fine materials from the boring in suspension.

Boring of any pile must be completed in one continuous operation without interruption. In case such interruptions are unavoidable, steps shall be taken to prevent the collapse of sides of the boreholes.

The Contractor shall be responsible in the event of bore collapse due to any reason, at the discretion of the Employer, re-boring or additional bores shall be carried out at no extra cost. If additional pile is driven and extra material is consumed due to strengthening of cap etc. such material shall be to Contractor's account.

Boring in rock shall be carried out either by chiselling or by any other approved method. The bottom of the borehole shall be cleaned off by air lifting all the spills and sediments so that the bases of piles shall be free from loose materials. Rock shall be classified in six grades I through VI in accordance with the classification made in BS 5930. Employer's interpretation in this context shall be final and binding.

The Contractor shall be responsible for the prompt removal from the Site of all spoil due to the boring upto a distance of 4 km and at places specified by the Employer. The cost of such disposal shall be deemed to have been included in the price.

Foundation elevation of each pile will be individually approved by the Employer on the basis of the Employer satisfying himself, from observations, designs in supporting of the founding levels and all data including SPT tests at his disposal, of the soundness of the end bearing stratum. However, the piles shall be socketed minimum 1(one) diameter into hard rock. For determining the founding strata, standard penetration tests shall be carried out in the borehole by “Nordmeyer Standard Penetrometer” for 2 piles in every 50 m, as decided by the Employer. Before commencing a penetrometer test, the bottom of the borehole shall be cleaned.

6.16.4 Drilling Fluid

Bentonite used in the works shall be of the best quality. Bentonite shall be mixed thoroughly with clean fresh water to make a suspension, which will maintain the stability of the pile excavation for the period, necessary to place concrete and complete construction. The fluid used shall be such as to form a suspension, which remains stable under the saline conditions likely to be encountered at the Site and suitable in all respects for the construction of marine piles.

Control test shall be carried out on the bentonite suspension using suitable apparatus. The frequency of testing the drilling fluid and the method and procedure of sampling shall be as directed by the Employer. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed.

The measuring device shall be calibrated to read to within 0.005 g/ml. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite used in the works.

6.16.5 Formation of Pile

The concrete to be placed under water or drilling fluid shall be placed by tremie unless otherwise approved and shall not be discharged freely into the water or drilling fluid. Before placing concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the boring and the Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the pipe of the tremie, has not accumulated in the bottom of the hole.

A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.15, the placing of concrete shall not proceed. In this event, the Contractor shall modify or replace the bentonite as directed by the Employer.

All equipment, material and operations employed in the formation of the piles shall be such as to ensure that the piles remain to the designed cross-section and shall be capable of carrying the specified test load 28 days after concreting.

The concrete shall be properly graded and well compacted without excess water, admixture of soil or other extraneous matter. The concrete shall be placed through a tremie pipe of 20 to 25 cm in dia. with a suitable hopper. The tremie pipes joints shall be airtight and hopper capacity shall be such that it produces a build-up of at least 2 m concrete in the pile. Great care shall be taken in the placement of the first pour using a suitable pig in the pour or a PVC plunger so that the concrete does not come in contact with water. The first pour is eventually brought up through successive pour of concrete and overflow at the end of concreting. The tremie pipe must extend down to the bottom of the borehole at the start and may be withdrawn in sections as the level of the concrete rises in the boreholes, but its discharge end shall at all times be immersed in the concrete to a minimum depth of one metre. Placing of concrete shall be continuous and the tremie pipe shall be held concentric in the hole. Special care shall be taken regarding compaction of concrete in the top section of the pile.

At all stages of work every precaution shall be taken to prevent the formation of voids in the concrete caused by the faulty consolidation or pockets of air trapped within it. The volume of concrete placed shall be checked against calculated volume of pile at the time of placing. Any shortfall in actual consumption of concrete in pile shall not be more than 5% of the theoretical volume.

The tremie pipes and funnel shall be filled and lifted just 15 cm above bottom before releasing the concrete column to facilitate flushing out the bottom. The concrete levels in the tremie shall be checked every few metres in order to note the difference, if any, between the theoretical quantity that should have been placed and actual quantity that has gone in. This is to locate the position of over – cut or caving in during boring.

Placing of concrete should be continuous and the tremie pipe should be held concentric in the hole. Special care shall be taken regarding compaction of concrete in the top section of the pile. Concrete shall be placed and compacted until green concrete is obtained above the cut off level. Any excess concrete above cut off level will be dismantled neatly upto the cut off level, removing all cracked, loose and unbound concrete. Top surface of pile shall be kept rough. The cost of the same is presumed to be included in the rates and prices.

6.16.6 Reinforcement

Any reinforcement used shall be made up into stiff cages sufficiently well wired or welded to withstand handling without any distortion or damage. The bars shall be so placed as not to impede the placing of the concrete. They shall be placed correctly in position and be supported away from the sides of the pile shaft by means of spacer blocks to assume concentric alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the piles without any distortion or displacement. Care shall be taken to preserve the correct cover and the alignment of the reinforcement throughout the whole operation of placing the concrete.

Normal lap between reinforcement cages shall be as per I.S. Specifications. The main reinforcing steel shall project for a length sufficient to develop bond above the cut-off level of the pile. The clear concrete cover to main reinforcement shall be 75 mm and suitable spacer blocks shall be provided at intervals not exceeding 2 m and wired to the main reinforcement.

6.16.7 Control of Alignment

The pile shall be cast as accurately as possible to the vertical. Any pile deviating from its proper alignment to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile ties shall, at the discretion of the Employer, be replaced or supplemented by additional piles at no extra cost. If any pile is deviated and extra material is consumed due to strengthening of cap etc. such material shall be to Contractor’s account.

6.16.8 Obstruction

If any obstruction is encountered, the installation shall cease and Contractor shall notify the Employer and submit for his approval, proposals for overcoming the difficulties. Notwithstanding any such approval, the Contractor will be entirely responsible for ensuring that the piles are completed to the required line, position and depth.

6.16.9 Volume Check

Concreting shall start as soon as possible after driving the liner or completion of boring. The volume of concrete placed shall be observed in the initially cast piles and the average figure obtained shall be used to check whether there is undue deviation in concrete consumption for the subsequent piles. If actual quantity is found to be considerably less, special investigation shall be conducted, and appropriate measures taken.

6.16.10 Inspection

For bored piles, the Contractor shall have the Employer's inspection to the bore hole for proper plumb, location, compaction of founding surface, pressure of water and other requisites. The depth of the borehole shall be measured by means of a chain to which a plumb weighing not less than 100 g is attached. The Contractor shall provide all the equipment required for the above inspection and he shall co-ordinate this work with the Employer. Concreting shall start only after the Employer has approved the borehole. All facilities, equipment and labour required for inspection by the Employer mentioned above shall be provided by the Contractor promptly and free of cost.

6.16.11 Load Tests

As per 5.8.14.

Vertical load tests shall be carried out on the specially constructed test piles. In addition to vertical load tests, the Contractor shall carry out horizontal load test on bored piles specially constructed for the purpose. Maximum test loads shall be as determined by the Employer according to I.S. Specifications considering the design horizontal loads.

6.16.11.1 Vertical Load Test

The test shall be carried out by applying a series of loads on the test pile. The load shall be preferably applied by means of hydraulic jacks reacting against a symmetrically erected loaded platform which shall be preloaded to not less than 1½ times the design load carrying capacity of the pile. The hydraulic jack shall be of adequate capacity and shall have a pressure gauge and remote control pump.

The Contractor shall arrange all the necessary equipment and kentledge with platform at his own expense well in advance of the load test. Detailed proposal together with a sketch for the load test arrangement shall be furnished by the Contractor to the Employer for the latter's checking and approval.

The pile to be tested shall be chipped and dressed to a well-levelled surface. It is important that reinforcing bars of the pile do not project beyond the top surface of the level pile top.

A round plate of suitable thickness and always greater than the diameter of the pile that is to be tested, shall be placed over a fine layer of sand spread over the top of the pile.

A jack or two jacks, depending on the capacity of the jacks and the ultimate test load shall be inserted between the gap formed by the top of the plate resting on the pile and the lower flange of the main RSJs of the loaded platform. The jacks should preferably be connected and operated by one pump.

The Contractor shall submit certificates showing the correctness of the calibration of the pressure gauges and the jacks before use. All jacks shall be fitted with locking devices.

Another plate of suitable thickness shall be placed over the ram of the jack, which is later raised by operating the hydraulic pump so that the plate on the top of the ram butts against the bottom flange of the main RSJs of the platform.

Readings of settlement and rebound shall be recorded with the help of four dial gauges of 0.02 mm sensitivity and resting on diametrically opposite ends of the pile cap.

The dial gauges shall be fixed to a datum bar whose ends rest upon non-movable supports. The supports should be at least 5 x d away clear from the pile where “d” is the diameter of the pile. Readings on the dial gauges are to be observed immediately before and after application of loads and immediately before and after release of loads.

The test load shall be applied in equal increments of about 1/5 of the design load until the test load is reached.

Each stage of loading and unloading shall be maintained until the rate of movement of the pile top is not more than 0.02 mm per hour. Unloading shall be done as under:

1. Test load to design load
2. Design load to 50% of the design load
3. 50% to 25% of the design load
4. 25% of the design loads to complete unloading

The rebound reading for each decrement shall be noted. The final rebounding shall be recorded 24 hours after the entire load is released. The safe carrying capacity of the pile shall be estimated in accordance with IS:2911.

6.16.11.2 Lateral Load Test on Piles

Two test piles shall be installed to the required depth and spacing as specified by the Employer. A hydraulic jack of adequate capacity shall be inserted in between them to apply the lateral load at the approximate cut-off level of the pile. Thrust pieces shall be inserted on either end of the jack to make up the gap. Lateral deflections shall be measured at the thrust level by means of dial gauges fixed to immovable supports.

The loading shall be applied in one half tonne increments till the rate of deflection reduces to 0.02 mm/hour and a load deflection curve shall be plotted.

The loading shall be continued till the deflection of the pile top reaches the estimated value or the estimated safe load whichever is earlier.

When the full test load is applied it shall be kept on for 24 hours with observations made every hour and then released in 3 stages.

6.16.11.3 Plant and Equipment

All temporary work, plant equipment, kentledge for applying the load and all necessary instruments for measurement of loads, deflection, etc. shall be provided by the Contractor. The equipment provided shall be capable of slowly applying and maintaining the required test loads to within an accuracy of 0.02 mm. The Contractor shall submit for approval of the Employer his detailed proposal for carrying out the load test.

6.16.11.4 Cost of Delay

The Contractor shall be deemed to have allowed in the construction programme the time required for testing of piles. No claim shall be entertained for any delay due to the testing programme.

6.16.11.5 Records

The Contractor shall submit to the Employer the following records of the tests:

(a) Make and specification of jack, pressure gauge and dial gauges;

(b) Calibration of pressure and dial gauges

(c) Design load of pile, description of location and identification marks of pile

The readings for settlement and rebound shall be entered in the following form:

Time			Settlement		Settlement	Mean Set	Remarks
1	2	3	4	5	6	7	8

6.16.11.6 Interpretation of Test Results

The pile shall be deemed to be acceptable under the following conditions:

Total settlement under the test load does not exceed 12 mm plus allowance for normal elastic deformation.

The increase in settlement between two consecutive increments of loading does not exceed 6 mm plus allowance for elastic deformation.

The elastic deformation is defined as shortening of the pile within the elastic limit of the materials forming the ingredients.

6.16.11.7 Standard of Acceptance

The piles shall be approved as satisfactory only when the work has been executed in accordance with the Specification and to the satisfaction of the Employer and the standards stated below.

(a) The head of the pile shall be within 75 mm of the specified position

(b) The pile shall not be out of plumb by more than 2%

(c) The toe of the pile shall be at the approved bearing level in each case

(d) The total volume of concrete shall not be less than 95% and not more than 120% of the calculated volume. The calculated volume for this purpose shall be cross sectional area inside the casing multiplied by the length of the shaft

(e) The concrete shall be of the design strength

Should a pile fail to meet the standard of approval specified above the Employer may take one of the following decisions:

(a) Instruct the Contractor to carry out additional tests to ensure the soundness of pile.

(b) Accept the work and allow the Contractor to make suitable alternation in the construction of piles/pile cap/and beams. The cost of modification in the pile/pile beams shall be borne by the Contractor.

(c) Reject the pile/piles and instruct the Contractor to install additional piles at Contractor's expense.

The piles which fail to fulfill the standard of approval specified under Para (f) above shall be rejected and the Contractor, at his own cost, shall install additional piles as directed by the Employer.

6.16.11.8 Integrity Testing

Non-destructive integrity testing of bored piles, for minimum of 10% of piles selected by the Employer, shall be conducted using the low strain sonic diagnostic system consisting of hammer, low 'g' accelerometer with amplifier, pile integrity tester, portable computer system, graphics printer etc. all complete. The test shall be conducted by the qualified and experienced specialists in this field. Employer's decision shall be final regarding approval of piles passing integrity test but of questionable workmanship.

6.16.11.9 Defective Piles

Piles, which have been declared defective by the Employer, shall either be removed or left in position as judged convenient by the Employer. If left in place, the cost of any modifications required in the pile/pile caps shall be borne by the Contractor in addition to the cost of construction of any replacement piles. If removed, all costs related to this shall be borne by the Contractor.

6.16.11.10 Finishing Pile Heads

The top of the piles shall be brought up above the finished level to permit all laitance and weak concrete to be removed and to ensure that it can be properly keyed into the cap. Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete and bonded into the old.

6.17 Site Grading

6.17.1 General

The Contractor shall first clear the area of any obstructions or old structures and carry out a detailed topographic survey of the whole area. Formation level shall be such that there shall be no flooding of the site. It is proposed to provide the formation level of **+ 38.5 m CD** within the Terminal area, upto the boundary wall of the IWT Terminal, road area and locations where buildings have to be constructed.

6.18 Material

6.18.1 Acceptable Fill Material

Fill material shall be granular, non-cohesive, naturally occurring and shall be free from organic and deleterious matter and shall have the following properties:

Maximum particle size	200 mm
Percentage maximum particle size	10%

Percentage passing 63 micron sieves	10% maximum
Liquid limit	35% maximum
Plasticity index	6% maximum
Chloride content (top 150mm only)	3.3% maximum
Sulphate content (top 150mm only)	2.0% maximum

6.18.2 Unsuitable Material

Material, which has been deposited in reclamation areas and does not comply with the specification requirements for filling, shall be removed by the Contractor and replaced with suitable fill.

6.18.3 Testing

Contractor shall carry out testing in the reclamation fill to determine whether or not the materials placed conform to the requirement of the specification. The results shall be in a form and give such information as the Employer may direct.

6.18.4 Sampling

Unless directed otherwise by the Employer, sampling shall be carried out as follows:

(i) Bag samples (large) (25kg)

Every day during the progress of filling, the Contractor shall take two bag samples of the materials placed in reclamation at locations directed by the Employer. Samples shall be taken at a maximum depth of 0.5m.

The Contractor shall carry out all of the following tests on each of the bag samples:

(a) Sieve analysis (BS1377 Part 2 - Section 9.2)

(b) Particle size distribution by hydrometer (BS1377 Part 2 - Section 9.5)

(c) Specific gravity (BS1377 Part 2 - Section 8)

(d) Bulk density (BS1377 Part 2 - Section 7)

6.18.5 Standards

Unless stated otherwise, testing of fill materials shall be carried out in accordance with BS812 and BS1377. The Relative Density of the reclamation fill shall be as defined in ASTM D4253 and the Contractor's attention is drawn to the requirement for both wet and dry methods of compaction to establish the maximum dry density. Alternative methods of assessing relative density, or density index as defined in Clause 4.6 of BS1377: Part 4, will be considered provided the Contractor undertakes comparative tests.

6.19 Compaction

6.19.1 General

During the filling process the Contractor shall place approved material within the fill area to achieve an in-situ density not less than 90% of the Maximum Dry Density (MDD) throughout the full thickness and lateral extent of the fill. The latter is defined in Clauses 3.5 & 3.6 of BS1377: Part 4: 1990 - Determination of the dry density/moisture content relationship using the 4.5kg rammer.

The uppermost zone of fill shall be placed and treated to ensure that the top 900mm of the fill has an in situ density not less than 95% MDD. The in situ density shall be measured using the appropriate method described in Clause 2.1 of BS1377: Part 9: 1990 or similar approved.

6.19.2 Testing

The presence of pockets and layers of fine material and the degree of compaction achieved from placing fill shall be established by drilling boreholes through the fill. Boreholes shall be carried out to the required depth as directed by the Employer. In each borehole continuous undisturbed sampling shall be performed using a good quality sampler that will ensure a high recovery ratio. The Contractor shall propose a sampler and shall seek approval from the Employer prior to its use. Immediately upon extraction, each sample shall be subjected to a bulk density determination.

Around each borehole position three static cone penetrometer soundings shall be made, approximately 1.5m away from the borehole. The cone penetrometer soundings shall be made before the drilling of boreholes. The penetrometer equipment shall record data electronically and the data shall be made available to the Employer in approved format.

Each sample shall be subjected to minimum and maximum density determinations in accordance with ASTM D4254 and ASTM D4253 standard tests respectively and to Maximum Dry Density testing in accordance with Clause 3.5 and 3.6 of BS1377 : Part 4 :1990. When available quantities of fill material from individual samples are less than specified for the particular tests, mixing from immediately adjacent samples shall be permitted with the specific approval of the Employer. From the above tests the relative density, as defined in ASTM D4254, corresponding to 90% MDD shall be established for each sample.

At each borehole location the Contractor shall establish a correlation between cone resistance and relative density and shall prepare a relationship between cone resistance and depth for fill having a Relative Density corresponding to 90% MDD. Once this relationship has been agreed with the Employer the cone resistance depth profile shall be used to monitor the density of the whole fill.

The Contractor shall perform static cone penetrometer soundings on a square grid of 25m for the whole extent and depth of the reclamation that has been filled with dredged material. There shall be an agreed time interval between filling and sounding to allow for the equilibration of in situ water pressures. Where the soundings show cone resistance values less than the agreed profile the Contractor shall submit his proposals for improving the density of the fill. Repeat soundings shall be undertaken following any ground improvement.

The Contractor may wish to submit alternative methods for demonstrating that the Fill has achieved the specified density, these shall be submitted as an alternative and he shall submit a detailed method statement for evaluation.

In situ density testing shall be carried out on the upper 900mm of fill in reclamation area to determine the degree of compaction achieved. The rate of testing shall be one test per nominal 2,500m^2 and the Employer shall select any depth within the upper 900mm of Fill.

The in situ density of the upper 900mm shall be determined in accordance with the method described in BS1377: Part 9 - Section 2.1 or 2.2.

Laboratory tests to determine the moisture content/dry density relationship shall be performed on a representative sample of the fill material for each 5,000m^2 of fill placed in reclamation area. The location and depth of the test sample shall be determined on site by the Employer.

Additional testing shall be carried out on the top 300 mm of fill in reclamation area as follows:

Table 6.13: Laboratory Test Frequency

Test	Test Frequency (Not less than one test per)
Dry density	600 m^2
Moisture content/maximum dry density relationship	2,000 m^2
Particle size distribution	2,000 m^2
Atterberg limits	2,000 m^2
Linear shrinkage	2,000 m^2
CBR	2,000 m^2
Sulphate content	2,000 m^2
Chloride content	2,000 m^2

6.19.3 Acceptance of Works

The Contractor shall undertake post-construction survey of the entire site so graded to confirm that the area has been developed to the required levels. The Employer shall not accept the Work unless the Contractor has carried out all the required tests with satisfactory results. The entire area of the graded site shall be taken over completely by the Employer upon completion. The Employer shall not take over part of the area.

Interim payment for reclamation fill shall be based on quantities measured net using the calculated difference between the agreed ground levels from the surveys and upto date ground levels from interim surveys. Simpson's formula shall be used for computing fill volumes.

6.20 Road & Pavement Works

6.20.1 General

This section covers the specification for the construction of roads, and paved open areas. The internal roads would be built along the boundary wall, from gate complex to Port buildings, Fire station, electrical substation, Berths and to Breakwaters Roadway. Any culverts required at the crossing of the drains and drainage system shall be provided.

These specifications include the requirements for the preparation of base and surfacing courses in accordance with these specifications and in conformity with the dimensions shown in the drawings and with the lines and grades established by the Contractor at site subject to approval by the Employer.

The pavements such as flexible pavement, concrete block pavement, concrete pavement with easy maintenance shall be provided as required. These pavements must be laid over sub-base courses that will distribute and transmit the loads to the under laying soil causing the least possible differential settlements.

The pavement shall be graded to allow to allow for storm water to the drainage system.

6.21 Water Bound Macadam Layers for Roads & Flexible Pavements

6.21.1 General

This specification covers the material and construction details for earthwork in filling for embankments, filling with sand/murrum, WBM sub-base, WBM base course and shoulders for roads and flexible pavements.

6.21.2 Reference Codes and Standards

Refer **Section 2 of Volume-II**.

6.22 Earth Work in Filling

6.22.1 Materials

Only material considered suitable by the Employer shall be used for the construction and that considered unsuitable shall be disposed off as directed by Employer at the Contractor's own cost and no claim for compensation will be entertained. The Contractor shall give the samples of earth, he proposes to use for filling along with the following characteristics of the sample to the Employer for approval, prior to collection and use.

Mechanical analysis or gain size analysis as per IS:2720 Part IV.

Liquid limit as per IS:2720 Part V.

Plastic limit as per IS:2720 Part V.

Moisture density relationship as per IS:2720 Part VIII.

The material (soil) used for filling shall be free from boulders, lumps, trees roots, rubbish or any organic deleterious matter.

Material (soil) having plasticity index less than 20 only shall be used for filling purposes.

Soil having laboratory maximum dry density of less than 1.5gm/cc shall not he used.

Care shall be taken to see that unsuitable waste material is disposed off in such a manner that there is no likelihood of its getting mixed with the materials proposed to be used for filling.

The work shall be so planned and executed such that the best available material (soil) is reserved for the top portion of embankments.

6.22.2 Filling for Embankments and Shoulders

The area where filling is to be placed must be cleared of all loose material and virgin soil must be exposed. Such exposed surface must be consolidated properly to obtain 90% of maximum laboratory dry density of the soil. All soft patches must be worked out to remove the soft soil and selected approved earth must be filled back and compacted.

Approved fill material shall be spread in uniform layers of thickness not exceeding 20 cm for embankment filling. Shoulder construction shall be so organised as to keep pace with the construction of different layers. All clods, lumps etc. shall be broken before compaction.

In general, the soil shall be spread uniformly over the entire width of embankment or shoulder as the case may be. For large embankments, the spreading of soil shall be as directed by Employer.

Successive layers of filling shall not be placed until the layer under construction has been thoroughly compacted to satisfy the requirements laid down in this specification.

Prior to rolling, the moisture content of material shall be brought to within plus or minus 2% of the optimum moisture content as described in IS:2720 - Part-VIII. The moisture content shall preferably be on the wet side for potentially expansive soils.

After adjusting the moisture content as described above, the layers shall be thoroughly compacted by means of rollers till 90% of maximum laboratory dry density is obtained as per IS:2720 part VIII.

Each layer shall be tested in field for density and accepted by Employer subject to achieving the required density before laying the next layer. A minimum of one test per 500 m^2 area for each layer shall be conducted.

The type of rollers that should be employed for compaction shall be as per direction of Employer.

If any layer fails to meet the required density, it shall be reworked or the material shall he replaced and method of construction altered as directed by Employer to obtain the required density.

The filling shall be finished in conformity with alignment, levels, cross-sections and dimensions as approved by the Employer.

Extra material shall be removed and disposed off as directed by Employer.

6.22.3 Tolerance

Embankment and shoulders for roads, units etc. shall be carried to within a tolerance of 3 cm. from final lines but shall be to the required grades and slopes.

6.22.4 Filling with Sand/Murrum

Sand for filling shall preferably be locally available sand, clean and free from any chemical or other impurities. Murrum for filling shall be clean and well graded. Sand/Murrum shall not contain any vegetation, organic, clayey or other material and shall be obtained from a source approved by Employer.

Murrum/Sand shall be spread in layers of thickness not exceeding 15 cm over the areas. Each layer shall be uniform in density, quality of material and moisture content before compaction. The moisture content shall be within two percent of the optimum moisture content as per IS:2720 Part VIII.

In case of pure sand, flooding with water is permissible.

Compaction of each layer shall be by mechanical means as per directions of Employer. Only inaccessible reaches shall be worked manually. Each layer shall be uniformly compacted to obtain 90% of maximum laboratory dry density of the material. If the material fails to achieve the required density, the layer shall he reworked with necessary alteration in compaction, so that the required compaction is obtained. A minimum of one test per 500 M^2area for each layer shall be conducted.

Subsequent layers shall be placed only after the layer already laid has been compacted to the required density and approved by Employer.

The finished surface must be dressed to required grade and slope. Excess material must be removed from compaction site, as directed by Employer.

6.22.5 Sub Base and Base Course

The sub-base course shall consist of one or more layers, each of 100 mm compacted thickness.

The base course shall consist of one or more layers, each of 75 mm compacted thickness.

6.22.6 Stone Aggregate for WBM

The coarse aggregates shall be hard, crushed or broken stone metal from quarries approved by Employer. It shall be hard, durable and free from flat, elongated, soft and disintegrated particles. It shall not contain dirt and other objectionable matter. The quality, size and grading of the coarse aggregate shall be conforming to IRC 19: Standard Specification and code of practice for WBM.

Samples of test shall be representative of the material to be used and collected as per I.S.2430.

The aggregates shall be stacked at the roadside on firm, well-drained ground in regular stacks, as directed by Employer. The various grades shall be stacked separately, and contamination by earth and other extraneous matter shall be prevented effectively.

6.22.7 Binding Material Murrum

The binding material shall be clean, dry murrum free from leaves, organic matter and any deleterious material.

It shall be obtained from quarries approved by Employer.

6.22.8 Spreading Coarse Aggregates

The sub grade or sub-base to receive WBM coarse shall be prepared to the required grade and camber. Before starting with WBM construction, side shoulders shall he constructed in advance to a thickness corresponding to the compacted layer of the WBM coarse for lateral confinement of aggregate. After shoulders are ready, the inside edge shall be trimmed vertical to receive the aggregate. The practice of constructing WBM in a trench section excavated on the embankment/formation must be avoided.

The coarse aggregate shall be spread uniformly and evenly on the prepared base in required quantities from the stacks. The aggregate shall be spread to proper profiles by using templates across the road at about 6m apart.

The surface of the aggregate spread shall be carefully, and all high or low spots remedied by removing or adding aggregate as may be required. The surface shall be checked from time to time, during the spreading and rolling of the coarse aggregate to ensure a finished surface without variation great than 12 mm, when a 3 m long straight edge is laid parallel to centre line of the road.

The WBM layer shall be tested by depth blocks. No segregation on large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pocket of fine materials.

The coarse aggregate shall not be spread in lengths more than 3 days average work in advance of the rolling, spreading murrum and bonding of the preceding section.

6.22.9 Rolling Road Metal

Immediately following the spreading of the coarse aggregates, it shall be compacted to full width by rolling with either three wheeled power roller of 8 to 10 T weight or equivalent vibratory roller true to the line and camber as shown in the drawing. The course shall not be rolled when the sub-grade is soft or yielding or the rolling causes a wave-like motion in the base course or sub-grade. When rolling develops irregularities that exceed 12mm when tested with a 3m straight edge, the irregular surface shall be loosened and then aggregate added to or removed from it as required and the area rolled until it gives uniform surface conforming to the desired cross-section and grade. The surface shall also be checked transversely by template and any irregularities corrected as above. The use of murrum to make up depression shall not be permitted.

The rolling shall begin from edges with roller running forward and backward until the edges have been firmly compacted. The rolling shall then progress gradually from edges to the centre parallel to the centre line of the road lapping uniformly each preceding rear wheel track by one half width and shall continue until the entire area of the course has been rolled by the rear wheel. On the super elevated portions of road, the rolling shall commence from the lower edge and progress gradually towards the upper edge of the road.

Rolling shall be discontinued when aggregates are thoroughly keyed. Slight sprinkling of water may he done if required.

6.23 Screenings

6.23.1 Material

Screenings to fill the voids in the coarse aggregates shall, as far as possible be the same material as the coarse aggregates. Where it is decided by the Employer to use other materials, the same shall be predominantly non-plastic materials such as Kankar nodules, gravel (other than river-borne rounded aggregate) or murrum, provided that the liquid limit and plasticity index of such material is below 20 and 6 respectively, and the fraction passing 75 micron sieve does not exceed 10 percent.

6.23.2 Grading Requirements of Screenings

Table 6.14: Grading Requirements for Screenings

Size of Screening	Sieve Designation (IS: 460)	% by Weight Passing the Sieve
13.2 mm	13.2 mm	100
	11.2 mm	95-100
	5.6 mm	15-35
	180 Microns	0-10

This grading, however, shall not he mandatory, in case either murrum or gravel is used as screenings.

6.23.3 Application of Screenings

After the coarse aggregate has been rolled as described in **Clause 0,** screenings shall be applied uniformly and gradually over the surface to completely fill the interstices. Dry rolling shall be continued while the screenings are being spread so that the jarring effect of the roller will cause them to settle into the voids of the coarse aggregates.

The screenings shall not be dumped in piles on coarse aggregate but shall be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders.

The screenings shall be applied at a uniform and slow rate (in three or more applications) so as to ensure filling of all voids. Rolling and brooming shall continue with the spreading of the screenings. Either mechanical brooms or hand brooms or both may be used. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface making the filling of voids difficult or preventing the direct bearings of the roller on the coarse aggregates. The spreading, rolling and brooming of screenings shall be performed on sections which can be completed within one day's operation and shall continue until no more screenings can be forced into the voids of the coarse aggregates. Damp and wet screenings shall not be used under any circumstances.

The quantity of screenings used shall be such as to fill all voids in the water hound macadam-courses.

6.23.4 Sprinkling and Grouting

After spreading the screenings, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling shall be continued and additional screenings applied where necessary until the coarse aggregates are well compacted and grout of screenings and water form a wave ahead of wheels of the roller. Care shall be taken to see that the base of sub-grade does not get damaged due to the addition of the excessive quantity of water during the construction.

6.23.5 Binding Material

Binding material, to prevent revelling of WBM shall consist of fine grained material possessing P.I Value upto 6.

Application of binding material shall not be necessary where murrum or gravel is used as screenings.

Binding material shall be obtained from quarries/sources approved by the Employer.

6.23.6 Application of Binding Material

After the application of screenings as described above, the binding material shall be applied at a uniform and slow rate (in two or more successive thin layers) so as to ensure filling of all voids.

After each application of binding material, the surface shall be copiously sprinkled with water and the resulting slurry swept in with hand brooms/mechanical brooms or both so as to fill the voids properly. This shall be followed by rolling with a 6 -10 tonne roller during which water shall be applied to the wheels to wash down the binding material that may get stuck to them. The spreading, rolling and brooming of binding material shall be performed on sections which can be completed within one day's operation and shall continue until no more binding material can be forced into the voids of the coarse aggregates and until the slurry of binding material and water forms a wave ahead of the wheels of moving roller. Damp and wet binding material shall not be used under any circumstances.

The quantity of binding material used shall be such as to fill all voids in the water bound macadam.

6.23.7 Subsequent Layers of WBM

Before laying the subsequent layers of WBM, the surface shall be scarified and reshaped to the required camber and profile, and all ruts, depressions, pot holes etc. made good. The second layer shall be laid after the surface preparation is approved by Employer. The specification for subsequent layers of WBM will be similar to that described before.

6.23.8 Construction of Shoulders or Berms

After the WBM course is laid and compacted, the existing surface at side berms or shoulders of the roadway must be scarified. Fresh quantity of approved earth must be spread in layers for building up of berms upto the required level and scope.

The earth must be consolidated by at least three passes of an 8-10 tonne road roller. The edges must be well consolidated by suitable means to prevent edge slips and the work properly trimmed and dressed.

6.24 Flexible Pavements

6.24.1 General

This specification establishes material and construction requirements for the flexible pavement with Bitumen Premix Carpet.

6.25 Bitumen Premix Carpet

6.25.1 Material

Coarse aggregate: The aggregate shall consist of crushed stone of clean, hard, tough, durable rock of uniform quality and shall be clean, free from excess of dust, flat or elongated pieces, soft or disintegrated stone, clay or other deleterious matter. The size of aggregate shall be as mentioned in the drawings.

Sand: The sand shall consist of clean hard, durable, uncoated, coarse dry particles and shall be free from injurious amounts of dust, soft or flaky particles, organic matter or other deleterious substances.

Binder: The binder shall be bitumen of penetration 80/100 conforming to IS:73. The bitumen shall be stored in drums at roadside. Any drum leaking or damaged shall not be accepted.

6.25.2 Quantities of Materials

- **For Premix Carpet 20mm thick**

	Material	For Premix Carpet per 100 m^2	For Seal Coat Per 100 m^2
i.	Coarse Aggregate 12mm	2.75 m^3	- and down size
ii.	Bitumen 80/100	150 kg.	68.3 kg.
iii.	Coarse sand as sealing aggregate	-	0.6 m^3

- **For Premix Carpet 25 mm thick**

i.	Coarse Aggregate 12mm and down size	3.5 m^3	
ii.	Bitumen 80/100	185 kg.	68.3 kg.
iii.	Coarse sand as sealing compound	0.6 m^3	

- **For Premix Carpet 50 mm thick**

i.	Coarse Aggregate 25mm and down size. *(For 35 mm thick carpet layer)*	5.5 m^3	
ii.	Coarse Aggregate 12 mm and down size (for 15 mm *thick carpet layer)*	*2.0 m^3*	
iii.	Bitumen 80/100		
	a) For 35mm thick Carpet (I layer)	269 kg.	68.3 kg.
	b) For 15mm thick Carpet (II layer)	110 kg.	
iv)	Coarse sand as sealing aggregate	0.6 m^3	

- **For Premix Carpet 75mm thick**

i)	Coarse Aggregate 25mm and down size (for 50mm thick layer)	8.5 m^3	
ii)	Corse Aggregate 12mm and down thick II layer	3.5 m^3	
iii)	Bitumen 80/100		
	a) For 50 thick I layer	375 kg.	68.3kg.
	b) For 25 thick II layer	185 kg.	
iv)	Coarse sand as sealing aggregate	0.6 m^3	

6.26 Laying

6.26.1 Preparation of Road Surface

The existing surface shall be thoroughly cleaned of dust, loose materials, caked mud and other foreign matter with the help of wire brush, chisel, picks etc. before laying the tack course. The cleaning shall be carried out in such a manner as to expose the stone metal to a depth of 1 to 2 mm without dislodging the interlocking of the metal. All dust and other material thus removed shall be carried away and dumped at suitable places as directed by the Employer.

If potholes or ruts are found on the existing road surface, these irregularities must be filled in with premix chippings and well rammed about a week before the carpet is laid.

6.26.2 Tack Coat

The bitumen shall be heated in asphalt boilers to 177°-188°C and shall be spread uniformly at the rate of 1 kg/m^2 by means of sprayers. The applied binder shall be evenly brushed.

The tack coat shall be applied just ahead, keeping pace with laying of premix carpet.

6.26.3 Preparation of Premix

Mechanical mixers shall be generally used for preparation of premix. Improvised hand mixing drums may be used if permitted by the Employer.

Stone chippings of specified size shall be thoroughly mixed dry in the mixer at the rate indicated above. Binder heated at temperature suitable for the grade of bitumen is added to the mixer drum at the specified rate per $100m^2$ of surface and thoroughly mixed till the stone chips are completely coated with the binder.

The premix shall be emptied on to wheelbarrows or stretchers and carried to work site.

6.26.4 Spreading of Premix

Immediately after applying the tack coat the premix shall be spread with rakes to the required thickness and distributed evenly by means of a drag spreader. The camber shall be checked by means of camber board and the unevenness shall be rectified.

6.26.5 Rolling

When the premix has been laid for a length of 15-20 meters, rolling shall be commenced with tandem rollers (8 to 10 tones) Rolling should commence from edges and proceed towards the centre longitudinally.

The wheels of the roller shall be continuously moistened to prevent the premix adhering to the wheels and being picked up.

After the preliminary rolling and honeycombing, high spot or depressions shall be rectified by adding or removing the premix as per requirements and the surface shall be rolled again to compaction. Camber shall be checked at every stage and any defects found shall be rectified, Excessive rolling shall be avoided.

6.26.6 Seal Coat

A premixed seal coat mixed preferably in a mechanical mixer after heating the sand should be applied immediately after laying the carpet and rolled. Materials required for this seal coat are as per **Clause 6.25**

Traffic may be allowed on the road preferably 24 hours after providing the seal coat.

6.27 Lean Concrete Base

6.27.1 Materials

The materials used for lean concrete base shall be natural or crushed gravel or crushed rock complying with IS:383 except as detailed below.

Aggregates shall have a maximum nominal size not more than 40 mm or less than 20 mm.

Cement shall be ordinary Portland cement complying with IS:269

Water shall comply with the requirements of the Specification - Plain and Reinforced Concrete.

6.27.2 Mixing Lean Concrete

Lean concrete shall be mixed in batch mixer complying with the relevant clauses of the Specification for Plain and Reinforced Concrete. Alternatively, it may be mixed in a continuous mixer provided that the proportioning of the mix is entirely by weight and the mixing is as satisfactory as mixing in a batch mixer. In both cases, the Contractor shall maintain the mixer in good working condition.

6.27.3 Laying Lean Concrete Base

Lean concrete base shall be laid by plant capable of distributing material in a layer of uniform thickness without segregation. Compaction shall be completed within one hour of adding water to the material. Care shall be taken to compact effectively at joints in layers and adjacent to structures, using small compactors if necessary, in confined spaces.

6.27.4 Quality Control

Samples of the mixed material shall be taken from the hopper of the spreader or paver at random intervals and at the rate of five samples for every 1000 m^2 of base laid. From each sample the Contractor shall prepare two 150mm cubes. The cubes shall be made, cured and tested in accordance with IS:516 except that they shall be compacted as described in Specification - Plain and Reinforced Concrete.

The average strength of each group of five samples tested at seven days shall be not less than 6 N/mm^2 or more than 16 N/mm^2. If more than one average group strength in five falls outside these limits the cement content of the mix shall immediately be altered to ensure compliance with the strength requirement.

6.27.5 Rectification of Surfaces

Any area of lean concrete base which is outside the tolerance of $\pm$ 6 mm shall be rectified as follows:

Provided not more than two hours have elapsed from the time of mixing, areas, which are high, shall be scarified to a depth of not less than 75 mm, the surplus material removed and the area re-compacted to comply with the Specification.

If the material has been mixed for longer than two hours, the material shall be removed to the full depth of the layer over the operating width of the paving machine and over a length sufficient to enable the paving machine to relay the area. The area shall then be re-laid to comply with the Specification.

Areas which are low lying shall be removed to a depth of the layer over the operating width of the paving machine and over a length sufficient to enable the paving machine to relay the area. The area shall then be re-laid to comply with the Specification.

6.28 Concrete Block Paving

6.28.1 Materials

Concrete paving blocks shall comply with relevant IS codes and requirements given hereunder:

6.28.2 Cement

The cement used in the manufacture of precast concrete paving blocks shall be ordinary Portland cement complying with IS:269. The cement content of the compacted concrete shall be not less than 380 kg/m^3

6.28.3 Aggregates

The fine and coarse aggregate shall be natural aggregates complying with IS:383 and as given in Specification-Materials.

The nominal maximum size of aggregate shall not exceed 20 mm.

6.28.4 Water

Water shall be clean, free from deleterious matter and comply with IS:3025.

6.28.5 Other Materials

Admixtures: Admixtures shall not be used without the approval of the Employer. The Contractor shall inform the Employer in writing of the admixtures to be used. Admixtures shall conform IS:9103.

Pigments: Any pigments used shall comply with IS:3493.

6.28.6 Finishes

Natural Colour Blocks: A block described as ‘natural colour’ shall not container pigment.

Surface finishes: Surface finishes, including colour, shall be as directed or approved by the Employer.

Pigmented blocks: When pigmented blocks are specified, samples shall be submitted to the Employer for approval.

6.28.7 Dimension and Tolerances

Dimensions:

Nominal sizes and aspect ratios

Standard rectangular blocks shall be manufactured with a work size length of 200 mm and a work size width of 100 mm. The work size thickness shall be 60 and 80 mm.

Wearing Surface Area

A chamfer round the wearing surface (no deeper than 7 mm) shall be permitted, and the work size and width of any chamber shall be declared by the manufacturers. The wearing surface area shall not be less than 70% of the plan area.

Tolerances:

The maximum dimensional deviations from the stated work sizes for paving blocks shall be as given below:

Length : ± 2mm

Width : ± 2mm

Thickness : ± 3mm

6.28.8 Samples and Testing

a) Sampling

Sampling procedure shall be in accordance with IS: codes or equivalent

The Employer shall at all reasonable time, be permitted access to the place where the paving blocks are manufactured or stored, for the purpose of examining and sampling the materials and the finished paving blocks.

b) Compressive Strength

The compressive strength of paving blocks sampled shall not be less than 49 N/mm^2 and the crushing strength of any individual block shall not be less than 40 N/mm^2.

c) Compliance with Specification

If concrete blocks are delivered to site from an approved manufacturer, the Contractor shall satisfy himself by testing that, at the time of delivery, the paving blocks comply with the requirements of this Specification and if requested by the Employer, shall forward a certificate to this effect, indicating the frequency of testing.

Should any of the test results, for either block manufactured on or delivered to Site, not comply with the requirements of this Specification, the consignment or batch as appropriate shall be rejected as not complying with the specifications.

6.28.9 Construction of Concrete Block Paving

Concrete block paving shall be laid to comply with IS:6509 and the requirements as given hereunder:

6.28.10 Subgrade

The preparation of the subgrade shall not commence until all subgrade drainage has been completed and side drains or channels are capable of removing water from the immediate vicinity of the formation.

The subgrade, sub-base and base shall be prepared so that:

(i) the surface levels are within the tolerances given in **Table 6.15**:

(ii) the longitudinal falls and cross falls are such that no depressions hold water. A minimum longitudinal fall of 1.25% and a minimum cross-fall of 2.5% shall generally be adopted.

(iii) The surface is tight and dense enough to prevent laying course material being lost into it during construction and use.

(iv) Provision is made to:

a. drain water from the laying course in service (e.g. by installation of drainage when the laying course is on impermeable foundations)

b. prevent migration and loss of laying course material into drainage (e.g, by use of a geotextile)

Trimming and regulation shall then be carried out to bring the formation to the correct level and grade within the tolerance stated in **Table 6.15**: and finally, the formation shall be re-rolled with a smooth wheeled roller having a load of not less than 2.5 t/m width of roll.

6.28.11 Sub-base

Materials for the sub-base shall comply with the requirements for granular sub-base given in **Clause 6.22.5** of the Specification. The sub-base layer shall be laid on the prepared formation and compacted in accordance with **Clause 6.22.5**. The thickness of the sub-base shall be as per approved design.

6.28.11.1 Lean Mix Concrete Base

Where shown on the approved drawings or if specified by the Employer, the Contractor shall lay a lean mix concrete base for block paving as per **Clause 6.27** of this specification.

6.28.11.2 Edge Restraints

Edge restraints shall be formed before compacting adjacent blocks.

6.28.11.3 Laying Course

The laying course shall consist of 2-10 mm naturally occurring coarse sand or crushed rock fines graded in accordance with IS:2386. The coarse sand or crushed rock fines shall not contain more than 3% by weight of clay, silt and fine dust. The moisture content of the laying course should be as uniform as possible and the material should be moist without being saturated.

The Contractor shall construct the laying course so that after compaction, it forms an approximately 50 mm thick layer below the paving blocks. The sand shall be stuck off to such a level that, when blocks have been vibrated, the upper face of the blocks shall be true to the finished level. Before the blocks are laid, the laying course shall not be subjected to any form of traffic including pedestrian traffic, before, after or during screeding.

6.28.11.4 Concrete Paving Blocks

Blocks shall be laid in herringbone bond, except where specifically instructed by the Employer. Blocks shall be placed firmly together without disturbance to the laying course and the order of placing the blocks shall ensure this.

At edges or obstructions such as gully grating or manholes, blocks shall generally be cut to fit. Cutting may be carried out with a hydraulic splitter, a hammer and bolster, or by sawing.

Immediately adjacent to gullies and manholes the tolerance shall be +3 mm, -0 mm.

The laid blocks shall be compacted to the finished levels by a vibrating plate compactor which transmits an effective force not less than 75 kN/m^2 at a frequency of 75-100 Hz and has a plate area not less than 0.25 m^2. Sufficient passes shall be made to compact the laying course to produce an even surface.

Vibration shall not be carried out within 1 m of an unrestrained edge or laying face.

After initial vibration, sand or crushed rock fines shall be brushed into joints and further passes of the vibrating plate compactor made to fill the joints, more sand being spread over the surface if required.

The tolerances in **Table 6.15**: apply on straight profiles. Equivalent tolerances shall apply on vertical curves. All profile devices such as pegs, pins, profile boards or guide wires shall be set to the true plan line with a maximum tolerance of ±25 mm and to the true level with a maximum tolerance of ±3 mm. Spacing of support pints for guide wires shall be less than 10 m.

Permissible tolerance on centre line of pavement construction relative to horizontal alignment: +10 mm.

Permissible tolerance on surface levels:

Table 6.15: Tolerances on Surface Level for Concrete Block Paving

Layer of Pavement	Maximum permissible in deviation from design level (mm)
Sub-grade	± 20
Sub-base	± 15
Road-base (Surface Course) Overall	± 6
Flatness	10 under a 3 m straight edge 2 between adjacent blocks
Adjacent to gullies, surface drainage channels and outlets (see Note)	+6, -0

Note: The permissible deviations for the upper level of drainage inlets and channels should be +0, -0 mm to ensure positive drainage.

6.29 Kerbs and Gutters

6.29.1 Kerbs

This work comprises the construction of concrete kerbs in situ, and installation of precast concrete kerbs on foundation concrete laid on prepared subgrade, sub-base, base-course, asphalt or concrete surface. Kerbs shall be provided at the locations to the lines, grades, and typical sections as per approved Drawings or established by the Employer.

6.29.2 Materials

Cement shall be ordinary Portland cement to IS:269.

Aggregates shall conform to the requirements of Specification - Materials. All aggregate shall be of a size appropriate to the sections and method of manufacture of the kerbs. The coarse aggregate to be used, when tested in accordance with IS:2386 shall not exceed the following limits:

- Aggregate crushing value 30%
- Flakiness Index 35%

The preparation and placing of concrete shall conform to the requirements of the Specification, **Clause 6.9.19** Plain and Reinforced Concrete.

Reinforcement, where used, shall comply with the Specification **Clause 6.14** Plain and Reinforced Concrete.

6.29.3 Equipment

Equipment shall be of the number and type outlined in the Contractor's Programme of Work as approved by the Employer.

6.29.4 In-situ Kerbs

Concrete Class

In situ kerbs shall be constructed of concrete OPC 25/20.

Expansion, contraction and construction joints for kerbs.

Joints shall be constructed at the intervals and places as approved by the Employer. All joints shall be of the type and materials and conform to the approved dimensions of the kerb.

When constructed in connection with or abutting concrete pavement, the method of constructing the joints in kerbs shall conform to the requirements for joints in the pavement.

When constructed separately from concrete pavement, or in connection with flexible base or surface courses, contraction joints in kerbs may be constructed by sawing through the kerb to a depth of not less than 32mm below the surface of the gutter. Alternatively, contraction joints may be formed by inserting an approved removable metal template in the fresh concrete, or by other methods approved by the Employer.

Sealing of the joints will not be required unless the kerb and is constructed in connection with or abutting concrete pavement.

6.29.5 Precast Kerbs

Precast concrete kerbs shall comply with IS:5758 and be manufactured by hydraulic pressing.

Form for precast kerb shall be constructed so that the kerb sections will conform to the approved shape and dimensions.

6.30 Construction Requirements

6.30.1 Subgrade

Soil below subgrade level to a depth of 200 mm in cut shall be scarified, broken up, adjusted to optimum moisture content and re-compacted to the required density. If Quality Control tests show the required compaction cannot be achieved, the layer shall be replaced with suitable excavated material.

Subgrade in cut shall have a minimum CBR value as per requirement of relevant IS Codes.

When the subgrade is formed on embankment, it shall be to the full width of the top of the embankment.

Material placed in the top 300 mm of embankments, shall exclude particle sizes greater than 75 mm and shall have a minimum subgrade CBR value as per requirement of relevant IS Codes.

The width to be excavated shall be 300 mm each side of the outside edges of the kerb or gutter. The subgrade shall be of uniform density as approved by the Employer. Rock, shale, or soft and yielding material shall be excavated 15 mm below subgrade elevation and replaced with suitable backfill

material. The backfill material shall be compacted to meet the compaction requirements specified in **Clause 6.19** of this specification. All subgrade shall be rolled or compacted to provide a smooth surface and shall be approved by the Employer before placing concrete.

6.30.2 Concrete

Concrete kerb foundation and backing concrete shall be OPC 15/20. The composition, consistency, proportioning, batching, mixing and curing of concrete shall conform to the requirements of **Clause 6.9**.

The area to be covered with the kerb shall, immediately after finishing, be cleaned of all laitance and roughened. The concrete shall be placed and compacted and then shaped with a steel tool conforming to the section. The Concrete shall be compacted with an approved internal vibrator or by hand spudding and tamping. The surface shall be shaped by use of a steel tool to produce the section. The edges shall be rounded by the use of wood moulding or by the use of an edger to form the required radius.

6.30.3 Reinforcement

Reinforcement, if required shall be held in the position by clips, bar chairs, or other approved devices.

6.30.4 Precast kerbs

Precast kerb sections shall not be moved (except as required for the removal of forms) or placed until the concrete has attained 75% of the design 28 day strength.

Precast kerb sections shall be set in a sand-cement grout on the concrete kerb foundation. They shall be butted up close together without mortared joints unless otherwise mentioned or instructed by the Employer.

Grouted joints, where indicated, shall consist of the one part Portland cement and three parts of fine aggregate, and one-fifth part of hydrated lime with sufficient water to produce a plastic mix as approved by the Employer. Grouted joints shall be cured by an approved method for a minimum period of four days.

Where kerbs are laid with concrete pavement, joints shall be provided in the kerb, foundation and backing in the same locations as in the pavement, and constructed and sealed to similar details using the same materials.

For curves of 12m radius or less, precast kerbs or appropriate radius or length shall be used.

Kerb units shall not deviate from line and level by more than 3mm in 3m. Standard precast concrete quadrant units shall be used where appropriate.

6.30.5 Finishes

a. In situ kerbs: surface shall be uniform and smooth finish

b. Precast kerb: surface shall be finished to a true and even. Surfaces concealed in the forms will require no finishing. All voids and honeycombed areas shall be repaired with a sand-cement grout.

6.30.6 Curing

Kerbs shall be cured in accordance with the provisions for curing for Plain and reinforced concrete as per **Clause 6.9.30.**

6.30.7 Backfill

The area adjacent to kerbs shall be backfilled with approved material to the top edges of the kerbs.

The backfill shall be placed and compacted to a density equal to or greater than the adjacent undisturbed natural ground.

6.30.8 Removal of Surplus Earth

Surplus earth and soil from excavation shall be removed from construction area to the area demarcated by the Employer.

6.30.9 Brick Pitching

6.30.9.1 Excavation

Trench shall be excavated/dressed true to line, section and grade as per approved drawings prior to starting the pitching work.

6.30.9.2 Material

Bricks shall be locally available best quality bricks as per Specification - Brick Masonry Work.

Cement, sand and water used shall be as per Specification - Material.

The concrete mix used for bedding shall be as per Specification - Plain and Reinforced Concrete.

6.30.9.3 Workmanship

The work of pitching shall be done after the bottom concrete has been laid and sides properly trimmed to the required grade and thoroughly compacted.

Brick pitching shall be done in 1:4 cement mortar using first class locally available bricks.

Bricks shall be laid in herringbone pattern with their length at 45° to the length of the ditch as shown in drawings.

Mortar joints shall never exceed 6mm in thickness and all bricks shall be laid with vertical joints quite full of mortar.

Bricks shall be soaked for a period of at least 12 hours immediately before use and no broken or damaged brick shall be used in any part of the work except such as will be required to close any line of bricks.

The face of pitching shall be made even and smooth.

The brickwork shall be raked, and flush pointed with cement mortar 1:3 as specified.

6.31 Traffic Markings

6.31.1 General

This work shall consist of the painting of white or yellow lines, chevron striping, arrows and lettering on road, pavements and painting on kerbs.

6.31.2 Material

Thermoplastic material for road markings shall comply with specification for road and bridge works published by IRC.

Road markings shall be white or they shall be yellow complying with IRC specifications and as directed by the Employer.

Chlorinated rubber paint for painting kerbs shall be plasticised and drying shall be by solvent evaporation alone. It shall have the properties given in **Table 6.16** given below.

Epoxy resin adhesive shall comply with AASHTO M237.

Table 6.16: Paint for Kerbs

Property	Allowable Limits
Relative density	1.48 minimum
Viscosity at 21^0C	65 to 70 KU
Drying Time	Approx. 10 –15 min
Coverage	3 m^2 per litre maximum
Brightness	80 minimum
Flexibility	Passes around 12 mm diameter mandrel
Chlorinated rubber content	9.0%

6.31.3 Quality Assurance

The quality and workmanship of the completed marking installation shall conform to the best modern practice.

The complete marking installation shall be warranted to the Employer from the date of issuance of certificate of final completion against peeling, chipping, flaking, delaminating and shoving for a period of one year or until the markings are normally worn away by traffic.

The Contractor shall submit his programme schedule, catalogues, manufacturer's specifications and test data of products proposed to use in this work to the Employer.

6.32 Construction Requirements

6.32.1 General

Traffic shall be kept off markings until the installation has fully cured.

6.32.2 Road Marking

Spraying equipment shall consist of a motor powered self-propelled machine with compressor. A minimum line width of 100 mm shall be sprayed in one pass. The bead gun shall be synchronized to spray glass spheres immediately onto the hot thermoplastic. An automatic skip mechanism shall be fitted to produce broken and dotted lines without pre-measurement.

If hand methods are used the Contractor shall provide stencils, specialised labour and anything necessary so that the results obtained match in quality and finish the mechanically sprayed work to the satisfaction of the Employer.

Lines, chevron striping, arrows and lettering shall be provided to the size and in the location as per approved Drawings and in accordance with the Indian Road Congress Standards.

Kerbs shall be painted alternately black and yellow covering the entire exposed surface. Changes in colours shall be made at joints between kerbs.

The surface to be painted shall be clean and dry. Pre-marking for painting shall be done manually on straight lines and curves using a 100 m long string. On straight the pre-marking shall consist of 1 dot mark every 3 m, and on curves every 1 m. The pre-marking dot shall be a circle of 40 mm diameter cut into an equal parts by a gap of 100 mm. Longitudinal changes in lines types shall be within 300 mm of the location as per the approved Drawings.

Paint shall be applied 1.5 mm thick for broken, dotted and continuous lines, stripping, pedestrian crossings, stop lines, special letters, arrows and symbols shall be 3 mm thick. In addition to the ballotini premixed in the material, a further quantity shall be sprayed onto the hot spray-plastic markings at a rate of application of 400 – 500 g/m^2.

6.32.2.1 Road Sign

Road sign to be supplied and fixed in accordance with the specification for road and bridge works published by Indian Road Congress or as directed by the Employer. The entire work of the installation and materials shall meet the approval of the Employer.

6.33 Storm Water Drainage

6.33.1 General

The intent is to drain the storm water of entire port area without any undue pooling and finally water to be let into the identified outfall point.

6.33.2 Scope

The schematic layout of drainage system is shown in **Section 7 of Vol II**.

Storm drainage consists of furnishing transportation, labour, equipment and materials to construct storm drainage system in accordance with Contractor own Design and Drawings complying Indian standards. The work includes construction and installation of the following:

(a) Reinforced concrete pipe for storm water conveyance.

(b) Open Concrete drain as well as box drains for collection and conveyance of storm water including nalla discharge.

(c) Pipe culverts for nalla discharge.

(d) Storm drain catch basins and related drainage structures and appurtenances.

(e) Storm drain outlets into identified outfall point including flap gates and related features.

(f) Sewage Collection & Transfer system.

6.34 Materials

6.34.1 Precast Concrete Pipe and Fittings

All reinforced concrete pipes shall be class NP3 conforming to IS: 458. RCC pipe shall be of NP4 type shall be used below road.

6.34.2 Flap Gate

The drainage gate shall be designed to allow free outflow and prevent backflow for maximum seating heads up to 7.6 meters (25ft). The gate shall be provided with adjustable, double pivoted hinge links so designed to permit complete seating, full opening, and with stops or other arrangements to prevent cover from rotating sufficiently to become wedged in the open position. Pivot lugs mounted to frame shall be adjustable to allow adjustment of hinge links without having to remove cover from gate. The hinge links shall be bronze-bushed, structural steel (or high strength ductile iron, cast manganese bronze or wrought stainless steel). All assembly hardware shall be stainless steel.

The frame shall be cast iron, cast in one piece, with reinforcing ribs and a cast on lining eye shall be provided for manual operation. The frame shall have a machined seating surface inclined from vertical at minimum of 2.5 degrees to assure positive closure.

All cast iron shall be painted with manufacturer's standard shop coat paint (or special paint). Structural steel hinge links shall be galvanized. All bronze and stainless steel parts do not require further finish.

6.35 Execution

6.35.1 Installation of Pipe, Fittings and Appurtenances

Excavation, trenching, installation, compacting soil and finishing operations for all pipe and soil materials shall conform to the Indian standards. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe. Provide all required equipment for lowering pipe safely into the trenches. The details of catch pit, drainage channel are shown in drawings.

6.35.2 Pipe Joints

All pipe joints shall be watertight and of such design as to remain sealed after possible settlement.

Pressure Testing: The length of pipe shall be tested as per Indian Standard.

6.35.3 Repair and Retesting

Sections of pipe not meeting the pressure test requirements shall have individual joints tested and sealed.

6.35.4 Storm Drain Cleaning

Prior to final acceptance and final catch basin-to-catch basin inspection of the storm drain system by Employer, flush and clean all parts of the system. Remove all accumulated construction debris, rocks, gravel, sand, silt, and other foreign material from the storm drain at or near the closest downstream manhole. If necessary, use mechanical rodding or bucketing equipment.

Upon Engineer's final catch basin-to-catch basin inspection of the storm drain system, if any foreign matter is still present in the system, reflush and clean the sections and portions of the lines as required.

6.35.5 Tolerances

Pipe Inverts: Plus 10 mm, minus 10 mm

Catch Basin Grates: Plus 0.00 mm, minus 10 mm

6.35.6 Inspection

Prior to final approval of any pipe installation, a thorough inspection shall be made of entire installation. Any indication of defects in material or workmanship, or obstruction to flow in the pipe system, shall be further investigated and corrected as necessary by the Contractor at no additional cost to the Employer.

6.36 Construction of Catch Basins and Trench Drains

6.36.1 Excavation and Backfill

Excavation and backfill as required accomplishing the construction. Backfill shall be as specified for the adjoining pipe trench.

Install catch basins and trench drains at the locations based on IS code and as specified herein. Construct forms to the dimensions and elevations required for cast-in-place units. Forms shall be tight and well braced.

6.37 Concrete Work

6.37.1 Cast-in-Place Concrete

Prior to placing formwork compact existing insitu soil and provide a layer of compacted bedding material.

Prior to placing the concrete, remove all water and debris from the forms. Place the concrete and screed the top surface of exposed slabs and walls. When the initial water has been absorbed, float the surfaces with a wood float and lightly trowel with a steel trowel to a smooth finish free from marks or irregularities. Finish exposed edges with a steel-edging tool. Remove forms and patch any defects in the concrete as required.

Cure concrete by preventing the loss of moisture for a period of 7 days. Accomplish with a membrane-forming curing compound. Apply the curing compound immediately after removal of forms or finishing of the slabs. Protect concrete from damage during the 7-day curing period.

6.37.2 Precast Units

Prior to placing precast units compact existing insitu soil and provide a layer of compacted bedding material.

6.37.3 Extensions

Extensions to be installed as per requirement. Lay risers in mortar with sides plumb and tops to grade. Joints shall be sealed with mortar, with interior and exterior troveled smooth. Prevent mortar from drying out and cure by applying a curing compound. Extensions shall be watertight.

6.37.4 Installation of Frames and Grates

Set frames and grates at elevations indicated or as determined in the field and in conformance with the design and Drawings. Frames may be cast in, or shall be set in mortar.

6.37.5 Cleaning

Upon completion, clean each structure of all silt, debris, and foreign matter.

6.37.6 Final Grades for Field Inlets

The final finish grades of top of grate on all storm water inlets and trench drains shall be adjusted to receive surface flows without pooling. No inlets will be acceptable if it protrudes above the finish-paving surface.

6.37.7 Installation of Flap Gate

Install flap gates at locations as per manufacturer's recommendations.

6.38 Earthwork

6.38.1 General

This section of the specifications includes requirements for accomplishing all earthworks including filling, anti-termite treatment, riprap and yard grading for this Contract.

6.38.2 Nature of the Ground

The Contractor shall judge for himself the nature of the ground and shall be fully responsible for ascertaining all necessary information concerning permanent water table period of rainfall, flooding of the site and all matters affecting the excavation & foundation work.

6.38.3 Earthwork Method

The Contractor shall not undertake any earthwork; including the operation of any borrow area or quarry, without having obtained the Employer’s prior approval to the methods which he proposes to employ. He shall not thereafter modify such methods without the consent of the Employer.

6.38.4 Correct Widths and Depths of Excavations

In the event of excavation being made larger than the sizes shown on the drawings, the Contractor shall fill in the excavated void to the correct profile with mass concrete as described under

specification for 'Plain and Reinforced Concrete' or other approved compacted material at his own expense.

6.38.5 Method of Excavation

Excavation may be carried out by machine or any other method approved by the Employer. In soil, excavations shall be taken to within 150 mm of the formation or foundation level and all subsequent excavation in any section must be carried out by hand not more than 24 hours before the commencement of construction in that section unless agreed otherwise by the Employer.

As soon as possible after inspection by the Employer, the bottom level of the excavation shall be sealed with blinding if specified and the required construction shall commence. No excavation for foundations shall be filled in or covered with concrete until the Contractor has notified the Employer that it is ready for inspection and has received sanction to proceed with the works. The Contractor shall give a minimum of 24 hours' notice of any inspection.

6.38.6 Shoring Excavations

The Contractor shall to the satisfaction of the Employer, shore the sides of the excavations for structures, trenches and pits to prevent them from slipping or falling. Should any slips, falls or settlement nevertheless occur they shall be made good by the Contractor at his own expense with selected fill or with mass concrete as may be directed by the Employer.

In removing shoring from the sides of excavations, care shall be taken to avoid loads on to any concrete until it has hardened sufficiently to carry such loads.

Timber or other materials used for shoring the sides of excavations shall be removed as the work proceeds except when ordered to be left in by the Employer.

The Contractor shall submit to the Employer for inspection calculations and working drawings for the proposed scheme of strutting and retaining the sides of the excavations not later than four weeks before commencing any excavations and shall not proceed with the appropriate section of the works until receipt of the Employer's written consent.

The receipt of such consent shall not relieve the Contractor of any of his duties and responsibilities under the Contract.

6.38.7 Staking

The earthwork operations comprise the establishment of layout plans and staking for the installations at the start of the work, in conformity with the construction plans. The general staking plan shall be submitted by the Contractor to the Employer for his approval before the start of the work. All of the topographical references as well as any other supplementary references which are deemed necessary for proper execution of the work shall be marked out on the drawings and established on the ground by visible and stable landmarks.

Additional supplementary staking shall be established as may be necessary for horizontal and vertical reference points subject to approval by the Employer.

The Employer reserves the right to make changes in grade to suit developed conditions.

6.38.8 Filling & Backfilling Generally

During compaction the backfill as specified in **Clauses 6.38.9 & 6.38.10** below shall have uniform moisture content within 2% of the optimum for the compaction plant employed or as may be directed by the Employer after tests. Where necessary the Contractor shall adjust the moisture content of the backfill material either by drying out or by adding water. After such drying out or adding of water, the backfill shall be thoroughly mixed until the moisture content is uniform. Should the material being placed as filling or as backfilling while acceptable at the time of selection, become unacceptable to the Employer due to exposure to weather conditions or due to flooding or have become puddled, soft or segregated during the process of the works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material.

When placing the filling or backfilling the Contractor shall make due allowance for any settlement that may occur before the end of the Period of Maintenance remove any excess material or make up any deficiency of backfilling to the specified levels.

6.38.9 Backfilling with Excavated Material

Foundation trenches, column bases and the like may be backfilled with selected excavated material if approved by the Employer, these being well rammed and consolidated by hand or compacted by an approved vibratory 5 ton roller or other approved vibratory equipment to the satisfaction of the Employer in layers not exceeding 150 mm thick, to achieve a dry density not less than the maximum dry density obtained as per IS 2720 (Part 8).

6.38.10 Selected Granular Fill

Where directed by the Employer or where the drawings indicate the use of selected granular fill, this shall comprise well graded non-plastic granular material, placed in layers not exceeding 150 mm. Each layer being well compacted by an approved vibratory 5 ton roller or other approved vibratory equipment before the next layer is placed. The density after compaction shall not be less than the maximum dry density obtained as per IS 2720 (Part 8).

Selected granular fill shall be obtained from an approved source and shall comply with **Clause 6.38.11** below.

6.38.11 Suitable Material

i) It shall be the responsibility of the Contractor to locate suitable material and carry out such tests as the Employer may require demonstrating the suitability of the fill to be supplied.

ii) The fill shall have minimum stone 75 mm, liquid limit not exceeding 25% and plasticity index not exceeding 6. Total water soluble salts shall not exceed 3%.

iii) Material shall have a CBR not less than 30% at 95% maximum dry density.

6.38.12 Hardcore Under Building Floor

Hardcore shall unless otherwise directed consist of gravels/crushed stone of 50 mm size and shall be free from dust, soil, rubbish, wood and other deleterious matter and shall be to the approval of the Employer. Approved hardcore materials shall be spread uniformly over prepared subgrade and packed properly, with interstices filled with sand. The hardcore shall then be compacted by suitable mechanical compactor to the satisfaction of the Employer. Top of the hardcore shall be flushed with sand to have smooth and curve surface for placing of polythene sheets.

6.38.13 Underwater Placement of Fill Material

The method of operation for underwater placement of material obtained from borrow locations, duly approved by the Employer is subject to the approval by the Employer. The methods of fill placement shall be designed so as not to result in any detrimental pollution of the waterway.

6.38.14 Compaction

Compaction methods and layers shall be submitted to the Employer for approval.

Compactions shall be performed with approved vibratory compaction equipment well suited to the soil being compacted. Material shall be moistured or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction. Finished slope fill shall be stable before placing slope protection.

6.38.15 Tolerance

After installation and compaction of fill and backfills the levelling tolerances will be as follows:

- 2 cm from the levels indicated on the drawings
- ½ % on any plane

On slope or vertical tolerance of ±10 cm at any point will be permitted before placing slope protection.

If these tolerances are not achieved the works will be corrected to the Employer's satisfaction at the Contractor's expenses.

6.38.16 Trimming of Slopes

The slopes of cuttings & embankments shall be trimmed by hand or by approved mechanical means to uniform batters as directed by the Employer.

Any rock or boulder appearing in the face of a cutting shall be trimmed back to within the tolerance specified above and in addition any such rock or boulder which in the opinion of the Employer is unstable shall be completely removed and the resulting void filled with compacted material with the approval of the Employer.

6.38.17 Draining of Excavation

All excavations shall be kept free of water at all times and the Contractor shall provide efficient appliances and drains for dealing with water to the satisfaction of the Employer.

Particular care shall be taken to keep dry, rock and other surfaces against or upon which concrete may be deposited and proper precautions shall be taken to prevent the leaching out of cement or otherwise damaging unset concrete.

6.38.18 Existing Levels

Before work commences at the site the Contractor shall agree to the existing ground levels with the Employer.

6.38.19 Disposal of Surplus Excavated Material

Subject to provision of this specification all materials arising from site clearance which are surplus or unsuitable for use in the Works shall become the property of the Contractor and shall be disposed of by him either off the site or to an approved tip off of if agreed by the Employer on the Site in an approved manner.

The Contractor shall propose two sites for disposal of unsuitable or surplus material, one of which shall be specified as having priority and which must be filled before the second is used, together with a separate location where hard debris, such as concrete, kerbing etc. shall be disposed of. The Contractor shall seek approval for all nominated sites from the concerned local authority before work commences.

6.38.20 Trench Excavation

The Contractor shall execute to the required alignment and depth separate trenches unless otherwise indicated, for each utility run. The trench shall be sufficiently wide for the proper laying of the utility and shall be excavated to a depth that provides necessary cover.

The bottom of all trenches may be over excavated to a minimum of 15 cm to allow for bedding material. Condition in the trench shall be such that connections can be accomplished without getting mud, silt, gravel or other materials to the joint. The trench shall be adequately dewatered before laying bedding.

The bottom of utility trenches shall be graded to secure the required slope and tamped as necessary to provide a firm bed. Backfilling in the trenches shall be well compacted to the satisfaction of the Employer.

When trench excavation is required across existing surfaced roads as well used tracks, the Contractor shall provide and maintain a suitable graded diversion complete with adequate signs, all to the satisfaction of the Employer. Such excavations shall be backfilled in accordance with **Clause 6.38.8 & 6.38.9**, Where road has a sealed surface this shall be replaced after the backfill has been suitably consolidated to the satisfaction of the Employer and approved.

6.38.21 Protection of Services

The Contractor shall ascertain for himself the location of all permanent main services, and shall maintain and protect these where affected by the works and shall in no way interfere with these permanent services without receiving the written permission of the Employer.

6.38.22 Trenches not to be Left Open

Trench excavations shall be carried out expeditiously and subject to any specified requirements of the Contract, the backfilling and surface reinstatement of the trench shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and joined.

6.38.23 Polythene Sheeting

Polythene sheeting where necessary shall be of 1000 gauge and of approved manufacture supplied in rolls and laid by rolling over the prepared base at the levels and in the areas shown on the drawings. Where a joint is necessary at the side or at the end of a sheet, this shall be double welt folded joint made by placing the edges together & folding over twice. The joint shall be prevented from opening prior to concreting by blocks placed at intervals on top of the joints.

The Contractor shall protect the sheets from damage during laying and subsequent operations and shall replace all damaged sheets to the satisfaction of the Employer.

6.38.24 Anti-Termite Treatment

The treatment shall be carried out by an approved specialist sub-contractor. The chemicals used shall conform to IS:8944.

6.38.25 Treatment to Soil Under Slabs at Plinth Level & Ground Floor

After earth filling and before the dry rubble or core packing, the centre surface of the filled earth will be treated with a chemical emulsion recommended by the specialist sub-contractor at the rate specified by the manufacturer. Light rodding shall be done to facilitate spraying and absorption.

6.38.26 Treatment to Junction of Wall & Floors

Rodding to be carried out along the junction of plinth beams and earth filling at 15 cm intervals and recommended chemical emulsion sprayed at the rate of 2 litres per linear meter so as to mix intimately with the soil.

Clause 6.38.25 & **6.38.26** shall be carried out simultaneously to establish the chemical barrier.

6.38.27 Treatment to Soil along the External Wall Perimeter

After levelling and before flagging or plinth protection is laid, soil along the external wall perimeter of the building upto a depth of 30 cm shall be treated at the rate of 4.5 litres emulsion per linear meter of plinth walls. If necessary, rodding at 30 cm intervals shall be carried out to facilitate spraying and absorption.

6.38.28 Treatment of Critical Areas

Soils under piers, utility pipe openings, floor drains, electrical conduit entry joints shall be thoroughly flooded with the chemical emulsion at an approximate rate of 25 to 30 litres per square meter. If drainage pipes are laid along the walls and the chemical barrier laid as per paragraph **6.38.26** is disturbed/broken, additional treatment to such areas will be necessary.

6.38.29 Guarantee for 5 Years

The specialist agency shall provide a guarantee that buildings shall be free from termite infestation for a period of 5 years from the expiry of defects liability period.

6.38.30 Precautions

Precautions shall be taken not to disturb the treated areas by levelling, digging or earth filling, as this will break the chemical barrier. In case such situation arises, the area is to be treated again to restore the chemical barrier.

6.39 Brick Masonry Works

6.39.1 General

This specification establishes the materials, dressing, laying, joining, curing, workmanship etc. for brick masonry works. Brick masonry shall also comply with all the requirements of IS:2212.

6.39.2 Materials

Refer specifications under ‘Materials’.

6.39.3 Cement Mortar

Cement mortar shall meet the requirements of IS:2250 and shall be prepared by mixing cement and sand by volume. Proportion of cement and sand shall be 1:6 (1 part of cement and 6 parts of sand), or as directed by the Employer for brick masonry of one brick thickness or more, while 1:4 cement mortar (1 part of cement and 4 parts of sand) shall be used for brick masonry of half brick thickness. The sand being used for mortar shall be sieved. The mortar shall be used as soon as possible after mixing and before it has begun to set and in any case within initial setting time of cement after water is added to the dry mixture. Mortar unused for more than initial setting time of cement, shall be rejected and removed from the site of work.

6.39.4 Proportioning

The unit of measurement for cement shall be a bag of cement weighing 50 kg and this shall be taken as 0.035 cubic metre. Sand shall be measured in boxes of suitable size on the basis of its dry volume. In case of damp sand, its quantity shall be increased suitably to allow for bulkage.

6.39.5 Mixing

The mixing of mortar shall be done in a mechanical mixer operated manually or by power. The Employer may, however, permit band-mixing as a special case, taking into account the magnitude, nature and location of work. The Contractor shall take the prior permission of Employer, in writing, for using hand-mixing before the commencement of work.

6.39.6 Mixing in Mechanical Mixer

Cement and sand in specified proportions, by volume, shall be thoroughly mixed dry in a mixer. Water shall then be added gradually and wet mixing continued for at least one minute. Care shall be taken not to add more water than that which shall bring the mortar to the consistency of stiff paste. Wet mix from the mixer shall be unloaded on water-tight masonry platform, made adjacent to the mixer. Platform shall be at least 150 mm above the levelled ground to avoid contact of surrounding earth with the mix. Size of the platform shall be such that it shall extend at least 300mm all-round the loaded wet mix area. Wet mix, so prepared, shall be utilised within initial setting time (thirty (30) minutes for ordinary Portland cement conforming to IS:269 after addition of water. Mixer shall be cleaned with water each time before suspending the work.

6.39.7 Hand Mixing

The measured quantity of sand shall be levelled on a clean water-tight masonry platform and cement bags emptied on top. The cement and sand shall be thoroughly mixed dry by being turned over and over, backward and forward, several times till the mixture is of uniform colour. The quantity of dry mix, which can be consumed within initial setting time of cement shall then be mixed with just sufficient quantity of water to bring the mortar to the consistency of stiff paste.

6.40 Construction Procedure

6.40.1 Soaking of Bricks

Bricks shall be soaked in water before use for a period that is sufficient for the water to just penetrate the whole depth of bricks as well as to remove dirt, dust and sand. Proper soaking of bricks shall prevent the suction of water from the wet mortar, as otherwise mortar will dry out soon and crumble before attaining any strength. The bricks shall not be too wet at the time of use as they are likely to

slip on mortar bed and there will be difficulty in achieving the plumbness of wall as well as proper adhesion of bricks to mortar. The period of soaking shall be determined at site by a field test by immersing the bricks in water for different periods and then breaking the bricks to find the extent of water penetration. The least period that corresponds to complete soaking, will be the one, to be allowed for in the construction work.

The soaked bricks shall be removed from the tank, sufficient early, so that at the time of laying, they are skin dry. The soaked bricks shall be stacked over a clean place, wooden planks or masonry platforms to avoid earth, dirt being smeared on them.

6.40.2 Laying

Brick Work (one or more brick thickness)

Brick work (one or more brick thickness) shall be laid in English Bond unless otherwise specified. Half or cut bricks shall not be used except when needed to complete the bond. In no case the defective bricks shall be used.

A layer of average thickness of 10mm of cement mortar shall be spread on full width over a suitable length of lower course or the concrete surface. In order to check and achieve uniformity in masonry, the thickness of bed joints shall be such that four courses and three joints taken consecutively shall measure equal to four times the actual thickness of the brick plus 30mm. Each brick with frog upward, shall be properly bedded and set in position by gently tapping will) handle of trowel or wooden mallet. Its inside faces shall be buttered with mortar before the next brick is laid and pressed against it. After completion of the course, all vertical joint shall be filled from top with mortar.

All brick courses shall be taken up truly plumb; if battered, the batter is to be truly maintained. All courses shall be laid truly horizontal and vertical joints shall be truly vertical. The level and verticality of work in walls shall be checked up at every 1 m interval.

The masonry walls of structures shall be carried up progressively, the brick work shall be raked back according to bond (and not left toothed) at an angle not more than 45 degrees but raking back shall not start within 60 cm of a corner. In all cases returns, buttresses, counter forts, pillars etc. shall be built up carefully course by course, and properly bonded with the main walls. The brick work shall not be raised more than fourteen (14) courses per day.

At the junction of any two walls, the bricks shall at each alternate course, be carried into each of the respective walls so as to thoroughly unite the work.

The courses at the top of plinth and sills, at the top of the wall just below the soffit of the roof slab or roof beam and at the top of the parapet, shall be laid with bricks on edge. Brick on edge course shall be so arranged as to tightly fit under the soffit of the roof beam or roof slab, restricting the mortar layer thickness upto 12mm, however, any gap between the finished brick work and soffit of roof slab /beam shall be suitably sealed with the mortar.

Brick Work (half brick thickness)

For brick walls of half brick thickness, all courses shall be laid with stretchers. Wall shall be reinforced with 2 nos. - 6mm diameter mild steel reinforcement bars, placed at every fourth course. The reinforcement bars, shall be straightened and thoroughly cleaned. Half the mortar thickness for the bedding joint shall be laid first and mild steel reinforcement, one on each face of the wall, shall be embedded, keeping a side cover of 12mm mortar. Subsequently, the other half of the mortar thickness shall be laid over the reinforcement covering it fully.

The reinforcement bars shall be carried at least 150mm into the adjoining walls or RCC columns. In case the adjoining wall being of half brick thickness, the length of bars shall be achieved by bending the bars in plan. During casting of reinforced concrete columns, 6mm dia. M.S. reinforcing bar shall be placed at every fourth course of brick masonry. At the junction of two walls, the brick shall, at each alternate course, be carried into each of the respective walls so as to thoroughly unite the work. The brick masonry work shall not be raised more than 14 courses per day.

Brick course under the soffit of beam or slab, shall be laid by restricting the mortar thickness to 12mm. However, any gap between the finished brickwork and soffit of slab/beam, shall be suitably sealed with the mortar.

Cavity Walls

Brick work in cavity walls shall be included with general brickwork. It shall consist of one wall of one or more brick thickness while the other wall shall be of half brick thickness at a clear gap of 50mm. The brick work on either side of cavity shall conform to the specifications already stated above. At the base of the cavity wall, the walls shall be solidly constructed upto 300mm above the ground level. The cavity wall shall be terminated 300mm below the soffit of roof slab/beam and the courses over this shall be continued in solid brickwork.

Cavity should be continuous and free from obstructions. Mortar droppings shall be prevented from falling down the cavity by the use of laths or by hayhands which shall be drawn up the cavity as the work proceeds. Any mortar which may unavoidably fall on the wall-ties, shall be removed daily and temporary openings shall be provided to permit the daily removal of mortar droppings from the bottom of the cavity.

The outer and inner leaves shall be tied by means of wall ties. Ties shall be of mild steel round bars of 8mm dia. 200 long with hooks at both the ends. These shall be placed not more than 750mm c/c horizontally and not more than 300mm vertically, and staggered. Additional ties shall be provided near the openings. There shall at least, be 5 ties per square metre of surface area of the wall. Ties shall be given a bituminous coat before placement, to protect them from corrosion.

In order to keep the cavity dry, air slots shall be provided in the cavity walls at bottom as well as top to the extent of 50 sq.cm area of vents to every 2.0 sq. metre area of the wall.

Circular Brick Work

The detailed specification for brick work covered in above subclause shall apply, in so far as these are applicable. Bricks forming skew backs, shall be dressed or cut so as to give proper radial bearing. Defects in dressing of bricks shall not be covered up by extravagant use of mortar, nor shall the use of chips etc, be permitted.

The circular brick work shall be carried up from both ends simultaneously and keyed in the centre. The bricks shall be flushed with mortar and well pressed into their positions so as to squeeze out a part of their mortar and leave the joints thin and compact. All joints shall be full of mortar and thickness of joints shall be between 5mm and 15mm.

6.40.3 Jointing

Joints shall be restricted to a width of 10mm with brickwork of any classification. All bed joints shall be normal to the pressure upon them i.e. horizontal in vertical walls, radial in circular brick masonry and at right angles to the face in the battered retaining walls. The vertical joints in alternate courses shall come directly one over the other and shall be truly vertical. Care shall be taken that all the joints are full of mortar, well flushed up. In case no pointing is to be done, cement mortar shall be neatly struck

as the work proceeds. The joints in faces which are to be plastered or pointed shall be squarely raked out to a depth of 12mm while the mortar is still green. The rake joints shall be brushed to remove loose particles. After the day's work, the faces of the brick work shall be cleaned on the same day with wire brush and all mortar droppings removed.

6.40.4 Curing

Green work shall be protected from rain or any other running water or accumulated water from any source, by suitable means. Masonry work, as it progresses, shall be kept thoroughly wet by sprinkling water at regular intervals, on all faces. Curing shall be done after 24 hours of completion of day's work and shall be done for atleast 10 days after completion. Proper watering cans with spray nozzles, rubber or PVC pipes shall be used for this purpose.

6.40.5 Staging / Scaffolding

Staging/scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. Design of staging/scaffolding shall be submitted for approval of the Employer, before commencement of work.

Single scaffolding having one set of vertical support, shall be used and other end of the horizontal scaffolding member shall rest in a hole provided in the header course. The support shall be sound and strongly clamped with the horizontal pieces over which the scaffolding planks shall be fixed. The holes left in the masonry work for supporting the scaffolding shall be filled and made good with plain cement concreteof grade 1:3:6 during plastering. Suitable access shall be provided to the working platform area. The scaffolding shall be strong enough to withstand all loads likely to come upon it and shall also meet the requirements specified in IS:2750.

Double scaffolding shall be provided for pillars less than one metre in width or for the first class masonry or for a building having more than two storeys.

The following measures shall also be considered during erection of the scaffolding/staging.

(a) Sufficient sills or underpinnings, in addition to base plates, shall be provided, particularly, where scaffoldings are erected on soft grounds.

(b) Adjustable bases to compensate for uneven ground shall be used.

(c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

(d) Horizontal braces shall be provided to prevent the scaffolding from rocking.

(e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

(f) The scaffolding/staging shall be checked at every stage for plumb line.

(g) Wherever the scaffolding/staging is found to be out of plumb line, it shall be dismantled and re-erected afresh. Efforts shall not be made to bring it in line with a physical force.

(h) All nuts and bolts shall be the clamps/couplings are firmly tightened to avoid slippage.

(i) Erection work of a scaffolding/staging, under no circumstance shall be left totally to semiskilled or skilled workmen and shall be carried out under the supervision of Contractor's technically qualified civil Employer.

For smaller works or works in remote areas wooden ballies may be permitted for scaffolding/staging by the Employer at his sole discretion.

6.40.6 Embedment of Fixtures

All fixtures, pipes, conduits, holdfasts of doors and windows etc. required to be built in walls, shall be embedded in plain cement concrete block of grade 1:3:6, at the required positions, as the work proceeds.

6.40.7 Compressible Joint Fillers

Soft board shall be used where specified at joints requested by the Employer. Filler shall be cut to exact widths and shall have all edges neatly trimmed. Fixing of filer shall be strictly in accordance with the manufacturer's printed instructions.

6.40.8 Polysulphide Sealant for Joints

Polysulphide joint sealer or other equal and approved shall be used. Application shall be strictly in accordance with the manufacturer's instructions.

6.40.9 Galvanised Mild Steel Butterfly Wall Ties

For all vertical joints between brick work and concrete galvanised mild steel butterfly pattern wall ties are to be cast in concrete at 400 mm vertical spacing and then built into the mortar bed joints of the wall.

Where specified, both skins of cavity walls are to be built in brickwall, the skins shall be tied together with galvanised mild steel butterfly pattern wall ties and spaced at the rate of one every 600 mm horizontally and 400 mm vertically, staggered every 400 mm verticaly at ends jambs and quoins.

6.41 Structural Steel Work

6.41.1 General

This section includes requirements of all structural steel work required for the completion of the Works, as shown on the drawings and as specified herein.

All structural steel used by the Contractor for the construction shall conform to relevant IS codes or equivalent as approved by the Employer and described in this specifications. If deviation or a substitution of material is sought, the Contractor shall submit written request to Employer along with necessary supporting documents including test results, manufacturer's certificate, etc. along with reasonable time for evaluation without disruption of the construction schedule. It shall be the Contractor's responsibility to satisfy the Employer that his proposed deviation or substitution will in no way be detrimental to the quality of the works intended in the Contract. In case of any doubt the Employer may ask for additional information, testing or retesting which the Employer may feel necessary, which the Contractor shall carry out to the Employer satisfaction and with no impact on the construction schedule.

It shall be noted that site fabrication and painting of steel members shall not be allowed. The Contractor has to make his arrangements accordingly.

6.41.2 Structural Steel

i) Steel Grades

Unless otherwise stated all steel shall conform to one of the following grades.

(a) Carbon Steel : ASTM A 36 or approved equivalent (Fee=36 Ksi) IS 2062 Gr A

(b) Intermediate strength steel : BS 7191 Gr 355D, API Spec.2 H Gr 50 or

APPROVED EQUIVALENT (FY=50kSI)

Steel supply to specifications equivalent to those listed above shall be considered as substitution and shall require written approval by Employer to this effect.

ii) Structural Steel Types

Rolled Shapes and Plates

All rolled shapes and plates shall be carbon steel grades as defined and unless otherwise specified.

a. Tubulars

All Tubulars shall be fabricated in accordance with API Spec. 2B, from plates which should conform to one of the steel grades indicated in clause (i) above.

Mill - manufactured line pipes, where acceptable shall be of prime quality and shall conform to API 5L Gr. B or equivalent, seamless.

The use of spirally welded and electric resistance welded pipes shall not be permitted for any load bearing structural member.

i) Usage

The usage of different grades of steels shall be as determined by design. For jacket type structures (if used by Contractor), the guidelines of API RP 2A shall be followed for material usage.

ii) General Requirements

a. Process

The steel shall be manufactured by the basic open hearth, electric furnace or basic oxygen process. No rimmed or capped steel shall be used.

b. Delivery, Storage and Handling

All rolled shapes and plates are to be delivered in accordance with ASTM A6, "Standard Specifications for General Requirement for Rolled Plates, Shapes sheet piling and bars for structural use".

Fabricated Tubulars shall conform to the dimensional tolerances of API Spec. 2B, "Specifications for Fabricated Structural Steel Pipe".

For mill manufactured pipes, where permitted for use, dimensional tolerances of API Spec. 5L, "Specification for Line Pipe", shall apply with additional requirements for straightness listed in API Spec. 2B.

All structural steel shall be stored and covered in a manner which will ensure that no damage shall occur to it from moisture, dirt, grease or any other cause which might impair bond with concrete.

a. Identification

A sufficient supply of approved structural steel shall be stored at the site at all times to ensure that there will be no delay of the work.

Steel will be reasonably free from defects, mill scale and rust.

Structural steel shall be bundled and tagged with grades, size and suitable identification mark for checking, sorting and placing size and mark numbers. Tags and markings shall be waterproof and shall not be removed until steel is placed.

b. Mill Tests

All mandatory inspection and testing listed in ASTM A6, "Standard Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet piling, and Bars for Structural Use", shall apply.

Supplementary inspection and tests when specified in individual specifications shall also apply.

In addition to above for all steel materials the following are mandatory requirements:

Product Analysis : One sample per heat. Acceptability standards as specified in ASTM designation A6 shall apply for all elements.

In addition, a field weldability test shall be performed in accordance with the requirements of relevant IS codes or equivalent with a heat input of 15–20 kj/cm and the results of the test shall meet the requirements specified for the base material. This requirement shall be a prerequisite for the acceptance of the material.

c. Mill Certificates

Contractor shall supply the Employer with a certificate indicating the process of manufacture, results of chemical and mechanical tests including specified supplementary tests for the material. Each test certificate shall bear the heat number and other identifidation marks such that the same can be correlated with the material. These certificates shall be signed by manufacturer’s representative and furnished alongwith material.

When any steel is supplied from stock, the Contractor shall satisfy the Employer that the steel has been manufactured and tested and complies with all the tests and requirements of the specification under which the steel is being furnished with necessary documentary proof of original manufacturers. The heat numbers on mill certificates should be correlated with markings on the material. Steel material without acceptable mill certificate shall not be used.

i. Special Requirements

a. Carbon Steel

All carbon steel material shall meet the following:
Max. Carbon (Cmax) = 0.22%
Max. Carbon Equivalent (CE) = 0.45
(For CE formula refer 2.5.2)

b. Intermediate Strength Steel

The carbon equivalent shall be a maximum of 0.43 (ladle analysis) as determined from the following formula:

$$CE = C + \frac{Cr + Mo + v}{5} + \frac{Cu + Ni}{15} + \frac{Mn}{6}$$

V less than or equal to 0.08%
Nb less than or equal to 0.05%
V+Nb less than or equal to 0.10%.

ii. Other Requirements

All plates shall be ultrasonically inspected for defects and discontinuities in accordance with ASTM A578. Acceptance Standard shall be level II.

If intended to use plates having defects requiring repair for welding procedure qualification, these plates shall be shipped clearly marked "For Welding Procedure Qualification Only".

iii. Heat Treatment

Heat Treatment shall be performed on all elements where properties have been degraded by forming and fabrication.

The use of furnaces is desirable for all heat treatments. When local heat treatments are deemed necessary, a detailed procedure shall be submitted to the Employer for approval prior to performing such heat treatments.

a. Stress Relief

Stress relief heat treatment shall be performed on all materials subject to the following conditions:

- Elements subjected to press or roll forming where the temperature of the steel is above 38° C or less than 427° C during the forming operation.
- Elements subjected to press or roll forming where the outer fibre strain exceeds five (5) percent as defined by the formula.

$$\text{Percent Strain} = \frac{100\ t}{D}$$

Where t = thickness of element
D = outside diameter

Welded assemblies containing one or more elements with the thickness exceeding 65 mm.

a) Stress Relief Temperatures

All stress relief shall be achieved by thermal methods by heating the element or assembly to a temperature between 590°C to 620°C for carbon steel and intermediate strength steel.

6.41.3 Quality Control

The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. Materials or workmanship shall meet with the provisions of specifications and approval of Employer.

Before start of work, Contractor shall submit a detailed quality control plan of fabrication and erection for Employer's approval. Such QC plan shall include inter alia, the welding process proposed, type of electrodes to be used, acceptable criteria to be used for error in erection etc.

The quality control procedure/operations shall cover but not be limited to the following items of work:

- Bolts, Nuts and Washers: Manufacturer's, certificate, dimension checks, material testing
- Electrodes: Manufacturer's certificate, thickness and quality of flux coating
- Welders: Qualifying Tests
- Welding Sets: Performance Tests
- Paints: Manufacturer's certificate, physical inspection reports regarding quality of paints, primers & thinners.
- Erection: Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.
- Grouting: Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency and strength of grout.
- Painting: Preparation of surface for painting, application and uniformity of coats.

6.41.4 Fabrication

The Contractor shall prepare detailed drawings giving complete information necessary for the fabrication of the steel works. All information should be clearly given and the drawings shall be in conformity with the best modern practice. A marking diagram allotting distinct identification marks to each separate piece of steel work shall be prepared in sufficient detail to ensure convenient assembly and erection. Symbols for welding used on the drawings shall be in accordance with IS:813 "Scheme of Symbols for Welding".

The Contractor shall prepare comprehensive bill of material sheets for each shop drawing giving therein all the items shown on the drawings together with their weights, mark numbers, cutting lengths, etc.

All fabrication shall be in accordance with IS:800 "Code of Practice for use of Structural Steel in General Building Construction".

6.41.5 Welding

Metal arc process shall be used for welding in all cases, unless otherwise specified by the Employer. The welding procedure shall be in accordance with the requirements of IS:816 "Code of Practice for Use of Metal Arc Welding for General Constructions in Mild Steel". The symbols for welding as shown on the drawings will be interpreted in accordance with IS:813.

Electrodes used for hand welding or for automatic welding machine shall conform to IS:814 "Covered Electrodes for Metal Arc Welding of Structural Steel".

6.41.6 Galvanising

Galvanising where specified shall be of the best quality conforming to IS:2629 "Recommended Practice for Hot Dip Galvanising of iron and Steel".

6.41.7 Installation

Install in locations shown, as indicated on Contractor's drawings, to line, plumb, and level, rigidly attached in placed with all connections to other work neatly made and drawing up tight. Joints caulked to provide weather-proof installation. Erection equipment shall be suitable and safe for the workmen. Errors in shop fabrication or deformations resulting from handling and transportation that prevent the proper assembly and fitting of parts shall be reported immediately to the Employer and approval of the method of correction shall be obtained.

Anchor bolts and anchors shall be properly located. After assembly the various parts of a completed frame or structure shall be aligned and adjusted accurately before being fastened. As erection progresses, the work shall be accurate fastened to take care of all dead loads, wind and erection stresses. Unless removal is required all erection bolts used in welded construction may be tightened securely and left in place. Drilling may be used in such a manner as not to distort or damage the metal. The use of gas-cutting torches in the field for connecting fabrication errors will not be permitted on any major member of the structural framing.

6.41.8 Bolting

Bolts shall be driven accurately in holes without damaging the thread. Bolt heads shall be protected from damage during driving. Bolt heads and nuts shall rest squarely against the metal. Where bolts are to be used on bevelled surfaces, bevelled washers shall be provided to give full bearing to the head or nut.

6.41.9 Shop Painting

Paint all surfaces, except those to be embedded in concrete with exterior ferrous metal primer on properly prepared surfaces, as specified under 'Painting'. Surfaces which will be embedded in concrete shall not be painted but shall be cleaned as required for painting.

6.41.10 Inspection & Testing

The Contractor shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Employer to carry out inspection and/or tests in accordance with the Contract.

The Contractor shall guarantee compliance with the provisions of this specification.

The Contractor shall carry out sampling and testing in accordance with the relevant British Standards or equivalent as directed by the Employer, unless otherwise specified in the Contract. The Contractor shall get the specimens tested in a laboratory approved by the Employer and submit to Employer the test results in triplicate within 3 (three) days after completion of the test.

6.42 Steel /Aluminium Doors, Windows and Ventilators

6.42.1 General

This section of the specification includes the requirements necessary to provide in place all steel / Aluminium doors, windows and ventilators conforming to the codes referred in **Section 2 of Volume-II.**

6.42.2 Pressed Steel Door/Window/Ventilator Frame

Pressed steel door/window/ventilator frame shall confirm to IS:4351.

The frames shall be made of 16gauge pressed steel bent to shape using bending machine, and mitred with square edges. The frames shall be provided with spacers by welding 50 mm x 5 mm flats to the portion of the frame in contact with the wall jambs @ 600 mm vertical spacing.

The frame shall be fixed to the masonry by means of 300 mm x 25mm x 6mm hold fast welded to the spacers and grouted with M-20 grade concrete in minimum 350 mm x 100 mm x 100 mm sized hole in the masonry.

In case of concrete, the frames shall be fixed by 96 mm long, 12 mm dia metallic counter sunk type dash fasteners through the frame and spacers.

Provisions for hinges, locking arrangement and other hardwares shall be provided in the frames by machine cutting required size cutout on the frame body and welded / screwed to 3 mm thick M.S. pad plates-already welded over the cut out from behind.

The frame surface shall be thoroughly cleaned of rust, mill scale, dirt, oil etc. and then finished with painting (by priming with red oxide zinc chromate primer conforming to 1S:2074 and painting on forming to 1S:1477 Part (II) or by approved shade electrostatic powder coating (25 micron).

6.42.3 Pressed Steel Door Shutter

Pressed steel shutters shall be hollow type with 18gauge pressed steel welded at meeting of the sheets with pad plate of M.S flat 3 mm thick all along perimeter. The cavity shall be packed with rigid phenolic foam board adequately cut into shape to fully fit into the box cavity without gaps.

The shutter shall be formed by machine bending of 18 gauge (as specified in item) pressed steel sheet in form of hollow box making an overall thickness of 40mm forming truly square edge in accordance with the shutter profile. It shall further be braced with channel shaped horizontal stiffeners formed by folding 16 gauge MS sheets (35mm wide) @ 500 mm max. And fixed by flush riveting. 3mm thick M.S. pad plates shall be welded inside at required locations for fixing of hardwares such as tower bolt, aldrop etc.

For double shutter doors, an M.S. angle 25mm x 45mm x 3 mm thick shall be welded to one of the shutters providing a minimum 25mm wide rebate for the other shutter at the meeting point during closed condition.

The shutter surfaces shall be painted with electrostatically powder coating/two coats of synthetic enamel paint over a priming coat of red oxide zinc chromate conforming to IS 2074/IS 1477 (Part-11). The shutters shall be fixed to the door frame by means of heavy duty MS butt hinges of 150mm size conforming to table 6 of IS 1341 @ 600mm max.

In case of air tight door shutters, approved quality continuous neoprene rubber beading shall be provided continuously along the door frame rebate fixed with neoprene rubber adhesive of approved make.

In case of partly glazed door shutter. Glassas specified shall be fixed with glazing clips and solid drawn 10 mm x 10 mm, MS beading backed with putty and fixed by countersunk screws. Necessary rebate for fixing the glass shall be provided by arranging the shutter bracing accordingly.

The shutters shall be provided with locking device, handles and other hardwares as specified.

6.42.4 Steel Windows & Ventilator

Steel windows, ventilators shall in general conform to IS 1081, IS 1038, IS 7452.

Rolled steel sections for the fabrication of steel windows, ventilators shall conform to IS 7452.

Glass Panes

Glass panes for glazing purpose shallbe as specified in item description. All glass panes shall have property squared corners and straight edges. Glass panes shall be of following types in accordance with item description :

i) 4 mm thick transparent sheet glass conforming to IS 2835 (wt. 7.2 kg/m)

ii) 5.5 mm thick wired glass conforming to IS 5437.

iii) 6.3 mm thick laminated safety glass conforming to IS 2553.

Workmanship

The profile and type of windows, ventilators (glazed, partly glazed/louvered, side hung/top hung/fixed shutter, composite) shall be as per Contractor's drawings.

The frames shall be fabricated of sections cut to size and metered. Corners shall be welded to form a fused welded joint. Process of welding shall be flash butt welding. The welded joints shall be grinded to square and flat edges.

Where larger units are to be formed by coupling individual units, the mullions, transoms shall be bedded in mastic to ensure weather tightness. Mastic shall be applied liberally to the channels of the outside frame sections before assembly, and the two units being coupled shall be drawn together tight with clamps, the mastic being squeezed out and cut off neatly when the units shall be screwed together tight.

Where fixed glazing units are placed over openable units a push fit weather bar shall be provided.

Before glazing, all opening parts shall be checked for their operational smoothness. The frame shall be completely cleaned and bedding putty shall be placed in the rebate before glazing. Glass then shall be cushioned into the bedding and shall be fronted with front putty in a manner so as to enable the painting to be done upto the sight line. The back putty oozing out over the glazing rebate shall be cut off square and smoothed down.

For panes exceeding 600 x 300 mm in size, glass shall be secured by special glazing clips inserted in holes already provided in the steel sections, before applying the front putty.

For glazing of very large areas, rust proof steel beading with metered corners shall be provided with screws @ 10 cm. from each corner and @ 20 cm. apart from each other. Putty shall be provided to the face of the bead in contact with glass, in addition to back putty.

Side hung shutters shall be connected to the frame by means of friction hinges. The handle for side hung shutters shall be of pressed brass mounted on a steel handle plate welded to the opening shutter frame and shall not be removable easily after glazing. The handle shall have a two point nose which shall engage with a brass striking plate on the fixed frame in a slightly openas well as in a fixed position.

Top hung shutters shall be provided with steel butt hinges welded to the fixed frame after cutting a slot in it. Top hung casements shall be provided with peg stay of 3 holes of pressed brass, 300 mm long

which when closed shall be held tightly by the locking bracket fitted to the fixed frame or to the window.

Before fixing the frames, the size of the opening shall first be checked and cleaned of all obstructions. The positions of the unit in the reveal shall be taken off and shall be marked on the reveal at the jambs using a plumb line. In case of fixing with masonry, holes for fixing the lugs/hold fasts shall be cut at required locations. In case of concrete or stone, the frames shall be fixed by means of dash fasteners. In case of masonry, the lugs shall be grouted in the holes with cement concrete, M-15 Grade when fixing to steel work, mastic shall be applied to the sill of the opening and the unit shall be placed on it with the jambs and head buttered with mastic and the unit shall be fixed with special fixing dips or with nuts and bolts.

The windows/ventilators shall be checked to ensure smooth operation, perfect level and plumb.

All the steel surfaces shall be thoroughly cleaned free of rust, mill scale, dirt, off etc. by sand and shot blasting and then finished with painting by priming with red oxide zinc chromate primer conforming to IS 2074 and painting conforming to IS 1477 (Part II) or by hot dippedgalvanizing confonning to IS 1477 Part (I). Putty shall also be provided with painting in a manner so as to seal the putty glass junction. Surfaces not meant for painting shall be cleaned of any strains of paint.

6.42.5 Rolling Shutters

6.42.5.1 General

Rolling shutters shall be of best quality conforming to IS 6248 - 1979 and obtained from approved make. These shall include necessary locking arrangement and handles, fixing bolts, safety devices, anchoring rods etc. These shall be suitable for fixing in position as specified i.e. outside or below lintel or between jambs of the opening. The door shall be push and pull type and also operated with chain crank as required. Electrically operated rolling shutters shall be used wherever specified.

6.42.5.2 Galvanising

All M.S. materials including lath sections, clips, guides, lock plate, guide channel, bracket plate, suspension shaft hood cover& other components shall be hot dip galvanised with a zinc coating containing not less than 97.5percent pure zinc. The weight of the zinc coating shall be not less than 750 mm/m^2 both sides and the coating shall be free from flaking or peeling conforming to IS: 1477 - 1977 (Part I& II).

6.42.5.3 Shutters

The shutters shall consist of M.S. lath sections conforming to IS 513-1986, 1.25 mm thick and 75 mm wide unless otherwise specified. The laths shall be machine rolled and straightened with an effective bridge depth of not less than 16 mm and shall be interlocked together throughout their entire length and joined together at the end with end locks by means of cast iron or galvanised mild steel clips conforming to IS 2108-1977 riveted at either end which shall prevent lateral movement of the individual lath sections. These shall be mounted on specifically designed pipe shaft. Each lath section shall be a continuous single strip piece without any joint.

6.42.5.4 Springs

The springs shall be, preferably of coiled type. The spring shall be manufactured from high tensile spring steel wire conforming to grade 2 of IS 4454-1981 or strip of adequate strength to balance the shutters in all positions. The spring pipe shaft etc. shall be supported on strong mild steel brackets.

6.42.5.5 Guide Channels

The guide channels shall be of mild steel deep channel section and of rolled, pressed or built-up construction. The thickness of the sheet used shall not be less than 3.15 mm. The minimum depth of guide channels shall be 60 mm for clear width of shutters upto 3.5 m and 75 mm for 3.5 m and above guide.

The gap between the two legs of the guide channel shall be sufficient to allow free movement of the curtain and at the same time close enough to prevent rattling of the curtain due to wind.

Each guide channel shall be provided with a minimum of three fixing cleats or supports for attachment to the walls or columns by means of heavy duty bolts or screws.

The guide channels shall be attached to jambs, in plumb either in the overlapping or projecting torsion or embedded in grooves, depending on method of fixing to the approval of the Employer.

6.42.5.6 Fixing

Brackets shall be fixed on the lintel or under the lintel as shown with metal fasteners, screws, bolts, etc. The shaft along with the spring shall then be fixed to the brackets.

The shutters shall be laid on the ground and the side guide channels shall be bound with it with ropes etc. The shutter shall then be placed in position and top fixed with pipe shaft with bolts and nuts. The side guide channels, and the cover frame shall then be fixed to the walls through the plate welded to the guides.

Fixing shall be done accurately in workman-like manner so that the operation of the shutter is easy and smooth.

6.42.5.7 Grilled Curtain

Wherever specified rolling shutter shall be provided with grilled curtain partly or fully, as required.

6.42.5.8 Electrical Devices

Suitable electrical devices, push buttons, etc. shall be provided at suitable location to control the opening and closing the rolling shutter. Suitable limit switches shall be provided to automatically stop motor when shutter reach the fully open and closed positions. The control switchgear, cabling, etc. should be of reputed make, conforming to relevant IS codes.

6.42.6 Aluminium Glazed Doors/Windows/Ventilators

6.42.6.1 General

Aluminium glazed doors/windows/ventilators shall be of specified sectional size, dimension and profile as per Contractor’s drawing.

6.42.6.2 Materials

All Aluminium sections shall be extruded sections of INDAL aluminium alloy as per IS:733 and 18:1285. Aluminium sections shall be anodized as per IS : 7088 to min. 25 microns.

Glass used for glazing shall be of following type in accordance with item description.

a) 5.5 mm thick wired glass conforming to IS 5437.

b) 6.3 mm thick laminated safety glass conforming to IS 2553.

c) 5.5 mm thick transparent sheet glass conforming to IS 2835 (wt. *72* kg/sqm)

6.42.6.3 Workmanship

Frames shall be square and flat, the comer of the frame being fabricated to true right angles. Details of construction of frames. shutters etc. shal be as per drgs.

Side hung window shutters shall either be fixed to the frame with pivots, or aluminium alloy hinges. For fixing the hinges, slots shall be cut in the fixed frames and the hinges inserted inside may be riveted to the frame. The hinges shall normally be of the projecting type conforming to IS designation A-5-M of IS 617, IS 733. In which case Peg stay of 300 mm long complete with Locking bracket and conforming to IS codes same as for hinges shall be provided. Friction hinges may also be provided in which case peg stays are not required.

The handles for side hung shutters shall be of cast aluminium conforming to IS designation A-5-M of IS 617 and shall be mounted on a handle plate rivetted to the opening frames. The handle shall have anodised finish with minimum anodic film thickness of 25 micron or electro colour finish. The handle shall have a two-point nose which shall engage with an aluminium striking plate on the fixed frame. The striking plate shall be finished in the same manner as for the handle.

In case of top hung shutters, aluminium alloy cast hinges and peg stays (same as per side hung shutters) shall be provided.

Centre hung shutters shall be hung on the two pairs of cup pivots of aluminium alloy of IS designation NS-4 of IS 737 and IS designation A-5-M of IS 617 or chromium/cadmium plated brass/bronze cup pivots riveted to the outer and inner frames to permit to swing through an angle of 85°. Cast aluminium (conforming to IS designation A-5-M of IS 617) or chromium/cadmium plated bronze spring catches shall be fitted in the centre of the top bar of the shutter. The spring catch shall be secured to the frame by screwing/riveting to the frame and shall close into an aluminium catch plate riveted/welded to the outside of the outer shutter frame bar. Aluminium or cadmium plated brass chord pulley wheel in an aluminium bracket shall be fitted at the sill of the shutter with Aluminium or galvanized/cadmium plated steel screws.

The door shutters shall be fitted with pivots as specified. The handle for doors shall be of Aluminium and as per design. The door shutters shall be provided with locking device, floor spring. 0/H door closer and any other hardwares, specified in item.

In case of composite Door/window/ventilator units, the units shall be coupled. Weather bar shall be provided whenever a couping member is fitted over an external opening shutter.

Glazing shall be fixed to the extruded sections by means of extruded aluminium beading. Glass panes shall be provided with rubber lining before fixing.

The aluminium frames shall be fixed to the masonry by means of aluminum lugs fixed to the frame (by counter sunk gatvanished machine screws) and grouted with M-15 grade concrete in the hole in the masonry. In case of concrete wall, the frames shall be fixed by 96 mm long, 12 mm dia metallic dash fasteners. Any steel material coming in contact with aluminium shall be galvanised.

The windows/ventilators/doors shall be checked to ensure smooth operation, perfect level and plumb.

6.43 Steel Sheet Roofing and Siding

6.43.1 General

This section includes all labour materials, and equipment necessary to furnish in place all steel roofing and siding, all flashings, closers, and accessories used in conjunction with the siding to make a weather tight installation and related hardware and fasteners required for completion of this Contract and as herein specified.

The Contractor shall supply, deliver and fix everything necessary to complete the installation of roofing, cladding in accordance with the specification.

The roof slope in general shall not be flatter than 1:5. The normal pitch if not specified shall be 1:2. Materials shall be from an approved manufacturer. The items supplied shall be free from cracks, chipped edges or corners or other damages. Storage and safety precautions shall be taken to avoid damage to the accessories.

Reference shall be made to the Indian Standards listed in **Section 2 of Volume-II.**

6.43.2 Materials

G.I. sheets shall be of specified thickness and of class-3 galvanised as per IS 277 and shall be of approved brand by the Employer. The thickness of the sheets shall be worked out based on the wind speed expected in the project area.

GI Ridges and Hips

These shall be of specified thickness and of class 3 plain galvanised and shall be bent to the required shape and dimensions as per Contractor's drawings without damaging the sheet in the process of bending.

GI Valleys and Flashings

These shall be of specified thickness and of class 3 plain galvanised and shall be bent to the required shape and size as per Contractor's drawings without damaging the sheet in the process of bending.

GI Gutters

These shall be of specified thickness and of class 3 plain galvanised and shall be constructed to the required shape and size as per Contractor's drawings.

Wind Ties

Wing ties of mild steel shall be as per requirement of the design.

6.43.3 Workmanship

6.43.3.1 Corrugated GI Sheet Roofing

Spacing of Purlins

One purlin each shall be provided at the ridge and the eaves. Spacing of the purlins shall be as per the requirement of the design. Purlin shall coincide with the centre line of the end lap. Ridge purlin shall be placed such that ridges can be placed properly. Portion overhanging the wall support should not be more than one fourth the purlin spacing.

Finish for Purlins

The top surfaces of the purlins shall be painted before fixing the sheets and the embedded portion shall be finished with two coats of coal tar.

Laying of sheets

Sheets shall be laid on the purlins to a true plain with the lines of Corrugation truly parallel or normal to the sides of area to be covered, unless otherwise specified. They shall be bent up along their side edges close to the wall and the junction shall be protected by flashing on projection drip course as specified.

Laps

End laps shall be 150 mm for 1:2 slope and 200 mm for flatter ones. Side lap shall be of two ridges of corrugations on each side.

Cutting of Shaft

Sheets shall be cut according to the dimensions. Sheets shall be cut with a straight edge and chisel to give a straight finish.

Fixing of sheets

The sheets shall be fixed to the roof members with J or L polymer coated bolts, polymer cap, seal washer and thrust washer. The bolts shall be long enough to project at least 12 mm above the top of their nuts. The grip of J or L hook bolts on the side of purlins shall not be less than 25 mm. There shall be at least three hook bolts placed at the ridges of Corrugations in each sheet in every purlin and their spacing shall not exceed 300 mm. Sheets shall be joined together at side laps by polymer coated bolts and nuts as specified, each bolt with a polymer cap (grease filled) steel washer and polymer coated thrust washer. Bolts shall be placed zigzag on overlapping Corrugations. The spacing of the beam bolts shall not exceed 600 mm in each of the staggered rows.

Holes

Holes for all bolts shall be drilled in the ridges of the corrugations from the underside before placing in position. The holes in the sheet shall be at least 50 mm from the edge. The holes in the washers shall be of diameter of the hook bolts or the seam bolls. The nuts shall be tightened from above to give a leak proof roof.

Ridges and Hips

The overlap for ridges and hips on either side of C.G.I, sheet and end legs shall be atleast 225 mm. Ridges & hips shall be fixed to the purlins with polymer coated hook bolts, thrust washer and polymer cap. Atleast one of the fixing bolts shall pass through the end laps of ridges and hips on either side. If it is not possible extra hook bolts shall be provided. Each endlap of ridges and hips shall be joined together by atleast galvanised iron seam bolts and GI washers. Ridges and hips shall fit squarely on the sheets.

Valleys and Flashings

The edge, wherever the roof sheeting or valley gutter is turned up against a wall shall be made weather proof with flashing. Flashing shall be bent to shape and fixed as specified. Lap over the sheet shall be minimum 150 mm. End laps between flashing sheets shall not be less than 225 mm.

Flashing shall be inserted into brick work or masonry joints to a depth of 50 mm and shall be filled with cement mortar (1:3). When flashing has to be laid at a slope, it shall be stepped at each course of masonry. The steps shall be cut back at an angle of atleast 30°.

Valleys shall be bent to shape and shall have at least 225 mm end lap and projection on either side under CGI sheet. Valleys shall be fixed to the root members below with polymer coated GI bolts, polymer cap, seal washer and polymer coated thrust washer. At least one fixing bolt shall pass through end laps of the valley piece.

Gutters

The longitudinal edges shall be turned back by 12 mm and beaten to form a rounded edge. The ends of the sheet at junctions of pieces shall be hooked into each other and beaten flush avoid leakage.

Gutters shall be laid to minimum 1:120 slope. Gutters shall be true to line and slope and shall be supported by brackets as specified.

Wind Ties

Wind ties shall be of 40 mm x 6 mm flat iron section and other size as specified. These shall be fixed at the two eaves end of the sheet. Fixing shall be done with the same loose bolls which secure sheets to the purlins. Slot holes shall be cut in the wind ties to allow for temperature variations.

6.43.3.2 Precoated Galvanized Sheet Roofing / Cladding

Material

The base metal of the roofing shall be Cold Reduced Steel Sheet conforming to IS-513. It shall be galvanised by Hot-dip process as per IS-277. The bottom unexposed surface shall then be coated with alkyd backer of min. 7 microns Top exposed surface shall have epoxy primer of min. 7 microns followed by polyester top coat of min. 16 microns of specified colour.

Properties

The precoated galvanised steel sheets shall meet the following performance standards:

Pencil Hardness	:	H-2H
Formability	:	2-3 t
Impact Resistance	:	40"/lb.
Salt spray test	:	750 hours
QUV-Wealterometer Test:	:	1000 hours
Humidity Test	:	1000 hours
Temperature Resistance	:	150° C
Fire performance	:	Class 1

Profile

The profiles shall have a depth of not less than 35mm and pitch of 190mm. Overall sheet thickness shall be 0.65mm min. and weight shall be 5.72 kg/sqm.

Accessories

All roofing accessories like ridge, gutters, north light curves etc. shall be fabricated out of the approved pre-coated sheet.

Metallic Fasteners and Fixing accessories shall be corrosion proof. Non-metallic fasteners shall be of neoprene. Sealants shall be neutral cure type and cold setting variety

6.44 Furnitures

6.44.1 Wooden Furniture

All wooden furniture is to be manufactured. All wooden furniture should be 1st class Teak wood, well-seasoned, free from knots, cracks, termites and bore etc. All wooden cabinets abutting outside walls / wet areas must have appropriate moisture protection and anti-termite treatment to prevent against dampness and seepage in the cabinet. All joints to be neatly levelled and aligned and there should be no unevenness or roughness between joined surfaces Shades and colour of all finishes including laminates/sunmica/veneer and paint to be finalised after approval of the Engineer. In laminate/sunmica finish surfaces on table tops, no joints are permissible on the surface and every surface/shutter must be laminated with one single homogenous sheet. All movable furniture will be stable and no error in the sizes of legs or levelling of the top surface will be accepted. All wooden shutters should be not less than 15mm thick.

For all wooden furniture, all exposed surfaces to be French polished with glossy finish and unexposed surfaces shall be smoothed by sandpaper, unless mentioned otherwise. Hidden and unexposed surfaces shall be finished smooth by sand papering.

Administrative reception table

The administrative reception table will be designed as a two level working counter made out of a combination of Teak wood and stainless steel, the design of which will be approved by the Engineer prior to commencement of work.

6.44.2 Computer tables

All computer tables will be on castors and will have sliding out drawer for keyboard. The table top will be laminated and will have a cut out provision for wires and cables.

6.44.3 Writing Table and Chair, Center Table, Side Table

All items to be made out of First Class and well-seasoned Teak wood. 12mm thick hard rubber caps to be provided to each leg. Visitors chair to have 50mm thick PU or MM foam with minimum 40 density and upholstery as per approved makes. Writing chair to have foam bottom and will additionally have armrests.

6.44.4 Steel Furniture

Procurement of all other steel furniture items include (but are not restricted to) the following items wherever applicable and will be of approved makes and will be having steel grades as per approved IS codes.

6.44.5 Almirah Steel (Large)

Approximate size to be 1985mm (H), 920mm (W) and 485mm (D). Material thickness of cold rolled steel for special make swing door of cupboard with 4 shelves and bottom tray should be minimum 0.8mm thick and with all other accessories.

6.44.6 Movable – Almirah Steel (Large)

Size to be the same as Fixed Almirah Large. Almirah will be on 4 castors, with each castor having a load carrying capability of 50kg

6.44.7 Filing Cabinet

Four drawer filing cabinet with anti-tilt device anti-rebound mechanism, recessed handles and telescopic runners of minimum size 470mm (W) x 620mm (D) x 1320mm (H), with steel thickness of minimum 0.8mm. Four lateral compartments with glass flip door and handle on every compartment.

6.44.8 Table Type 1- Engineers

Table top size to be 1800mm (L) x 1050mm (W) x 760mm (H) with rigid square steel framework, laminated top finish and full length foot rest. The table must have side storage units with 3 box drawers and a pull out tray in right side and storage cabinet with a shelf and shutter on the left side including locking arrangements. A centrally placed 50mm deep centre drawer also needs to be provided.

6.44.9 Table Type 2- Port Staff

Table top size to be 1500mm (L) x 760mm (W) x 750mm (H) with rigid square steel frame work and laminated top finish with PVC edge lipping. The table must have three drawers in right hand side and a side cabinet with one shelf and shutter at the left side including locking arrangements.

6.44.10 Table Type 3- for CEO and Directors

This is an executive table with size 2200mm (L) x 1190mm (W). The table also has a side return unit with Pedestal (1380 x 480 x 700mm) and mobile pedestal (406 x 550 x 640mm) with laminated finish and PVC edge lipping.

6.45 Woodwork

6.45.1 General

This section of the specification includes requirements for furnishing and installing all woodwork including iron mongery as specified for the completion of all of the work of the Contract.

The Contractor shall supply all timber, fittings, ancillary materials for fixing such as glue, screws, bolts, hold fasts etc. required for the works all in accordance with dimensions and sizes required.

The Contractor shall ensure that any timber entering the site for incorporation in the permanent works is of an approved quality.

Pre-fabricated & assemble doors, windows and / or any other unit shall on arrival at the site, be subjected to a thorough inspection and approval by the Employer.

Timber for joinery work shall be wrought to the exact sizes and all surfaces shall be rubbed down and left clean for painting or staining.

6.45.2 Indian Standards

Refer **Section 2 of Volume-II**.

6.45.3 Material

Teakwood

Teakwood shall be second class Indian Teakwood conforming to IS:4021 of good quality, well-seasoned and free from defects such as cracks, dead knots, sapwood etc. No individual hard and sound knot shall be more than 15 sq.cm in size and the aggregate area of such knots shall not exceed 2% of the areas of the piece. The timber shall be fairly close grained having not less than 2 growth rings per cm, width in cross-section.

Hard Wood

Hard wood shall be first class wood conforming to 1S:4021 of good quality, well-seasoned and free from defects such as dead knots, cracks, sapwood etc. No individual hard and sound knot shall exceed 6 sq. cm in size with no dimension more than 50 mm and the aggregate area of such knots shall not be more than 1% of the area of the piece. There shall not be less than 5 growth rings per cm, width in cross-sections.

Moisture Content in Timber

The maximum permissible percentage of moisture content for well-seasoned timber shall be as per IS 287.

Workmanship of Wood Work

Workmanship for wood and joinery shall be as per 1S:1200 and IS:4021.

Painting / Polishing of Wood Work

Painting/polishing of wood work shall be in accordance with specifications under ‘Painting’.

6.45.4 Wooden Door / Window Frame

Wooden Door / Window frame shall be made of specified wood as per item description and shall be in accordance with detailed drawings of Contractor.

The wooden members of the frame shall be planed smooth and accurate to the full dimensions. Rebates, rounding, moulding etc. shall be done before the members are jointed into frames

Joints in the frame work shall be perfect with square edges and shall be pinned with hard wood/bamboo pins of 10 to 15 mm dia.

Wood work shall be painted/polished or otherwise treated as specified. All exposed portions shall be coated with wood primer and concealed surface by bituminous paints as per specifications under ‘Painting’.

Before any surface treatment is applied, the wood work shall be got approved by the Employer. The frames shall be fixed only after acceptance by the Employer. The frames shall be fixed to the masonry by 300 mm x 25 mm x 6 mm MS hold fasts embedded. In M-15 grade concrete block of 350 mm x 100 mm x 100 mm in the hole of the masonry. In case of concrete, frames shall be fixed by 96 mm long 12 mm dia metallic dash fasteners.

6.45.5 Shutters

6.45.5.1 Particle Board Flush Shutter

Particle board flush shutter shall in general conform to IS:2202.

Materials

i) Particle Board

Panicle board shall conform to IS 3097 and shall be three layer flat pressed teakwood based and of exterior grade (Grade-1), type-1, BWP type bonded with phenol Formaldehyde synthetic resin conforming to IS 848.

ii) Veneers

Veneers shall conform to class-I ofIS:303 and (BS:476 Part-7)

iii) Teakwood

Specification of Teakwood shall be same as specified in **Clause 6.45.3** of this section.

iv) Hinges

Hinges shall be of Extruded Aluminium Alloy and butt type conforming to IS:205. Size of hinges shall be in accordance with shutter width and as per IS:205.

Workmanship

The particle board of required size and thickness shall be lipped on all the edges with T-type teakwood lipping. The overall board lipping composition shall be of uniform and specified thickness and shall be property sized in view of the operation of shutter.

All the four edges of the door shutter shall be square. The shutter shall be free from twist or warp in its plane. In case of double leaf shutters, the meeting of the stiles shall be rebated by one third the thickness of shutter. The rebating shall be splayed.

The shutter then shall be veneered on both faces by gluing approved shade and textured commercial type 0.5 mm thick veneering conforming to class 1 of IS 303.

The veneering shall be done by gluing the veneer with BWP type, phenol formaldehyde synthetic resin conforming to IS 848 by hot press process on the shutter. Workmanship and finish of the veneering shall conform to IS 303.

The exposed surfaces of the lipping of the edges shall be French polished in accordance with specifications under ‘Painting’.

The shutter shall be fixed to the door frame, by means of hinges @ minimum 3 hinges per leaf. Maximum spacing of hinges being 600 mm with suitable sized screws.

The shutter when fitted to the frame shall satisfy all operational aspects of the door like smooth movement, proper closing against the door frame etc.

6.45.5.2 Medium Density Fibre Board Panel Shutter

MDF board panelled shutter shall in general conform to IS: 1003.

Materials

i) MDR-board

Medium density fibreboard shall conform to IS: 12406 Exterior grade (EGSB). It shall be dense, homogeneous and manufactured from agro based lingo-cellulosic fibres bonded with BWP type phenol formaldehyde synthetic resin conforming to IS:848. It shall be categorised as class I for Surfaces of very low flame spread as per IS-1642.

ii) Teakwood

Specifications of Teakwood shall be same as specified in **Clause 6.45.3** of this section.

iii) Synthetic Enamel Paint and Primer

Synthetic Enamel paint conforming to IS:1932 of approved brand and manufacturer and of the required colour shall be used for the top coat and undercoat of shade to match the top coat as recommended by the manufacturer and specified under 'Painting'.

iv) Hinges Specification of hinges shall be same as specified in **Clause 6.45.5.1** (iv)

Workmanship

Teakwood stiles, top rail and bottom rail of specified thickness and size shall be provided with suitable rebate.

The MDF board shall be fitted in by means of teakwood moulded beading of appropriate cross section. The beading shall be fixed by means of approved make neoprene based adhesive and nailing.

All the four edges of the door shutter shall be square. The shutter shall be free from twist or warp in its plane. In case of double leaf shutters, the meeting of the stiles shall be rebated by one third the thickness of shutter. The rebating shall be splayed. The surface of the teakwood stiles and rails shall be coated with 2 layers of approved quality polyurethane transparent coat with strainer to achieve the desired shade.

The shutter shall be fixed to the door frame be means of hinges @ minimum 3 hinges per leaf, maximum spacing of hinges being 600 mm. with suitable sized screws.

The shutter when fitted to the frame shall satisfy all operational aspects of door like smooth movement, proper closing against the door frame etc.

The joints between stiles / rails and the panel shall be properly finished. Extra neoprene adhesive shall be removed and no gap between panel and stiles/rails shall be permitted. Any stain of paint on the panel surface shall be properly removed.

6.45.5.3 Glazed Wooden Door Shutter

Materials

i) Wood

Teakwood for various members like stiles, rails, etc. shall be as specified-in **Clause 6.45.3** of this section.

ii) Glazing

Glass sheets for glazing shall be

a) 4 mm thick plain glass (wt. 7.2 kg/m^2) conforming IS:2835, or

b) 5.5 mm thick wired glass conforming to IS:5437 or

c) 6.3 mm thick laminated glass conforming to 1S:2553 as the case may be as per item description or

d) 5.5 mm thick toughened glass.

Glass sheets shall be free from flaws, scratches, cracks, bubbles etc.

iii) Hinges

Hinges shall be as specified in clause 6.45.5.1 (iv)

Workmanship

Teakwood stiles and rails of size as specified in item description shall be cut accurately and planed smoothly to required dimensions. The stiles and rails shall be provided with rebates for fixing the glazing and shall be joined together to form the profile of the shutter. The joinery work shall be as approved by Employer. Only after such approval, the joints shall be coated with white lead, pressed and secured by hardwood pins of about 6 mm dia. All the four edges of the shutter shall be square. In case of double leaf doors, rebates shall be provided at the meeting of stiles. Rebates shall be splayed type and one third the thickness of the stiles.

The glass sheets for glazing shall be fixed by teak wood beading having mitred joints and shall be fixed by means of approved neoprene based adhesive and nailing, the spacing between the nails being no more than 300 mm.

All wooden surfaces shall be coated with 2 coats of approved make polyurethane with strainer mixed to achieve desired shade.

The shutter shall be fixed to the door frame, by means of hinge @ minimum 3 hinges per leaf, maximum spacing of hinges being 600 mm with suitable sized screws.

The shutter when fitted to the frame shall satisfy all operational aspects of the door like smooth movement, proper closing against the door frame etc.

6.45.5.4 Flymesh Shutter for Door and Window

Specifications for Flymesh shutter shall be similar to specification for wooden glazed door, excepting following features:

i) In place of glass, net of galvanised MS wire-mesh of IS gauge designation 856 wire and dia 0.56 mm shall be fixed to the shutter frame with teakwood beading.

ii) Flymesh shutter shall be for both doors as well as windows.

iii) All wooden surfaces shall be painted with synthetic enamel paint of approved shade in two coats over a priming coat in place of French polishing.

6.45.6 Fire Resisting Door

Frame

Door frame with heat activated intumescent fire seal strips of size 12 mm x 4 mm (for smoke sealing) mounted in the groove in frame suitable for mounting 60/30 minutes fire rated shutters with one coat of anti-termite fire retardant primer.

Shutters / Panels

The shutters of the door shall be of approved make conforming to IS:3614 (Part I) shall be so designed so as to provide the specified fire resistance when tested as per IS:3614 (Part 2) and BS:2750 to suit the specified requirement and the manufacturer must produce certificates of the recognised laboratory to the satisfaction of the Employer.

Asbestos free composite fire/smoke check shutters of 60 min, fire resistance rating, conforming to BS:476 part 22/IS:3614 Part 2) and shall comprise two non-combustible boards each 12 mm thick sand-witching 20 mm thick fire resistant insulation faced with 3 mm commercial ply veneering on both faces and seasoned teak wood lipping around the shutters with heat activated intumescent fire seal strips of size 12 mm x 4 mm mounted in the grooves in the shutters/panels on all sides except bottom.

Seal

A heat activated intumescent seal of approved quality and make conform to BS:476 (Part 8) shall be provided on all edges of doors to check the spread of smoke in case of fire.

Paint

The door frame and panel/shutter shall be treated with ready mixed silicate type fire retardant anti-terminal primer& paint of approved shade and manufacturer as per IS: 162 (BS:476-Part I)

6.45.7 Hold Fast

Hold fasts for use with wooden doors shall be made from mild steel flats not less than 5 mm thick in accordance to IS: 7196 and shall be galvanised. The shutter shall be supported by hinges as specified in **Clause 6.45.5.1** (iv)

Hold fasts shall be fixed with the timber frame by steel screws only. The framed in masonry wall shall be fixed in cement concrete blocks as directed by Employer.

6.45.8 Iron Mongery

The Contractor shall submit a complete schedule of iron mongery for approval by the Employer. The schedule of iron mongery shall indicate the manufacturer's catalogue number, function, material, finish and other information required.

The Contractor shall supply and fix all iron mongery including cutting all necessary mortices rebates and the like.

a) Cargo Doors: All hardware by manufacturer. No lockset, padlocks shall be of the pin tubular type with solid or laminated brass case and steel hardened shackles.

b) Personnel Doors:

Hardware assembly No. 1 : Exterior doors double leaf

3 pairs butts : 12 cm x 12 cm

2 each flush bolts :

1 each lockset

1 each stop

Hardware assembly No. 2 : Exterior doors single leaf

1½ pair butts : 12 cm x 12 cm

1 each lockset

1 each stop

Hardware assembly No. 3 : Interior doors (except toilets)

1½ pair butts : 12 cm x 12 cm

1 each lockset

1 each stop

Hardware assembly No. 4 : Toilet doors (0.70 x 2.00)

1 pair butts : 12 cm x 12 cm

1 each lockset

1 each stop

c) Windows / Ventilators

Hardware assembly No. 5 : Leaf opening windows

Non-ferrous metal holders and 1 latch set

1 pair hinges

Hardware assembly No. 6 : Sliding Windows

Roller

1 latch set

1 lockset

Operated door locks shall be cored and three keys for each lock and six master keys shall be furnished. Each key shall have a blank bow, one side for stamping purposes. Locks shall be keyed individually and in groups and master keyed in one series as directed by the Employer. The master keys shall be delivered directly to the Employer.

6.46 Roofing Treatment

6.46.1 General

This section of the specifications includes the requirements to provide, in place, all roofing treatments specified herein, or as required to provide a complete installation.

6.46.2 Material

The material shall consist of 2 pack clear / pigmented aliphatic polyurethane using polyurethane using polyether polyois (polyster or Castor Oil based polyois not acceptable), with iso-cynorate for rendering flame resistant characteristic. The 2 pack system, consisting of pigment and the solvent (Xylene/Toulene, no filler) shall be mixed in definite ratio by weight strictly as per approved manufacturer's specification, for preparing the coating for application. The coating shall have physical features like high resistance to impact, abrasion and cracking, superior tensile strength (80 kg/cm^2 after 4 weeks at ambient temp.), and perfectly smooth, dust free, glossy finish retained at least upto3 years. It should also be resistant to acid, alkalies and have a very low water absorption rate (0.5% max. at ambient temp. after 7 days).

The packs shall not be older than 9 months after the date of manufacture and packing

6.46.3 Workmanship

6.46.3.1 Preparation of Surface

The roof surface shall be thoroughly cleaned with a wire brush and all foreign matter etc. shall be removed. Well defined cracks on the surface shall be cut to 'V section, cleaned and filled up flush with a paste of 2 component polyurethane based crack filling compound and white cement in a ratio of 1:2.

6.46.3.2 Primer Coat

It shall consist of 2 pack polyurethane. Primer coat shall be mixed in the ratio as per manufacturer's specification. A single coal of this primer shall be applied by brush over the prepared bed as an adhesion coat.

The primer shall be allowed to dry for a min. of 8 hrs. time before the successive finishing coats are applied Finishing coats:

6.46.3.3 Finishing Coats

The finishing coats shall consist of three successive pigmented sealing coats each of 2 pack polyurethane mixed in the ratio as per manufacturer's spec. Application shall be with brush, to a smooth and even finish. The overall dry film thickness shall be 450 microns or min. covering capacity shall be200gms/m^2 per coat.

Each coat shall be allowed to dry for min. 12 hours before applying next coat. Care shall be taken for quick application after mixing the 2 pack primer in view of short pot life of the mix and shall be fully consumed within the stipulated period as per manufacturer's spec (Max. 60 minutes at 30°C)

The finishing coating shall be continued up the parapets/walls for a min. of 150mm over the finished roof surface. It shall be continued into rain water pipes by at least 100mm.

6.46.3.4 Cement Screed

The final finishing coat when tacky shall be sprinkled with 300 micron layer of clean sand. Plain cement concrete (1:2:4) of 25mm min. thickness with 24 SWG chicken wire mesh shall be laid to slope in panels not exceeding 6 M^2 area per panel over this. The joints between panels shall be raked out neatly (after stipulated curing period) to a min. 6mm x 6mm v-groove and filled up with an approved quality elastomeric compound sealant. Drain outlet shall be provided for all spouts/rain water pipes by suitable rounding, filling and sloping of PCC. At the junction of the roof and parapet or any other vertical surface, a fillet of 75mm radius shall be formed in cement mortar (1 cement: 4 coarse sand).

6.46.4 Guarantee

The applicator shall execute a form of Roofing Treatment Guarantee.

6.47 Plastering and Pointing

6.47.1 General

This section shall cover all plastering (internal/external) and painting works as specified herein. Before commencing the work sample of works shall be made in accordance with the specification and got approved by the Employer.

6.47.2 Materials

6.47.2.1 Cement

Cement shall conform to specifications under ‘Material’ unless otherwise specified.

6.47.2.2 Sand

Sand for plastering and pointing shall conform to IS 1542. Sand shall be hard, durable, dean and free from adherent coatings and organic matter and shall not contain any appreciable amount of silt, day balls or pellets. Sand shad not contain harmful impurities such as iron pyrites, coal particles, lignite, mica shale etc.

Sand whose grading falls outside the limits of IS 460 due to excess or deficiency of coarse or fine panicles shall be processed to comply with the standards.

Fine sand shaft be obtained from river beds not affected by tidal water of the sea and shall be clean, sharp and free from excessive deleterious matter. The sand shall not contain more than 8 per cent of mud and silt as determined by field test with a measuring cylinder.

6.47.2.3 Water

Water for plastering and pointing shall conform to specifications under ‘Material’.

6.47.2.4 Cement Mortar

Preparation of cement mortar shall conform to specifications under ‘Brick Masonry’ unless otherwise mentioned.

6.47.2.5 Cement Mortar with Waterproofing Compound

Waterproof compound shall conform to IS 2645 of approved make. The compound shall be well mixed with dry cement in the proportion of 3% by weight or as recommended by manufacturer. Further procedures for preparation of cement mortar shall be as per **Clause 6.47.2.4** above.

6.47.3 Workmanship

6.47.3.1 Preparation of Background Surface

The surface shall be cleaned off all dust, loose mortar droppings, traces of algae, efflorescence and other foreign matter by water or by brushing. Smooth surfaces shall be roughened by wire brushing or hacking for non-hard and hard surfaces respectively. Projections on surfaces shall be trimmed wherever necessary to get even surfaces. In case of brick/stone masonry, raking of joints shall be carried out wherever necessary. The masonry shall be allowed to dry out for sufficient period before carrying out the plasterwork. The masonry shall not be soaked but only damped evenly thereafter before applying the plaster.

In case of concrete work, projecting burrs of mortar formed due to the gaps of joints in shuttering shall be removed. Such surface shall be scrubbed clean with wire brushes. The surface shall be pock marked with a pointed tool at spacing of not more than 50 mm centers, the pocks being made not less than 3 mm deep to ensure a proper key for the plaster. The surface shall be washed off and cleaned of all oil, grease etc. and well wetted before the plaster is applied.

6.47.3.2 Sequence of Operation

For external plaster, the plastering operations shall be started from the top floor and carried downwards. For internal plaster, the plastering may be started wherever the building frame, roofing, and brickwork are ready.

The surfaces to be plastered, shall first be prepared as described in Preparation of background surface in **Clause 6.47.3.1** above.

The first underlay shall then be applied to ceilings. After the ceiling plaster to complete and scaffolding for the same removed, plastering on wall shall be started.

After a suitable time interval as detailed under various types of plaster in subsequent paras, depending upon the type of mortar, the secondary layers if required shall be applied. After a further suitable time interval as detailed under various type of plaster in subsequent paras, the finishing coat shall be applied first to the ceiling and then to the walls.

Plastering of cornices, decorative features, etc., shall be completed before the finishing coat is applied. Unless otherwise specified Corners and edges shall be rounded off to a radius of 25mm, such rounding off shall be completed along with the finishing coat to prevent any joint marks showing out later.

6.47.3.3 Scaffolding/Staging

Scaffolding/staging for plastering/pointing shall be as per specification under Brick Masonry, **Clause 6.40.5** of Specification.

6.47.3.4 Damage Rectification

Any cracks, damages, any part of work which sound hollow when tapped or found damaged or defective otherwise shall be cut out in rectangular shape and redone as directed by Employer.

6.47.4 Plain Cement Plaster

6.47.4.1 Preparation of Mortars

The mortars of specified mix shall be used as per the specifications of “Cement Mortar’ described in **Clause 6.47.2.4** above.

6.47.4.2 Application of Plaster

One Layer Plaster Work

To ensure even, specified thickness, plaster of 150 mm x 150 mm shall be first applied horizontally and vertically at not more than 2 meter interval over the entire surface to serve as gauges. The surface of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall be brought to true surface by working with a wooden straight edge reaching across the gauges with small upward and sideways movements at a time. Finally the surface shall be finished off true with a trowel or wooden float to obtain a smooth texture. Excessive trowelling or overworking the float shall be avoided. All corners, arises, angles and junctions shall be truly vertical/horizontal and shall be carefully finished. Rounding or chamfering of corners, arises, junctions etc., shall be carried out with proper templates to the size required.

In suspending the work, the plaster shall be left, cut clean to line, both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped clean and wetted before plastering the adjoining area. Plastering work shall be closed on the border of the wall and nearer than 150 mm to any corners or arises and shall not be closed on the body of the features such as plaster bands, cornices nor at the comers or arises.

Two Layer Plaster Work

First or under layer

The first or underlay of the specified thickness shall be applied as described above in **Clause 6.47.4.2**. Before the first coat hardens, surface of it shall be beaten up by edges of wooden tapers and close dents shall be made on the surface. The subsequent coat shall be applied after this coat has been allowed to set for 3 to 5 days depending upon weather conditions. The surface shall not be allowed to dry during this period.

Second or finishing layer

The second layer shall be complete to the specified thickness in the same manner as for first layer.

6.47.4.3 Curing

Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of 7 days. During this period the plaster shall be suitably protected from all damages by such means as approved by the Employer. The date of execution of plastering shall be marked on the plastering to ensure the proper duration of curing.

6.47.5 Sand Face Plaster

6.47.5.1 Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in **Clause 6.47.2.4.**

Application of Plaster

Sand face plaster shall consist of 13 mm thick (1 cement: 4 coarse sand by vol) underlayer and 7 mm thick (1 cement: 2 coarse sand by volume) top layer. Application of plaster shall be as described in 'two coat plaster work' in **Clause 6.47.4.2** above.

The surface of the sand face plaster shall be finished rough with sponge or as directed by the Employer.

Curing

Curing shall be as described above in **Clause 6.47.4.3**.

6.47.6 Exposed Aggregate Finish Plaster

6.47.6.1 Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in **Clause 6.47.2.4.** White and coloured marble chips shall be of 6 mm to 12mm size out of Makrana/Ambaji, grade 1 or Dongri Chittor Brown/Rajnagar/Abu green grade-1 quality. Marble dust shall be obtained from crushing hard marble stone. It shall not be less than 1.0.

6.47.6.2 Application of Plaster

Exposed aggregate finish plaster shall consist of 12mm thick plain cement plaster underlayer (1cement: 4 coarse sand by volume) finished rough and 20 mm thick top layer. Underlayer shall be applied in accordance with "One layer plaster work" described above in **Clause 6.47.4.2.**

Top layer shall be 20 mm thick admixture of white cement and grey cement (mix. ratio 1:1 by volume) mixed with while/coloured marble chips/pebbles of 6mm to 12mm nominal size as per item description. Mix ratio shall be 1cement: 1 marble chips/pebbles by volume Marble dust @ 15% by volume shall be added to the admixture. The pebbles to be used shall be well washed and drained. The admixture shall be thrown wet on to the under layer while it is still plastic using strong whipping motion at right angles to the lace of the wall. One coat of neat cement slurry @ 2.75 kg cement per square metre of area shall be applied on to the underlayer to receive the top layer The whole plastering laid in panels with 12mm x 20mm grooves in between formed by holding removable wooden battons of 12mmx x 25mm size over the under layer.

The top layer admixture pressed flat over the underlayer filling uncovered parts by hand, so that the finished surface represents a homogeneous surface. Loose mortar etc. on the top surface shall be cleaned/removed by brushing/washing/spraying with water jet after initial setting of mortar.

6.47.6.3 Curing

Curing shall be as described above in **Clause 6.47.4.3**.

6.47.7 Pointing

Pointing shall be of the type specified such as flush, cut or weather struck, raised and cut etc.

6.47.7.1 Preparation of Base Surface

The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunken surface of the finished pointing or from the edge of the brick shall be less than 20 mm.

Mortar

Mortar shall be in accordance with the specifications of cement mortar described above in **Clause 6.47.2.4**

Application of Mortar and Finishing

The mortar shall be pressed into the raked out joints with a pointing trowel according to the type of pointing specified. The mortar shall be spread over the corner edges or surfaces of the masonry. The pointing shall then be finished with the pointed tool.

The superfluous mortar shall be cut off from the edges.

Flush Pointing

The mortar shall be pressed into joints and shall be finished off flush and levelled. The edges shall be neatly trimmed with trowel and straight edges.

Cut or Weather Struck Pointing

The mortar shall first be pressed into joints. The top of the horizontal joints shall then be neatly pressed back by about 15 mm with the pointing tool so that the joint is sloping from top to bottom. The vertical joint shall also be similarly pointed. The junctions of vertical joints with the horizontal joints shall be at true right angles in case of brick & coursed rubble masonry.

Raised and Cut Pointing

This type of pointing shall project from the wall facing with its edges cut parallel so as to have a uniformly raised band about 6 mm and width 10 mm more as directed. The pointing shall be finished to a smooth but hard surface.

Curing

Curing shall be as described above in **Clause 6.47.4.3**.

6.48 Floor Finishing

6.48.1 General

This section shall cover all flooring and wall tiling work and specified herein. No work under this section shall be started until specifically allowed by the Employer and until all other major works such as plastering, embedding of conduits and pipes channels, window fixing etc. have been completed. Samples of basic materials and work of adequate size representing the nature of variation including quality, size, texture after finishing to be used in the flooring work shall be prepared for all work and got approved by the Employer sufficiently prior to ordering. The approved samples shall be retained

upto the end of the project. The works shall be got done by skilled and specialised workmen experienced in the respective trade of work.

Reference shall be made to the Indian Standards listed in the **Section 2 of Volume-II.**

6.48.2 Cement Concrete Flooring General

6.48.2.1 General

Cement concrete flooring shall in general conform to IS 2571. Cement conrete flooring shall consist of a sub base (laid on the compacted earth or sand fill In case of ground floor only) a base course laid on the sub-base and then finishing layer of floor finishing. Where the cement concrete flooring is to be laid directly on the RCC slab, the surface of RCC slab shall be cleaned and the laitance shall be removed and a coat of cement slurry at 2 kg. of cement per sq.m. shall be applied, so as to get good bond between RCC slab and concrete floor. In case of ground floor, the filled and compacted bed on which the sub-base is to be laid, shall beas per specifications.

The bed for flooring shall be prepared either level or sloped as instructed by Employer.

6.48.2.2 Workmanship

Sub-base

The sub-base which shall be laid on the prepared bed shall be of specified thickness as per specifications.

The sub-base shall be of cement concrete. In case of upper floors, the structural RCC slab shall be treated as sub-base.

Base Course

Base course shall be of cement concrete of specified mix and of specified thickness/item descriptions and snail generally conform to specification (Plain and Reinforced Cement Concrete).

The floor space on which base course is to be laid shall be divided into square/ rectangular or as per designed panels to prevent cracks in the floor finish. No dimension of the panels shall exceed 2m and length of the panel shall not exceed 1.5 times its breadth. Base course shall be laid on alternate panels. The borders of the panels shall have mitred joints at the comers of the room and intermediate joints shall be in straight line with panel joints.

The panels shall be bound by MS strips/PVC strips etc. These shall be fixed in position with their top at proper level, giving stope wherever required.

The flooring shall butt against masonry of wall which shall not be plastered.

When the base course is to be laid on hardened base, the sub-base shall be roughened by steel wire brushing and cleaned. Before laying the base course, neat cement slurry shall be brushed into the prepared surface.

Cement concrete shall be placed in position and beaten with trowel and finished smooth. Beating shall cease as soon as surface is found covered with cream of mortar. Necessary slope shall be provided.

Floor Finishing

Finishing of the surface shall follow immediately after the completion of base course. The base course shall be free of excessive moisture before starting the floor finishing. Use of dry cement, cement sand mixture sprinkled on the surface to stiffen the concrete or absorb excessive moisture shall not be permitted.

While the concrete is still green, cement @ 2.75 kg per square meter of floor area shall be mixed with water to form a thick slurry and spread over the surface. It shall be pressed twice by means of iron floats, once when the slurry is applied and second time when the cement starts setting.

The junction of floor with wall plaster, cladding, skirting shall be rounded off uniformly upto a radius of 25mm unless otherwise mentioned.

Curing

Each finished portion of floor, on completion shall be kept wet with ponding for a minimum period of 7 days.

6.48.3 Cement Concrete Granolithic Flooring

6.48.3.1 General

Cement concrete granolithic flooring shall consist of a sub-base, a base course, finishing layer of floor finish. Workmanship, shall in general be same as for cement concrete flooring, unless otherwise mentioned.

6.48.3.2 Workmanship

Workmanship shall in general conform to IS : 5491.

Sub-base

Refer Clause 6.48.2.2 above.

Base Course (under-layer)

Refer Clause 6.48.2.2 above.

Wearing Top Layer

The top layers shall be laid over first layer within 15 minutes of laying the first layer. The cement and aggregates for the top layer shall be mixed dry. After mixing, sufficient quantity of sand and water shall be added to make the mix plastic but not flowing. The top and bottom layer shall firmly grip together.

Floor Finishing

Refer Clause 6.48.2.2 above.

Curing

Refer Clause 6.48.2.2 above.

6.48.4 Heavy Duty Flooring

6.48.4.1 General

Heavy duty Flooring in workshop shall consist of a sub-base, a base course and a finishing layer of floor finish.

6.48.4.2 Workmanship

Sub-base

Refer Clause 6.48.2.2 above.

Base Course

Base course shall consist of one layer of cement concrete of speficied mix and thickness laid on sub-base in panels in accordance with clause **Clause 6.48.2.2** above.

Floor Finish

Finishing layer shal be of cement, hardener and stone aggregate mix of specified proportion and thickness laid over the base course. Unless otherwise mentioned, one part of approved quality hardner and four parts ofcement by weight shall be mixed dry. This dry mixture shall be mixed with stone grit of 6mm and down size in the ratio of 1 hardener and cement mixture : 2 stone grit by volume. Just enough water shall then be added to the mix.

The mixture so obtained shall then be laid on the base course within 2 to 4hours of later's laying It shall be firmly pressed into bottom concrete so as to have a good bond with it. After the starting of initial setting, the surface shall be finished smooth and true with steel floats.

6.48.5 Precast Hydraulically Pressed Cement Tiles Flooring

6.48.5.1 Materials

Cement Concrete Tiles

Cement conrete tiles shall conform to IS 1237 and shall be of approved shade, with 10 mm down size stone aggregates and using a 1:6 or as directed mixture of white and ordinary cement and shall be of specified thickness and apprd. shade.

Pigments

Pigments to be admixed with mortar or for grouting shall conform to Table 1 of IS 2114.

Cement Mortar

Cement mortar shall be of specified mix and thickness and shall be in accordance with **Clause 6.47.2.4** of the specification under ‘Materials’.

Workmanship

Workmanship shall in general conform to IS : 1443. The base on which tiles are to be laid shall be cleaned of all dust, dirt and property wetted without allowing water pools. Cement mortar of specified thickness shall then be spread over the base for two rows of tiles and 3-5 metres in length. The mortar shall be laid in slope as per requirements and thickness of mortar shall not be less than 10mm at any

place. The top of the mortar shall not be less than 10mm at any place. The top of the mortar shall be kept rough so that cement slurry can be absorbed. Laying shall be from centre & proceed outwards in the two directions at 90°. Cut tiles of uniform sizes shall be laid along periphery, if necessary. Neat cement slurry @ 4.4 kg. of cement per Sq.M. shall be spread over the mortar bed laying 20 tites at a time. The tiles shall then be fixed in this grout one after the other, each tile being gently tapped and properly bedded in line and level. The joints shall not exceed 1.5mm in width. After the day's work, the excess cement slurry on top and the joints shall be cleaned with broom stick and washed before the slurry sets hard. Next day, the joints shall be filled with the cement grout of the same shade as the matrix of the tile.

Tiles along the periphery shall be continued by average 12 mm under the wall plaster, skirting or dado.

Curing

The flooring shall be cured for 7 days by keeping it wet with ponding. Heavy traffic on the flooring shall be permitted only after 14 days.

Grinding and Polishing

Grinding shall be commenced after 14 days when the tiles and the joints are property set. Grinding shall be done by machines except for skirting and small areas. First grinding shall be done with carborundum stones of 48 to 60 grade grit fitted in the machine. Water shall be properly used during grinding. When the chips show up and the floor has been uniformly rubbed, it shall be cleaned with water baring all pin holes. It shall then be coverred with a thin coat of grey/white cement mixed with pigments to match with colour of the flooring. This grout shall be kept moist for a week. Thereafter the second grinding shall be started with carborundum stone of 120 grit. Grinding and curing shall follow again. Final grinding shall be with carborundum of grade 220 to 350 grit using water in abundance. The floor shall be washed clean with water, oxalic add powder shall then be dusted at 33 gms/sq. m. on the surface rubbed with machine fitted hessian bobs or rubbed hard with woolen rags. The floor shall then be washed clean and dried with a soft cloth or linen. If any tile is disturbed or damaged, it shall be refitted or replaced proper jointed and polished.

6.48.6 Cement Plaster Skirting

6.48.6.1 Material

Cement plaster skirting shall be laid with cement mortar as per **Clause 6.39.3** specification under Brick Masonry Work and shall be of specified proportion and thickness.

6.48.6.2 Workmanship

The surface on which the skirting is to be applied shall be prepared and skirting of specified thickness shall be laid in accordance with **Clause 6.47.3.1**, specification under Plastering & Pointing. The junction between flooring and wall shall be rounded off to a radius of 25mm if not otherwise mentioned.

While the mortar is still green, cement @ 2.75kg per square metre shall be mixed with water to form a thick slurry and applied over the mortar. It shall be pressed twice by means of iron floats, once when the slurry is applied and second time when the cement starts setting.

6.48.7 Cast-In-Situ Terrazzo Flooring

6.48.7.1 Material

Cement Concrete

Specification of cement concrete shall be same as in Specification under Plain and Reinforced Concrete.

Aggregates for Terrazzo Topping

The aggregate to be used in topping shall be marble chips of plain white Pink, Makrana. Grade Baroda green etc. as specrfied which shall be of 10mm nominal size. Marble powder to be used in terrazzo topping shall pass through IS Sieve Terazzo. Marble chips shall be hard, sound, dense and homogenous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. All proportions of Materials used should be as directed by the Employer described in the item.

Pigment

Pigments to be used in Terrazzo shall be of permanent colour and shall conform to IS-2114, Table-1.

6.48.7.2 Workmanship

Workmanship shall in general conform to IS -2114. Terrazzo flooring shall be of specified thickness and shall be laid in two layers and in panels. Under layer or base course shall be of cement concrete laid over sub-base and top layer shall be of terrazzo floor finish.

Top layer shall consist of mix of white cement, marble powder, marble chips, water and pigments. Cement and marble powder mix proportion shall be 3 : 1 by weight. Cement, marble powder mix shall be mixed with marble chips in the proportion of 4:7 by volume. Quality and shade of chips and powder shall be as specified with a view to avoid variation in colour. Sufficient quantity of while cement shall be added in the cement mix to obtain the desired shade. Mixing shall be done in a trough or tub and complete quantities of white cement and pigment for a particular unit of job shall be dry mixed with aggregates. Water shall be added in small quantities to this dry mix to get a proper consistency. The mix shall be plastic but not so wet to flow. The mix shall be used within 30 minutes of its preparation.

The base course/under layer shall be divided in panels with dividing strips (G.I./Aluminium Alloy /PVC) upto the finished surface levels. The sub-base shall be cleaned of all dust, dirt or any loose material. It shall then be wetted with water, mopped and smeared with neat cement slurry.

Terrazzo topping shall be laid while the underlayer is still plastic but has hardened enough which is normally achieved between 18-24 hours after laying the underiayer. A cement slurry pigmented with the same colour as the topping be brushed on the surface immediately before laying the topping. The terrazzo mix shall be laid to a uniform thickness and be compacted throughly by tamping or rolling and trowelled and brought true to required level by a straight edge and steel floats so that the maximum amount of marble chips come up and spreaded uniformly over the surface and no part of the surface is left without the chips.

Curing

The surface shall be left dry for air curing for a period of 12-18 hours. Thereafter water shall be allowed to stand overnight in pools for a period of minimum four days.

Grinding and Polishing

Grinding and polishing shall be done wtth machines and shall start after 7 days of laying. First griinding shall be done with carborundum stone of 60 grit size. The surface shall then be washed clean and grouted with a grout of cement and/of colouring matter in same mix and proportion as the topping in order to fill any pin notes that appear. It shall then be allowed to dry for 24 hours and wet cured in the same manner as mentioned above in this clause. The second grinding shall be done with carborundum stone of 80 grit size. The surface shall then be prepared as after first grinding.

The third grinding shall be done wtth carborundum stone of 120 to 150 grit size. The surface shall then be prepared againas after first grinding.

The fourth griniding shall be done with carborundum stone of 320 to 400 grit size. The surface shall then be washed clean and rubbed hard with felt and slightty moistened oxalic acid powder @ 33 gms per square metre of floor surface. After the finishing works are over, the surface shall be washed with dilute oxalic acid solution and dried. Floor polishing machine fitted with felt on hessian bobs shall then be run over it until the floor shines.

In case of polishing, wax polish shall be applied on the surface with the help of soft linen over a clean and dry surface. Then the polishing machine fitted with bobs shall be run over it. Clean saw dust shall be spread over the floor surface and polishing machine again operated to remove excess wax.

6.48.8 Cast-In-Situ Terrazzo Skirting and Dados

6.48.8.1 Material

Refer **Clause 6.48.7.1** above.

6.48.8.2 Workmanship

Cast-in-situ Terrazzo in skirting and dado shall be of specified thickness and of same shadeas that of the flooring.

Underlayer for terrazzo on vertical surfaces shall be of stiff cement mortar 1:3 (1 cement: 3 coarse sand by volume) finished rough so as to give a good bond to the topping. Terrazzo topping shall be average 12mm thick and underlayer shall be 13 mm thick. Terrazzo topping shall be laid on the underlayer in accordance with **Clause 6.48.7.2** above. Other details shall be same as for flooring excepting grinding which shall be manual.

6.48.9 Precast Hydraulically Pressed Terrazzo Tile Flooring

6.48.9.1 Materials

Terrazzo Tiles

Terrazzo tiles shall be of specified thickness and shade and shall generally conform in all respects to IS-1237.

Pigment

Refer **Clause 6.48.7.1** above.

Cement Mortar

Refer **Clause 6.48.5.1** above.

6.48.9.2 Workmanship

Refer Clause 6.48.8.2 above.

Curing

Refer **Clause 6.48.7.2** above.

Grinding and Polishing

Refer **Clause 6.48.7.2** above.

6.48.10 Terrazzo Tiles in Risers of Steps, Skirting and Dado

6.48.10.1 Material

Terrazzo Tiles

Same as in **Clause 6.48.9.1** above. The average thickness of tiles shall however be 20mm.

Pigments

Same as in **Clause 6.48.7.1** above.

Cement Mortar

Same as in **Clause 6.48.5.1** above.

6.48.10.2 Workmanship

In case of brick masonry wall, the joints shall be raked out to a depth of at least 15mm white the masonry is being laid. In case of concrete work, the surface shall be hauled and roughened with wire brushes.

The wall surface shall be uniformly and evenly covered with 12mm thick backing of cement mortar 1:3 (1 cement: 3 coarse hand by volume). Before hardening of the cushioning mortar, back of each tile shall be covered with a neat layer of cement slurry @ 4.4.kg of cement per Sqm. and edges with white cement with or without pigment to match the shade of tiles and the tiles then shall be pressed on the backing and tapped.

The tiles shall be corrected to proper planes with joints truly vertical in required pattern and butt jointed. The fixing shall be done from bottom upward. The top of skirting and dado shall be truly horizontal.

Curing, Grinding and Polishing

Same as in **Clause 6.48.7.2** above.

6.48.11 Glazed Tiles Work

6.48.11.1 Material

Tiles

Glazed tiles shall conform to 1S: 777 and shall be of specified shade, size and of approved manufacturer.

Pigments

Same as in **Clause 6.48.7.1** above.

Cement Mortar

Same as in **Clause 6.48.5.1** above.

6.48.11.2 Workmanship

The tiles shall be laid over a coating of specified adhesive (as per approved manufacturer's specification) laid on base floor/ wall plaster. The joints of the tiles shall be flush pointed with cement paste (white cement and pigment conforming to IS-2114, Table-1) matching the shade of colours.

Curing

Same as in Clause 6.48.7.2 above.

6.48.12 Glazed Tiles in Risers of Steps, Skirting and Dado

6.48.12.1 Materials

Same as in **Clause 6.48.11.1** above.

6.48.12.2 Workmanship

Same as in **Clause 6.48.11.2** above.

Curing

Same as in **Clause 6.48.7.2** above.

6.48.13 Kota Stone Flooring

6.48.13.1 Materials

The slabs shall be of selected quality and shade, hard, sound, dense, homogenous in texture, free from cracks, decay,.weathering and flakes. These shall be machine cut to the requisite size and thickness and chisel dressed.

The slabs shall have the top (exposed) face polished before being brought to site. Before starting the work, the Contractor shall get the samples of slabs approved by the Employer.

6.48.13.2 Workmanship

Each slab shall be machine cut to the required size and shape and fine chisel dressed at all edges to full depth and machine rubbed to a smooth surface finish. All angles and edges of the slabs shall be true square and free from chippings carving a plane and smooth surface.

Preparation of Surface

Cement mortar 1:6 (1 cement: 6 coarse sand by volume) of specified thickness shall be laid over the base after making it rough and cleaning thoroughly.

The mortar shall be laid for facing one slab at a time.

Laying

The slab shall be washed clean before laying. It shall be laid over cement mortar bedding on top, pressed, lapped gentry to bring it in level. It shall be then lifted and laid aside. Top surface of the mortar then shall be corrected by adding fresh mortar at hollows and depressions. The mortar then shall be allowed to harden and cement slurry of honey like consistency @ 4.4 kg of cement per Sqm shall be spread over the mortar. The edges of the slabs shall be buttered with white cement with or

without pigment grout to match the shade of the slabs. The slabs shall then be gently placed in position and tapped with wooden mallets till it is property bedded in level. The joints shall be as fine as possible. Surplus cement on the surface of the slab shall be removed. The slabs in flooring shall continue for not less than 10 mm under the plaster/ skirting. The finished surface shall be true to levels and slopes as instructed by the Employer.

The slabs shall be laid in patterns and size shall not be less than 310mm X310mm. Cut uniform size may be used along periphery as required.

Curing

The floor shall be cured for a minimum period of 7 days by wetting.

Polishing and Finishing

Unevenness at the meeting edges of slabs shall be removed by fine chiselling. Polishing etc. shall be done in accordance with **Clause 6.48.7.2** mentioned above except that cement slurry shall not be applied on the surface before each polishing.

6.48.14 Kota Stone in Risers of Steps, Skirting and Dado

6.48.14.1 Materials

Same as in **Clause 6.48.13.1** above.

6.48.14.2 Workmanship

Same as in **Clause 6.48.13.2** above.

Curing, Polishing And Finishing

Refer **Clause 6.48.7.2** above.

6.48.15 Marble Stone Flooring

6.48.15.1 Materials

Marble Slabs

The slabs shall be of the kind of marble specified in the item. The marble from which the slabs are made shall be of selected quality, hard, sound, dense, homogenous in texture, free from cracks, decay, weathering and flakes. The sample of Marble stone slabs shall be got approved from the Employer.

The slabs shall he machine cut to the requisite dimensions.

Pigments

Same as in **Clause 6.48.7.1** above.

Cement Mortar

Same as in **Clause 6.48.5.1** above.

6.48.15.2 Workmanship

Same as in **Clause 6.48.3.2** above.

Curing

Same as in **Clause 6.48.3.2** above.

Polishing and Finishing

Same as in **Clause 6.48.7.2** above.

6.48.16 Marble Stone in Risers of Steps and Skirting

6.48.16.1 Materials

Same as in **Clause 6.48.5.1** above.

6.48.16.2 Workmanship

Same as in Clause **6.48.3.2** above.

Curing, Polishing and Finishing

Same as in **Clause 6.48.7.2** above.

6.48.17 P.V.C. Flooring

6.48.17.1 Materials

P.V.C. Roll/ Tiles

P.V.C. Roll shall be of homogenous, un-backed, flexible type of approved, colour and pattern, conforming to IS - 3462/3461 and of specified thickness.

Antistatic PVC Roll

Antistatic P.V.C. roll shall conform to B.S.2050. Table-2 in addition to IS-3462

Adhesive

Adhesive shall be neoprene based rubber adhesive of approved make.

6.48.17.2 Workmanship

Preparation of Base

The preparation of sub-base and base course shall be same as in **Clause 6.48.2.2.**

Finishing Layer

The base course shall be thoroughly dried and cleaned well before the laying of P.V.C. rolls/ tiles.

P.V.C. rolls/tiles shall be brought to the temperature of the area in which it is to be laid and stacked suitably near the site for a period of about 24 hours.

The layout of P.V.C. flooring shall first be marked with guidelines on the base course to required pattern without adhesive. The adhesive then shall be applied by spatula to the base floor and back of the PVC roll/tile. PVC rolls shall be placed in position from one end onwards slowly without creation on any air pockets between the roll and the base course. PVC rolls/ tiles shaft be placed only when the adhesive is set sufficiently for laying. When set sufficiently for laying, the adhesive will be sticky to the touch but shall not mark the fingers. After placing, the roll shall be pressed suitably with a wooden roller weighing about 5 kg. The joint between adjacent rolls shall be thin hairline type. For PVC tiles

laying shall start from centre and proceed outwards in the two right angle directions till the periphery of the room/area is reached. Fractional tiles of uniform cut sizes may be laid only along the peripheral border if so required owing to size of the room/area.

PVC rolls in flooring shall be continued for 100mm high skirting without any joints and with 50mm radius rounded corner at the junction of skirting and flooring. Any excess adhesive squeezing out of the surface shall be wiped off immediately with a wet cloth. In case of such excess adhesive becoming hard, it shall be removed with a solution of one part of commercial Butyle Acetate and three parts of turpentine oil or any other solution as advised by the manufacturer of the roll.

After a minimum period of 24 hours after laying the rolls/ tiles, the finished floor shall be cleaned with a wet cloth soaked in warm soap solution of 2 spoons of soft soap powder in 5 litres of warm water or detergent as per approved manufacturer's specifications.

6.48.18 Acid Resistant Tiles in Floors

6.48.18.1 Material

The tiles shall be vitrified ceramic tiles and shall be homogeneous. They shall have the following properties.

Table 6.17: Tiles Specifications

S. No.	Characteristics	Value Required	Norms
1)	Water Absorptions	$\pm$ 0.5%	ASTM C 373
2)	Scratch Resistance	$\geq$ 6	ASTM C 373
3)	Chemical Resistance	Unaffected	ASTM C 650
4)	Abrasion Resistance (Hardness)	$\geq$ 100	ASTM C 501
5)	Breaking Strength	1400 kg/sq.cm	ASTM C 648
6)	Density	$\geq$ 2.0 Gm/CC	

6.48.18.2 Workmanship

The base course shall be in accordance with clause 6.48.3.2 and background surface shall be prepared as per **Clause 6.48.3.2** and IS: 4443.

Tiles shall be fixed on the prepared surface over a bitumen priming layer, bitumen mastic layer and resin type chemical resistant mortar. The bitumen shall conform to IS-702 and laying of bitumen mastic shall confirm to IS-1196.

Joints shall be allowed to set for 24 hours. The floor shall then be washed as per manufacturer's specifications to totally remove all marks from tile surface.

6.48.19 Epoxy Floor Coating

6.48.19.1 General

Epoxy floor coating shall consist of a solvent based, two pack system with epoxy resins and amine curing agents, chosen to withstand high degrees of chemical and abrasive action.

6.48.19.2 Materials

Screed

The screed shall be a solvent free combination of epoxy resin, modified amine hardeners filled with specially graded and selected chemically inert aggregates of high strength. The system shall include an epoxy resin primer and screed which are both supplied in pre-weighed units ready for on-site mixing and application.

Finishing Coat

An epoxy resin sealing coat of specified thickness shall form the topping coat.

6.48.19.3 Workmanship

Preparation of Surface

The surface shall be sound, clean and dry in order to achieve maximum adhesion with the primer coating.

Laying

The primer shall be applied by brush and shall be allowed to become tacky. The screed shall be prepared as per manufacturers specification and laid in specified thickness evenly over the base floor by trowel. The finished, cured screed shall have a slightly granular texture of uniform brown.

The epoxy resin topping shall be applied at least 24 hours after the laying of the screed. This topping shall be applied by brush or sprayed to a specified thickness in two coats with 3-5 hours interval between them. Care shall be taken to finish the topping perfectly smooth and devoid of any bubbles and unevenness. The newly laid floor shall be protected from dust or moisture and allowed to be used only after a minimum lapse of 48 hours

6.49 Painting

6.49.1 General

This section of specifications includes all requirements necessary for the white washing, colour washing, distempering, painting, and polishing of all surfaces specified herein or as may be necessary for the completion of the areas intended.

When shop priming, specified under other sections of these specifications is provided, this may serve as the first of the number of coats herein specified.

All materials required for the execution of painting work shall be obtained direct from approved manufacturers and shall be brought to the site in makers drums, kegs etc. with seals unbroken.

If in case of ready mixed paints, thinning if necessary, the brand of thinner shall be as per recommendations of the manufacturer.

Paint shall be applied by brushing or spraying. The brushing operations are to be adjusted to the spreading capacity advised by the manufacturer. During painting, every time after the paint has been worked out of the brush bristles, the bristles shall be opened up by striking the brush suitably.

Spray machine used may be of high pressure type or low pressure depending on the nature and location of work. After work, the brushes shall be completely cleaned off paint and shall be hung in a thinner if intended to be used afterwards. The spray guns shall be cleaned thoroughly after every break in work. The paint containers, when not used shall be kept close and free from air.

After the finishing of work, the adjacent surfaces not intended to be washed/ distempered/painted/polished, shall be thoroughly cleaned of all paint patches and shall be finished in accordance with surface finishing of such surfaces.

Refer Section-6A of Volume-II for the relevant IS Codes.

6.49.2 White Washing

White washing in general shall confirm to IS 6278.

6.49.2.1 Workmanship

Scaffolding

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be white/colour washed. For white washing of ceiling, proper stage scaffolding shall be erected.

Preparation of Surfaces

The surface shall be thoroughly cleaned of all dirt, dust, mortar dropping and other foreign matter before white wash is to be applied.

Surfaces already white/colour washed shall be broomed down to remove all dust, dirt, loose scales of white wash or other foreign matters.

All damaged portions of the surface plaster shall be removed to full depth of plaster in rectangular patches and plastered again after raking the joints in masonry properly. Such portions shall be wetted and allowed to dry before any operation.

All holes, cracks, patches etc. not exceeding 0.1 sq. m. in area shall be made good with material similar to that of the surface. Surfaces affected by efflorescence, moss, fungi, algae, lichen etc. shall be treated in accordance with IS 2395.

Preparation of White Wash

The fat lime confirming to IS 712 shall be slaked at site and shall be mixed and stirred with about 5 litres of water for 1 kg. of unslaked lime to make thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth. 4 kg of gum dissolved m hot water shall be added to each cubic metre of lime cream. Approved quality uttermarine blue conforming to IS 55 @ 3 grams per kg of lime shall also be added to the solution. The whole solution shall be stirred thoroughly before use.

Application

White wash shall be applied with 'Moonj' brush to the specified number of coats. The operation for each coat shall consist of stroke of the brush from the top to down wards, another from the down to upwards over the first stroke. Similarly one stroke horizontally from right and another stroke from the left. Each coat shall be allowed to dry before the next coat is applied.

The white washing on ceiling should be done prior to that on walls.

Protective Measures

Surfaces of doors, windows, floors etc. which are not to be white washed shall be protected from being splashed upon. Such surfaces shall be cleaned of white wash splashed if any.

6.49.3 Colour Washing

Scaffolding

Scaffolding shall be as per **Clause 6.49.2.1** above.

Preparation of Surface

Refer **Clause 6.49.2.1** above.

Preparation of Colour Wash

Sufficient quantity of colour wash enough for the complete job shall be prepared in one operation to avoid any difference in colour. The basic white wash solution shall be prepared in accordance with above **Clause 6.49.2.1**.Mineral colours of approved shade and quality not affected by lime shall be added to the white wash solution in proportions as directed by Employer. Solid lumps etc. in the colour powder shall be ground to fine powder, sieved and mixed evenly and thoroughly to the white wash solution.

Application of Colour Wash

Application of colour wash shall be in accordance with above **Clause 6.49.2.1**.

Protective Measure

Same as in **Clause 6.49.2.1** above.

6.49.4 Dry Distempering

Scaffolding

Same as **Clause 6.49.2.1** above.

Preparation of Surface

The surface shall be thoroughly brushed free from dust, dirt, grease, mortar droppings, other foreign matter and shall be made smooth by sand papering.

In case of distempering over existing distempered surface, the existing distempering shall be scrapped by steel scrappers leaving a clean surface.

All nails shall be removed. Pitting in plaster shall be made good with plaster of paris mixed with dry distemper of colour to be used. The surface then shall be rubbed down again with a fine grade sand paper and made smooth. A coat of distemper shall be applied over the patches. The surface shall be allowed to dry thoroughly before the regular coat of distemper is allowed.

The surface affected by moss, fungus, algae efflorescence shall be treated in accordance with IS 2395.

Priming Coat

A priming coat of whiting conforming to IS 63 shall be applied over the prepared surface. The priming coat shall be prepared by mixing 2.5 kg of whiting and one litre of glue solution (prepared by mixing 250 gm. glue conforming to IS 852 with boiling water) together and placing it in a covered vessel with enough water to cover the mixture which shall be left to cool until it becomes a jelly.

The application of priming coat shall be in accordance with above **Clause 6.49.2.1**

Preparation of Distemper

The dry distemper of approved shade and quality conforming to IS 427 shall be stirred slowly in clean warm water using 0.6 litres of water per kg of distemper. It shall be allowed to settle for at least 30 minutes before applying. The mixture shall be well stirred before and during use to maintain an even consistency.

Application of Distemper

After the priming coat has dried for atleast 48 hours, the surface shaft be lightly sand papered and dusted off avoiding rubbing off of the priming coat

Prepared distemper shall then be applied in minimum two coats with proper distemper brushes in horizontal strokes immediately followed by vertical ones which together shall constitute one coat. The subsequent coats shall be applied only after the previous coat has dried. The finished surface shall be even and uniform without patches, marks, distemper drops etc.

The application of a coat in each room shall be finished in one operation

After each days work, brushes shall be thoroughly washed in hot water and hung down to dry.

Protective Measure

Same as in **Clause 6.49.2.1** above.

6.49.5 Oil Bound Distempering

Scaffolding

Same as in **Clause 6.49.2.1** above.

Preparation of Surface

Preparation of surface shall in general be in accordance with above **Clause 6.49.2.1** except that any unevenness shall be made good by applying putty made of plaster of paris mixed with water including filling up the undulation and then sand papering the same after it is dry.

Primer Coat

The primer coat shall be alkali resistant primer or distemper primer and shall be of the same manufacture as oil bound distemper.

If the wall surface plaster has not dried completely, alkali resistant primer otherwise distemper primer shall be applied. The mixture of alkali resistant primer shall be prepared as per approved manufacturer's instructions.

The application of primer coat shall be in accordance with **clause 6.49.2.1** above.

Preparation of Oil Bound Distemper

The distemper shall confirm to IS 428 and shall be diluted with water or any other prescribed thinner recommended by the manufacturer.

Application of Distemper

After the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered and dusted off avoiding rubbing off of the primer coat. Minimum two coats of distemper shall be applied with brushes in horizontal strokes followed by immediate vertical strokes which together shall constitute one coat. The subsequent coats shall be applied after atleast 24 hours between consecutive coats to permit proper drying of the preceding coat.

The finished surface shall be even and uniform without patches, brush marks drops etc. Application of a coat in each room shall be finished in one operation.

14 cm. double bristled distemper brushes shall be used. After each days work/brushes shall be thoroughly washed in hot water with soap solution and hung down to dry.

Protective Measures

Same as in clause 6.49.2.1 above.

6.49.6 Waterproof Cement Paint

Scaffolding

Same as in **Clause 6.49.2.1** above.

Preparation of Surface

Preparation of surface shall be in accordance with **Clause 6.49.2.1**. The surface so prepared shall be thoroughly wetted with clean water before the paint is applied.

Preparation of Paint

Waterproof cement paint of approved make shall be mixed with- water and stirred to obtain a thick paste which shall then be diluted to brushable consistency. The proportion of mixture shall be as manufacturers recommendation. The paint shall be mixed in such quantity which can be used up within an hour of mixing to avoid setting and thickening of the paint.

Application of Paint

The surface shall be treated with minimum two coats of waterproof cement paint. No less than 24 hours shad be allowed between two coats and the subsequent coats shall be applied only after the preceding coat has become hard to resist marking by subsequent brushing.

The finished surface shall be even and uniform in shade without patches brush marks, paint drops etc. Cement paints shall be applied with a brush with relatively short stiff hog of fiber bristles.

Curing

Curing shall be started after the paint has hardened. Curing shall be done by sprinkling with water two or three times a day. This shall be done between coats and for atleast two days following the final coat.

Protective Measure

Same as In **Clause 6.49.2.1** above.

6.49.7 Acrylic Emulsion Painting

Scaffolding

Same as in **Clause 6.49.2.1** above.

Preparation of Surface

Same as in above **clause 6.49.5** under specification of oil bound distempering

Preparation of Mix

Plastic emulsion paint shall conform to IS 5411 (Part-1) and shall be of approved shade. Preparation of mix shall be as per manufacturer's instructions.

Application of Paint

The paint mix shall be continuously stirred while applying for maintaining uniform consistency. Number of coats shall be as per item description. The painting shall be laid evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard at first, then brushing alternately in opposite direction 2/3 times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks, no hair marks no clogging of paint puddles shall be permitted. The full process of crossing and laying off will constitute one coat.

The paint shall be applied by means of brush or roller.

Before starting painting with plastic emulsion paint, the prepared surface shall be treated with two coats of primer consisting of cement, primer, whiting and plastic emulsion paint shall start only after the preceding coat has become sufficiently hard to resist brush marking. Subsequent coats of plastic emulsion paint shall also be started after the preceding coat is dried by evaporation of water content.

The surface on finishing shall present a flat, velvety smooth finish, even and uniform shade without patches, marks, paint drops etc.

Precautions

a) Brushes shall be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush. Old brushes, if used shall be completely dried of turpentine/oil paints by washing in warm soap water.

b) No oil base putties shall be used in filling cracks/holes.

c) Washing of painted surface shall not be done within 3-4 weeks of application.

Protective Measures

Same as in **Clause 6.49.2.1** above.

6.49.8 Acrylic Copolymer Aggregate Finish

It shall be an acrylic based textured wall coating consisting of quartz and silica aggregate, inorganic pigments and other additives to form a crack free, flexible, tough, waterproof coating.

Preparation of Surface

The surface to be coated shall be cleaned and all dirt, dust, grease and loose particles shall be removed. Any old textured surface shall be removed with removing agent as per manufacturer's instructions.

Application

Bonding agent and water shall be mixed first. Then the flakes/granules shall be added and mixed thoroughly and kneaded till no lumps are found. The dough shall be left for 20-30 minutes before starting application. The bonding agent, flakes/granules and water shall be mixed in different ratios for different finishes as per manufacturer’s specifications.

The first application shall be by steel trowel. It shall be smoothened, if the specified finish requires, by a plastic trowel.

6.49.9 Painting to Woodwork

Preparation of surface shall conform to IS 2338 (Part-1) in general. All wood work shall be dry and free from any foreign manor. Nails shall be punched well below the surface. The surface shall be smoothened off with abrasive paper used across the grain prior to painting, with the grain prior to the staining. Any knots, resinous, or bluish sap wood, cutting out of which is not justified shall be covered with red lead conforming to IS 103.

Plywood and block board shall be treated in the same manner as for wood work.

Particle boards surface shall be filled with a thin brushable filler and finished as for solid wood.

Priming

Priming shall be in accordance with IS 2338 (Part I and II). Dirt or any other extraneous material on the surface shall be removed and the priming shall be applied by brushing.

Priming shad be done on all exposed and unexposed surfaces. Unless specified otherwise, all joinery work intended to be painted shall receive atleast 2 coats of primer.

Type of primer shall be in accordance with Table-1 and Table-2 of IS 2338 (Part-II).

Stopping and Filling

Stopping and filling shall be done after priming. Stopping shall be made to the consistency of stiff paste and shall be used to fill holes and cracks. Filter shall be used to level up slight irregularities of the surface. Filler shall be applied with a putty knife and subsequently rubbed down to a level surface with abrasive paper.

The filler coat shall be allowed to fully flatten and harden before subsequent coat is applied.

Application of Under Coat

Under coat shall be applied after the surface has been primed, stopped and filled, and rubbed down to a smooth surface. Under coat may be brushed or sprayed. After drying the coat shall be carefully rubbed down and wiped clean before the next coat is applied.

The type of under coat shall be depending upon the finishing and in accordance with Table-1 and Table-2 of IS 2338 (Part 11).

Finishing

The finishing paint shall be as specified in the item description and shall be applied either by the brush or by spraying.

Reference shall be made to the Table-1 and Table-2 of IS 2338 (Part-II)

Application of Clear Finishes

For the application of dear finishes, the following procedures shall generally be adopted in accordance with IS 2338 (Part-I)

i) Filling

Fillers shall be applied to prevent the excessive penetration of the finish to the surface for obtaining a smooth finish. Fillers shall be conforming to IS 345.

Fillers shall be heavily applied to the wood surface by hand, using hessian or jute rag across the grain. It shall be rubbed when still wet to get better penetration. After 5-10 minutes it shall be wiped off by and across the grain followed by a height wipe with the grain. The filled surface shall be dried preferably overnight and smoothened with abrasive paper.

ii) Staining

a) Spirit Stains

Spirit stains are solutions of spirit soluble dyes in Industrial methylated spirit.

b) Oil Stains

Oil stains are solutions of oil soluble dyes in lineseed oil, but usually consist of insoluble, semi-transparent pigments ground in lineseed oil and thinned with turpentine or other solvent.

c) Preparation of wood for Staining

Surface intended for staining shall be kept scrupulously clean and free from greasy finger marks. It shall be prepared by careful smoothing with fine abrasive paper used in the direction of the grain.

Small cracks/nail holes shall be stopped with plastic wood/fine plaster of paris. The stopping shall be rubbed down with fine abrasive paper when hard and touched with a thinned knotting before staining. In case of oil staining stopping shall be done after staining using tinted putty or wood filler.

d) Application of Stains

Stains shall be applied by brushing, and wiping or by spraying. The stain shall be so thinned that it can be applied fairly, liberally without over staining and over lapping.

iii) Sealing

A suitable sealer shall be applied on the filled and sanded surface to prevent absorption by the wood of the succeeding coats of finish and to seal stain and filler and thus preclude their bleeding into the finish coat.

Sealer may be sprayed on taking care not to flood the surface and it shall be allowed to dry hard.

When fully dry the surface shall be sanded taking care not to cut through at comers and edges. Dust shall be blown off and surface wiped with a clean rag.

iv) Finishing

The stained surface shall be varnished, wax-polished or trench polished as required after it is dried.

a) Varnishing

Varnishing of wood and wood based material shall be in accordance with IS 2338 (Part-I).

Surfaces to be Varnished shall be prepared to produce a smooth, dry and matt surface and all dust and dirt shall be removed from the surface.

The Varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with short light strokes to avoid frothing. It shall be allowed to flow out white the next section is being laid in. Excess Varnish shall be scraped out of the brush and then the first section be crossed, re crossed and laid off lightly. The Varnish, once it has begun to set, shall not be retouched. In case of any mistake, the Varnish shall be removed and the work shall be started afresh.

Where two coats of varnish are applied, the first coat shall be a hard drying under coating or flatting varnish which shall be allowed to dry hard and then be flatted down before applying the finishing coat. Sufficient time shall be allowed in between two coats.

When flat varnishing is used for finishing, a preparatory coat of hard drying undercoating of flatting varnish shall first be applied and shall be allowed to harden thoroughly. It shall then be tightly rubbed down before the flat varnish is applied. On larger areas, the flat varnish shall be applied rapidly, and the edges of each patch applied shall not be allowed to set, but shall be followed up whilst in free working conditions.

b) French Polish

French polish shall conform to IS 348. Suitable pigments shall be added to get the required colour.

The surface to be French polished shall be rubbed down to smoothness with sand paper and shall be well dusted. Pores in the surface shall be filled up with fillers.

A pad of woolen cloth covered by a fine doth shall be used to apply the finish. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil may be used on the face of the pad for the purpose. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and nigh gloss.

6.49.10 Painting to Steel and Other Metal Surface

6.49.10.1 General

(i) Items to be Painted

All structural steel work and metals including handrails, brackets and steel inserts shall be painted except if otherwise specified.

(ii) Standard

The operations, workmanship, schedules and equipment for painting shall generally comply with the requirements of IS:1477 (Part I & II) “Code of Practice for Painting of Ferrous Metals in Buildings” & IS 2524 except in so far as this Specification modifies it.

(iii) General Requirements

All surfaces shall be thoroughly cleaned of all foreign matters adhering to the steel surface to Swedish Standard specification Sa 2½ by means of blasting with sand. Use of scraper wire brush and pig hammer is acceptable wherever blasting with sand is not possible due to lack of access.

Air less spray shall be used for painting of all structural steel. Painting by brush shall only be allowed in places where use of air less spray not possible.

The finished coat shall be generally smooth, of a dense and uniform texture and free from sharp protuberances or pinholes. Each coating shall be checked for thickness by “Elcometer”. Areas where the thickness is less than what is specified shall receive additional treatment.

All operations such as handling & transportation etc. shall be carried out in a manner that there is no damage to the coating.

Painting shall generally be done immediately after cleaning. The cleaned surface shall not be allowed to stand overnight before painting. Where galvanised surfaces are to be painted, they shall be cleaned and washed with a solution of copper sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Employer.

(iv) Schedule

a) One coat of Organic Zinc Rich Primer (thickness, 60 m DFT).

b) Strip coat on each weld joint and edge of structure by surface tolerant Epoxy – 75 m DFT by Brush – One Coat

c) Two coats of High Build Abrasive Epoxy (DFT 100 m for each coat)

Total System Thickness = 250 m DFT without Strip Coat

d) Strip coat and one coat of high build epoxy should be immediately followed by primer. It is not permitted to keep organic Zinc Rick Primer exposed to atmosphere for long time.

e) Painting system shall be guaranteed for 5 (five) years.

After completion of erection and stanchion grouting, all the painted surface shall be carefully examined for any damage to the painting system and shall be rectified as directed by the Employer.

6.49.10.2 Preparation of Surface

The surface, before painting, shall be cleaned of all rust, scale, dirt and other foreign matter with wire brushes, steel wool, scrappers, sand paper etc. The surface shall then be wiped finally with mineral turpentine, which shall then be removed of grease etc. The surface then shall be allowed to dry.

In case of GI surface, surface so prepared shall be treated with Mordant solution (5 litres for about 100 sqm) by rubbing the solution generously with brush. After about half an hour, the surface if required shall be retouched and washed down thoroughly with clean cold water and allowed to dry.

6.49.10.3 Application of Priming and Paints

Approved quality primer and paint in specified no. of coats shall be applied as per manufacturer's recommendations either by brushing or spraying. Each subsequent coat shall be applied only after the preceding coat is dried.

6.50 Sanitary and Plumbing Works (Buildings)

6.50.1 General

The work comprises supply, installation, commissioning and testing of sewerage and drainage, sanitary fixtures and fittings within including water supply the building and upto 1.0 m outside the building wall. The work includes supply of all materials as per specifications and drawings, laying, fitting, fixing, installation and commissioning of the same.

All the water supply and sanitary works shall be carried out by the licensed plumbers approved by the Employer and skilled workmen, experienced in the trade.

All works shall be completely concealed either within shafts or chases or in fills and dropped ceilings unless specifically shown in drawings or required otherwise.

All work shall be adequately protected, to the satisfaction of the Employer, so that the whole work is free from damage throughout the period of construction upto the time of handing over.

No work shall be covered without approval of the Employer.

The Contractor shall be responsible for coordinating the work with works of other trades sufficiently ahead of time to avoid unnecessary hold-ups. Hangers, sleeves, recesses, etc. shall be left in time as the work proceeds whether or not these are shown in drawings.

All clamps, screws, brackets, hangers and all miscellaneous steel work needed in the work shall be fully galvanized.

Only specified brand of material will be used subject to the approval of the sample.

The Contractor shall submit as directed by the Employer samples, manufacturer’s drawings, equipment characteristics and capability data etc. of all equipment, accessories, devices etc. that he proposes to use in the installation, to the Employer for approval.

The Contractor shall prepare and submit to the Employer for approval before the work is commenced, all drawings.

The work shall commence only after the drawings are approved by the Employer.

Before the work is handed over, the Contractor shall clean all fixtures removing all plaster, stickers, rust stains and other foreign matter of discoloration of fixtures, leaving every part in acceptable condition and ready for use, to the satisfaction of the Employer.

All sanitary ware and fittings shall conform to IS standards. The Contractor shall submit samples of all fittings and fixtures proposed to be used to the Employer for his approval. The approved samples shall remain with the Employer till the completion of the work.

All workmanship shall conform to Indian Standard Codes of Practice. The fixing and finishing shall be neat, true to level and plumb. Manufacturer’s instructions shall be followed closely regarding installation and commissioning.

All fixtures shall be protected throughout the progress of the work from damage. Special care shall be taken to prevent damage and scratching of fittings. Tool marks on exposed fixtures shall not be accepted. Protective paper on fixtures shall be removed with hot water only at the final completion of work.

All the water supply, drainage and sanitary works shall be carried out strictly as per specifications, ISI codes and National Building Code with amendments upto date.

6.50.2 Bye-Laws and Regulations

The installation shall be in conformity with the Bye-laws, Regulations and Standards of the local authorities concerned of Assam, in so far as these become applicable to the installation. But if these Specifications and Drawings call for a higher standard of materials and/or workmanship that those required by any of the above regulations and standards, then these specifications and drawings shall take precedence over the said regulations and standards. However, if the drawings and specifications require something, which violates the Bye-laws and Regulations, then the Bye-laws and regulations shall govern the requirement of this installation.

6.50.3 Fees and Permits

The Contractor shall obtain all permits/licenses and pay for any and all fees required for the inspection, approval and commissioning of their installation and shall bear all expenses if any for the same.

6.50.4 Completion Certificate

On completion of the installation for Plumbing, a certificate shall be furnished by the Contractor. This certificate shall be in the prescribed form as required by the local authority.

The Contractor shall be responsible for getting the entire installation approved by the authorities concerned as required and shall bear expenses if any, in connection with the same.

6.50.5 Maintenance During Defects Liability Period

Contractor shall be required to carry out the maintenance of the Plumbing installation during defect liability period.

The Contractor shall receive calls for any and all problems experienced in the operation of the system under this Contract, attend to these within 10 hours of receiving the complaints and shall take steps to immediately correct any deficiencies that may exit.

All equipment that require repairing shall be immediately serviced and repaired.

6.50.6 Water Supply

6.50.6.1 G.I. Pipes& Fittings

G.I. Pipes

All pipes for water supply inside the building shall be genuine galvanised steel tubes conforming to IS:1239 Part I (heavy grade ‘C’ class pipe).

The GI pipes shall be of approved make as per the list of approved makes.

G.I. Fittings

All fittings shall be malleable cast iron fittings as per IS:1879 (or as revised). All fittings shall have manufacturer's trademark stamped on it. Fittings in G.I. pipelines shall include elbows, tees, bends, reducers, nipples, union, bushes, G.I. Clamps of approved design, G.I. flanges with 3 mm rubber insertion, nuts, bolts, washers, etc. All fittings shall be tested at manufacturer's works. Contractors may be required to produce certificate to this effect from the manufacture.

Laying and Jointing of G.I. Pipes (External)

a) Trenches

The galvanised iron pipes and fittings shall be laid in trenches. The widths and depths of the trenches for different diameters of the pipes shall be as in Table below:

Table 6.18: Trench & Pipe Dimension

Dia of Pipe	Width of Trench	Depth of Trench
15 mm to 50 mm	30 cm	60 cm

At the joints the trench width shall be widened where necessary. The work of excavation and refilling shall be done true to line and gradient in accordance with general specifications earthwork in trenches.

b) Cutting and Threading

Where the pipes have to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be carefully threaded conforming to the requirements of IS:554-1964 with pipe dies and tapes in such a manner as will not result in slackness of joints when the two pieces screwed together. The screw threads of pipes and fittings shall protected from damage until they are fitted.

c) Jointing

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped around the screwed end of the pipes. The end shall then be screwed in the socket, tee etc. with the pipe wrench. Care shall be taken that all pipes and fittings are properly jointed so as to make the joints completely water tights and pipes are kept at all times free from dust and dirt during fixing. Burr from the joints shall be removed after screwing. After laying, the ends of the pipes shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

d) Pipe, Coating & Wrapping

All underground pipes shall be protected by pipecoat primer and pipecoat wrapping. The pipe coat primer shall have a density of 0.92 gm/cc and drying time of 24 hours at RH 70% and temp 30 deg. C. Viscosity shall be 1000 – 2000 cps.

The pipe coat shall be a puncture resistant non-woven polyester mat 4 mm thick of high mechanical strength. The mat shall be in 7 layers. The layers shall be so arranged as to also give extra protection to high molecular high density polythene core which is the main permeable agent in the system.

Pipecoat primer shall be applied on the pipe in a uniform coat leaving no drop runs.

The entire surface of pipe shall be primed without any patch left out. Unprimed surfaces shall reprimed immediately. Any uncleaned pipe shall be scraped down to surface of pipe and reprimed pipecoat primer shall essentially be in a layer for quicker drying.

The surface shall be dry at the time of applying pipecoat primer. Freshly primed pipe shall be placed on clean square cut skids and shall not be allowed to come in contact with ground or any foreign matter. It shall remain on skids until lifted or cradled after coating and wrapping operation.

All primed pipes which have excessive coat of dust accumulated over them before primer is dry or where primer has become dead, shall be primed. Drying time shall be minimum 245 hours. The application of pipecoat membrane shall be taken up soon after primer coat has dried up completely and in case within three days after priming. Otherwise fresh coat of primer shall be applied.

Membrane shall be blown under tension by means of a blowtorch. In this process, the inner surface of the membrane, being 10 micron thick polyethylene layer is burnt while at the same time the polymeric mix under it is softened taking care that the centre core is not over heated. This molten polymeric mix is then pressed over pipe surface so that no air is entrapped or voids formed underneath.

Pipecoat primer shall be applied with brushes after cleaning the pipe thoroughly. Pipecoat membrane shall be wrapped as mentioned above.

No wrinkling of the wrapper shall be allowed and all overlaps shall be firmly fused to secure a firm wrapping. Coating shall be absolutely free from pinholes, bubbles and holidays.

6.50.6.2 Testing of Joints

After laying and jointing, the pipes and fittings shall be inspected under working condition of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra cost.

The pipes and fittings after they are laid shall be tested to hydraulic pressure of 1.5 times the working pressure. The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock or water hammer. The draw of traps and stop cocks shall then be closed and specified hydraulic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrated before the test. The test pump having been stopped, the test pressure should be maintained without loss for at least two hours. The pipes and fittings shall be tested in sections as the work of laying proceeds, having the joints exposed for inspection during the testing.

6.50.6.3 Trench Filling

The pipes shall be laid on a layer of 7.5 cm sand and filled upto 15 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth as specified and directed and the surplus earth shall be disposed off as directed by the Employer.

6.50.6.4 Laying and Jointing G.I. Pipes (Internal Work)

Cutting, threading ad jointing – Ref. **Clause 6.50.6.1**.

6.50.6.5 Fixing of GI Pipes

All exposed GI pipes shall be fixed by means of standard pattern holder bat clamps, keeping pipes 1.5 cm clear of the wall. If the pipes are fixed in chases they shall be fixed in position by iron hooks.

6.50.7 Soil, Waste, Vent and Rain Water Pipes and Fittings

Cast Iron Pipes and Fittings

Cast iron pipes and fittings to IS:3989 shall be used for soil, waste and vent pipes. Pipes and fittings with irregular bore, blow holes and other manufacturing defects shall not be allowed to be used for work.

All fittings shall be of the degree specified or as required at site.

All cast iron soil, waste, vent and rain water pipes used at basement in exposed condition or where specified shall be centrifugally cast spun iron class (LA) pipes conforming to IS 1536. These shall be with spigot an socket ends.

The fittings for centrifugally cast spun iron pipes conform to IS 1538.

Holder Bat Clamps

Holder bat clamps shall be of a standard design fabricated from MS galvanised flat 32 x 1.5 mm thick and 12 mm dia. M.S, bar and 6 mm nuts and bolts. Holder bat clamps shall be fixed in cement concrete (1:2:4) blocks 100 x 100 x 100mm.

M.S. Stays and Clamps

The clamps shall be made from 2.0 mm thick MS flat of 32 mm width, bent to the required shape and size to fit tightly on the socket, when tightened with screw bolts. It shall be formed of two semi-circular pieces with flanged ends on both sides with holes to fit in the screws, bolts and nuts, 40 mm long. The stay shall be minimum one metre long of 10 mm dia MS bar. One end of the stay shall be bent for embedding in the wall in cement concrete block of size 20 x 20 x 20 cm in 1:2:4 mix (1 cement: 2 coarse sand : 4 graded stone aggregate 20 mm nominal size). The concrete shall be finished to match with the surrounding surface.

Floor Traps

Floor taps shall be cast iron deep steal type P or S traps with a minimum seal of 75 mm. they shall be with or without vent. All traps shall be set in cement concrete blocks 1:2:4 mix without additional cost. Traps shall be provided with CP brass screwed down or hinged grating. Traps shall be provided with suitable extension piece where required with CP brass grating to flush with the floor without any extra cost.

Paintings

All pipes in ducts and exposed positions shall be painted with two coats of synthetic enamel paint of any colour approve by the Employer over a coat of primer of approved quality.

6.50.7.1 Concrete

All soil ad waste pipes below ground floor fills and in wall chases (but not in open ducts) shall be supported and covered with 75 mm cement concrete 1:2:4 in bed and all around. Encasement of such pipes shall be done after testing of pipes.

6.50.7.2 Cutting and Making Good

All pipes shall be fixed and tested as building work proceeds. Cutting and chasing shall be kept to minimum. No extra shall be allowed for cutting holes, chases etc. in wall and floors.

6.50.7.3 Jointing

All joints for CI soil waste and vent pipes conforming to IS:1729/IS:3989 shall be made with maleable pig lead and spun yard. Pig lead shall conform to IS:782 for caulking. Spun yard shall be of hemp and of good quality. It shall be soaked in hot coal-tar or bitumen and cooled before use. The quantity of lead to be filled per joint in various sizes of cast iron drainage pipes shall be as follows:

50 mm dia	=	0.75 kg.
80 mm dia	=	0.80 kg.
10 mm dia	=	0.90 kg.
150 mm dia	=	1.60 kg.

The joints for all CI centrifugally cast (Spun) iron pipes conforming to IS:1536 and fittings conforming to IS:1538 shall be made with pig lead. The quantity of lead per joint in various sizes of these pipes shall be as follows:

80 mm dia	=	1.8 kg.
100 mm dia	=	2.2 kg.
150 mm dia	=	3.4 kg.
200 mm dia	=	5.0 kg.
250 mm dia	=	6.1 kg.

6.50.7.4 Testing

All soil, waste and vent pipes shall be tested by filling up the whole or part of stack with water. All openings for connections, etc. shall be suitably plugged.

Contractor shall remove and replace all pipes having holes, cracks, etc. All leaking joints and access doors shall be replaced or remade to the entire satisfaction of the Employer. Water shall be retained in stack for a maximum period of 2 hours. After all plumbing fixtures are installed, Contractor shall apply the smoke test to the entire stack to the satisfaction of the Employer.

The smoke test shall be carried out as under.

Smoke shall be pumped into the pipes at the lowest end from a smoke machine which consists of a bellow and burner. The material burnt shall be greasy cotton waste which gives out to a clear pungent smoke easily detectable by sight as well as by smell if there is leak at any point of drain.

6.50.8 Sanitary Fixtures and Fittings

6.50.8.1 General

All sanitary fittings are glazed earthen ware shall be ‘Hindustan Sanitary Ware/Nycer/Parry’ or equivalent of approved make, white in colour and of one piece construction. All metallic fixtures like taps, stop cocks, soap holders etc. shall be of CP brass ‘Parco’, ‘GEM’ or approved equivalent make. PVC fixtures shall be of ‘Caliplast’, ‘Brite’ or equivalent approved make. All wall fittings shall be fixed with wooden cleats and CP brass screws and washers.

6.50.8.2 Workmanship

All sanitary ware shall be fixed in a neat workmanlike manner, true to the level and plumb. Manufacturer’s instructions shall be followed closely regarding installation and commissioning. Cutting or making good of tiles is not permitted anywhere while fixing of fixtures and fittings.

6.50.8.3 Protection of Fixtures

Fixtures shall be protected throughout the progress of the work from damage. Special care shall be taken to prevent damage and scratching of chromium plated fittings. Tool marks on chromium fixtures etc. shall not be accepted.

6.50.8.4 Sanitary-ware

6.50.8.4.1 Indian Type Water Closet

Orissa Pan W.C. shall be 580 mm long conforming to IS:2556 Part III. The closet shall be fixed I the floor with 150 mm thick sand cushion and shall be connected with 100 mm dia C.I. or stone ware S or P trap. The closet shall also be fitted with a low level earthen ware cistern conforming to IS 774 of 12½ litres capacity with wiped solder joints, internal overflow arrangement, 40 mm dia C.P. flushing pipe. The cistern shall be fixed on MS or CI Brackets at a minimum height or 610 mm from top of pan. All exposed metallic surfaces shall be painted with two coats of white enamel paint of approved quality over a coat of primer.

Orissa Pan type W.C. of size 580 mm long with concealed 32 mm dia flush valve push button/lever with regulator or ‘Nelson’, ‘Orient’ or approved equivalent, CP flush pipe and clamp with rubber joint to W.C. complete including cutting walls and floors and making good the same.

6.50.8.4.2 Wash Down Type Water Closet

Wash down water closet shall be pattern 1 conforming to IS:2556 Part II. This shall be fixed with plastic seat and cover as per IS:2548 of ‘Brite’ or approved equivalent make, fixed with CP brass hinges and rubber buffers and an integral 100 mm dia ‘S’ or ‘P’ trap with anti-syphonage vent horn.

A low level earthenware cistern conforming to IS:774 of about 10 litres capacity, with 15 mm dia PVC inlet pipe and brass union with wiped solder joint, internal overflow arrangement, 40 mm dia CP brass flushing pipe, CI or MS supporting brackets shall be fixed with the water closet. The closet shall be fixed firmly in the floor with matching cement mortar. All exposed metallic surface shall be painted with two coats of white enamel paint of approved quality over a coat of primer. The cistern shall be fixed at a height not exceeding 300 mm between the top of the pan and the underside of the cistern.

6.50.8.4.3 Urinals

Half stall type urinal shall be conforming to IS:2556 Part VI. These shall be mounted on walls. The flushing inlet pipe shall be of CP brass 15 mm dia and waste pipe 32 mm dia G.I. 750 mm long, with necessary unions and CP bottle trap.

Rawl plugs with CP brass screws, shall be used for fixing the urinal. Fixing shall ensure that no liquid is left over in the pan after flushing. Unless otherwise indicated height above finished floors shall be 650 mm.

Urinals shall be connected to automatic flushing cistern either individually, or in groups where individually connected to flushing cistern, the cistern capacity shall be 5 litres. For two urinals, one cistern of 10 litres capacity and for three urinals, one cistern of 15 litres capacity shall be provided.

Cistern inlet shall be 15 mm dia PVC pipe with brass union. Outlet pipe from cistern shall be 25 mm CP brass main, with 15mm CP distributor pipe of sufficient lengths to reach each bowl. Where individual cisterns are provided, the outlet shall be of 15 mm CP brass. All expose metallic surfaces shall be painted with two coats of approved white enamel paint over a coat of primer, cistern interior

shall be painted with two coats of anticorrosive paint of approved quality, wherever called for the waste from urinals shall be collected and disposed through concealed pipes and suitable means to clean and maintain the system shall be provided.

6.50.8.4.4 Wash Basin

Wash basin shall be flat back of 550 mm x 400 mm size with one tap or two tap hole confirming to IS:2556 Part –IV. This shall be fitted on CI or MS brackets conforming to IS:775. Brackets shall be given two coats of white enamel paint or enamel paint or aluminium paint, over a coat of primer.

The wall side shall be fixed well flushed with the plaster of wall and the joint if any, shall be properly stopped with mortar and painted white. Pillar cocks, PVC connecting pipe with brass union, a CP brass bottle trap with union, CP brass chain and rubber PVC stopper, 32 mm dia, GI waste pipe shall also be supplied and fitted with the wash basin, the top of rim of the wash basin shall be fixed at 800 mm above finished floor level unless otherwise specified.

6.50.8.4.5 Mirrors

The mirror shall be of the best quality of 'Atul'/'Swastic' or equivalent approved make of size 600 mm x 650 mm x 5.5 mm thick. The mirror shall have ½" thick commercial board backing and shall be provided with aluminium beading all around. It shall be fixed to the wall on wooden blocks with CP brass screws and CP washers.

6.50.8.4.6 Sink

Providing and fixing stainless steel sink of size 485 mm x 385 mm c 190 mm deep or nearest equivalent with R.S. or CI brackets, 40 mm CP waste, CP brass chain and rubber plug, 4 mm CP. Cast brass bottle trap, with pipe to wall and CP wall flange, rubber adapter for waste connection.

6.50.8.4.7 Towel Rail

Towel rail shall be of aluminium/C.P. brass pipe with suitable brackets. The tower rail shall be 20 mm dia and 1.25 mm thick 600 mm long. It shall be approved by the Employer. It shall be fixed at specified locations shown in the drawing or as directed by the Employer.

6.50.8.4.8 Liquid Soap Container

The liquid soap container shall be of superior quality chromium plated brass of 'PARCO', GEM make or equivalent as approved by the Employer.

It shall be fixed with CP brass screws on wooden cleat.

6.50.8.4.9 Showers

The shower head shall be chromium plated brass, 100/150 mm dia with holes of one millimeter diameter each is sufficiently large for all ordinary requirements. It shall be fixed at a height of 2.0 m from floor level or as directed by Employer. It shall conform to IS:2064.

6.50.8.4.10 Toilet Paper Holder

Toilet paper holders shall be of chromium plated brass as approved by the Employer. It shall be 100 mm long. It shall be fixed on wooden cleats as directed by Employer.

6.50.8.4.11 Coat and hat Hooks

Coat and hat hooks shall be chromium plated brass of 'Ego' or equivalent as approved by Employer. They shall be fixed on teak wood plate of 75 mm x 75 mm and 12 mm thick. Teak wood plate shall be properly polished. Wooden cleats shall be inserted in wall to fix wooden plates. CP brass screws shall be used.

6.50.8.4.12 Bib and Stop Cocks

Bid and stop cocks of screw-down type shall conform to IS:781. All taps shall be of heavy grade. The taps shall be chromium plated brass or ordinary brass easy cleaning type as specified.

6.50.8.4.13 HCl Nahni Trap (Floor Trap)

Nahni trap shall be of heavy cast iron as per IS:3989 with 100 mm inlet and 80/100 mm outlet with CP pressed steel grating. It shall be of self-cleaning design (Grating shall be of either hinged or screwed down type).

It shall be fixed in cement mortar 1:2 and as directed by Employer.

6.50.8.4.14 Stoneware Gully Trap Chamber

The square mouth gully trap shall be of 100 mm dia, conforming to IS:651 of specified and/or approved quality stoneware, complete with cast iron grating, and shall be got approved by the Employer. The size of CI frame and cover shall be 300 mm x 300 mm. It shall be properly fixed as directed by the Employer.

The size of the chamber shall be 300 x 300 x 675 mm (internal). It shall be constructed of brick masonry walls 115 mm thick in 1:4 cement mortar and M-15 concrete foundations. Inside and outside faces of the masonry walls shall be plastered with 1:3 cement mortar. The top of the chamber shall be provided with CI cover and frame.

6.50.8.4.15 Brick Masonry (Manholes/Inspection Chamber & Valve Chamber)

The size of the manholes and valve chambers shall be as specified in the drawings. It shall be constructed of brick masonry walls 230 mm thick in CM 1:4 (1 cement:4 sand) resting on M-15 concrete foundations. The inside and outside faced of the masonry wall shall be plastered with 13 mm thick plaster of cement mortar 1:3 (1 cement: 3 sand).

The top of the chamber shall be provided with reinforced concrete M-20 grade slab as per drawing and directions of the Employer.

MS rungs made out of 16 mm dia MS bars shall be fixed inside the manhole as shown in the drawing after applying two coats of anticorrosive paint.

Valve chambers shall be provided and fixed with a light duty CI cover and frame.

The top of chamber shall be provided with reinforced cement concrete M-15 grade as per drawings and direction of the Employer.

The CI manhole covers and frames shall conform to IS:726. The type, size and grade shall be as per drawing and direction of the Employer.

The frame shall be fixed in position during concreting of top slab, inside faces of frame and cover shall be given two coats of approved anti-corrosive paint.

The specification for brick masonry, plastering, concreting, excavation and back filling, etc. as given under relevant clauses shall be applicable for this work also.

6.50.8.4.16 Gun Metal Valve

All full way and globe valves shall be heavy gunmetal and tested at 300 psi and shall be approved by the Employer. Valves shall conform to IS:778. Size of valve chamber shall be as per item description, construction of valve chamber shall be carried out as detailed above. Valve chamber shall be provided & fixed with heavy duty CI surface box conforming to IS:3950. The surface box shall be hinged pin open type & shall be fixed in the chamber slab. It shall have a hole for opening.

6.50.8.4.17 Marble Partitions

The marble partition shall be 25 mm thick and approved by the Employer.

The edges of marble shall be cut by machine to have proper smooth edges.

Vertical face shall be fixed in position with cement mortar (1:3) as directed by the Employer for minimum depth of 100 mm in the wall. It shall be polished after fixing. Two horizontal faces shall be supported by MS channels of size 35 mm deep embedded into wall.

6.51 Internal Electrification Work of Buildings

6.51.1 General

LT power distribution shall be done by installing 6.6/0.433 kV transformer and LT panels, Power Control Centre in substations.

LT power for internal lighting, electrical fittings, air condition & ventilation of all the buildings shall be taken from the respective feeder pillars and distributed inside the building using standard distribution boards as required. The list of the buildings is as follows:

- IWT Administration building
- Port in call office
- Custom’s office building
- Workshop (to be built by operator)
- Canteen & Restroom
- Weigh Bridge building (to be built by operator)
- Storage Sheds
- Security Cabin – 2 Nos.
- Main Receiving Station & Substation
- Watch Towers

- Raw and Fire water pumps and Miscellaneous

One DG set of 365 kVA would be provided to meet the emergency power load requirement.

6.51.2 Scope of Work

i) The scope of work covers design, supply, installation, testing and commissioning of complete electrical distribution system in all respect and shall include but not limited to the following:

ii) All Air-conditioning and ventilation work related to building as mentioned in foregoing paragraph.

iii) Internal illumination and electrification of building including wiring & installation of fixtures, switches, sockets, fans, conduits, brackets, junction boxes, main power distribution board at respective buildings, LT switch panels, sub-distribution board, etc.

iv) The illumination levels shall be in line with national building code and relevant IS codes as referred in subsequent paragraph.

v) Complete earthing & lightning protection system comprising of earth stations, earthing conductors including all accessories & hardware.

vi) Computer, internet, Local Area Network (LAN) and telephone wiring with sockets, wires and conduits, etc.

vii) All civil works related to cut outs on walls for taking cables, drilling & fixing of fasteners for fixing of fixtures/cables/ conduits etc.

viii) Coordination with other Contractors wherever required.

ix) Since the project/works is on EPC basis, the items/components not specifically mentioned but are required for proper functioning of works shall be considered and included in the bid.

6.51.3 Codes and Standards

Refer **Section 2 of Volume-II**.

6.51.4 Internal Electrical Works

6.51.4.1 General

The Scope of work under Internal Electrical Works shall cover the supply, installation, testing and commissioning of the complete Internal Electrical Installation.

a) Design, manufacture, supply, installation, testing and commissioning distribution boards for Power Lighting & Emergency Supply.

b) Supply, installation, testing and commissioning of light control switches, lighting and power receptacle units, all wiring and submains, conduiting including point wiring, circuit wiring along with wiring accessories and all other items necessary for lighting system. All internal wiring shall be in recessed with UPVC conduits and surface with MS conduits.

c) Obtaining approvals from the Chief Electrical Inspector and all other statutory authorities for the completed scope of work.

It is not the intent to specify completely herein all aspects of design and constructional features of equipments and details of the work to be carried out, nevertheless, the equipment and work shall conform in all respects to high standards of Engineering, design and workmanship and shall be capable of performing in continuous operation in a manner acceptable to the Employer who will interpret the meaning of the specifications and drawings and shall have right to reject or accept any work or material which in his assessment is not complete to meet the requirement of this specifications and or applicable code and standards mentioned elsewhere in this specifications.

6.51.4.2 Fabrication Drawings

The Contractor shall submit all the fabrication details based on the equipment offered in the tender for the approval of the Employer before commencing the work. The details shall contain all setting out details and physical dimensions of all fabrication works, equipment offered and their foundation/mounting details.

6.51.4.3 Brochures and Data

The Contractor shall submit four copies of all brochures, Contractor's description data and similar literature. One copy will be returned to the Contractor after approval.

6.51.4.4 Scale

Electrical layout plans shall be drawn to the scale as established on drawings and shall indicate the size and location of all equipments and accessories herein. The Contractor shall obtain all dimensions preferably at the site and check those plans for interference with the building structure and other equipment.

6.51.4.5 Approval

The Employer's approval of such drawings, schedule, brochures, etc. will be an approval of general details and arrangements only and shall not relieve the Contractor from responsibility for deviation from drawings or specifications unless he has in writing called the Employer’s attention to such deviations at the time of submission nor shall it relieve the Contractor from responsibility for errors or omissions of any kind in the shop drawings when approved.

6.51.4.6 Storage

All materials and equipment shall be stored properly to the satisfaction of the Employer so that physical handling and climatic conditions do not affect the equipment.

6.51.4.7 Cutting & Patching

Cutting, patching and redoing shall be kept to the minimum. Wherever such works are required to be carried out, necessary permission shall be obtained from Employer before cutting and patching up. Those shall be subsequently furnished properly to the satisfaction of Employer. Care shall be taken to prevent spreading of equipment and finishing.

6.51.4.8 Protection

All work, equipment and material shall be protected at all times to prevent obstructions, damage or breakage. All equipment shall be covered and protected against water, dust, sand as well as chemical and or mechanical damage. At the completion of the work, all equipment shall be thoroughly cleaned and delivered in a perfect unblemished and working conditions.

6.51.4.9 Vibration noise Isolation

The Contractor shall provide equipment vibration isolation base for floor mounted equipment. Bases shall be separated from building floor by means of approved vibration isolation pads to be provided by the Contractor.

6.51.4.10 Maintenance and Operation

The Contractor shall advise the operating personnel of the Employer in the maintenance and operation of installation, including necessary training to the Employer's personnel at no extra cost.

6.51.4.11 Lighting System Equipment

6.51.4.11.1 General

This specification covers the design, manufacture, testing, inspection and delivery to site of lighting system equipment such as light control switches, lighting and power receptacle units, wires, ceiling fans, lighting fixtures, conduits and other similar items necessary for lighting system.

Sub-Distribution Boards (Normal & Emergency)

6.51.4.11.2 Constructional Features

Boards shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP:52. The sheet steel used shall be cold rolled and 2 mm thick.

All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketted all round with neoprene gaskets. For wall mounting, lighting panels when provided with MCBs, a hinged, latched front door shall be provided with key-locking facility and a slotted backelite sheet shall be provided inside. Only the MCBs operating knobs shall project out of the backelite sheet slots for safe operation and neat appearance.

All accessible live connections/metals shall be shrouded, and it shall be possible to change individual MCBs from the front of the boards/panels without danger of contact with live metal.

Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.

Two earthing terminals shall be provided to suit the Employer's earthing conductor.

All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognised phosphating process. The steel works shall then be painted with two coats of Zinc-chromate primer and two coats of final stove-enamelled finish paint of colour. For chemical/corrosive areas, epoxy paint shall be used.

6.52 Busbars

6.52.1 Busbars shall be of aluminium alloy of E91E grade.

Busbars shall be provided with at least the minimum clearances in air as per applicable standards for a 500V, 3 phase system.

Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers and contacts does not exceed 85oC under site reference temperature.

The busbars, busbar connections and busbar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the fuse/MCB's let through/cut-off current associated with the specified short-circuit level of the system.

Busbar supports shall be made from suitable insulating material such as Hylamsheets, glass reinforced moulded plastic materials, permmali wood or cast resin. Separate supports shall be provided for each phase of the busbars. If a common support is provided for all three phases, anti-tracking barriers shall be incorporated.

The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase busbars. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase busbars. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

6.53 Panels/Boards' Component Equipment

6.53.1 Miniature Circuit Breakers (MCB)

MCBs shall be hand operated, air break, quick make, quick break type conforming to applicable standards.

MCB shall be provided with overload/sort-circuit protective device for protection under overload and short-circuit conditions. The minimum breaking capacity of MCBs shall be 9 kA r.m.s. at 415V.

DB's shall be provided with locking facility.

6.53.2 Internal Wiring

Panel/boards shall be supplied completely wired, ready for the Employer's external connections at the terminal blocks. Wiring shall be carried out with 1100/650V grade, FRLS, PVC insulated, stranded copper conductors. Conductors of adequate size shall be used to suit the rated circuit current.

Engraved identification ferrules marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded, 550V, of reputed make, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20A.

Terminals for circuits with voltage exceeding 125V shall be shrouded.

Terminals shall be numbered and provided with identification strip for identification of the circuit.

6.53.3 Labels & Diagram Plate

All door mounted equipment as well as equipment mounted inside the switchboards/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/panel as furnished by the Employer.

Labels shall be made of non-rusting metal, 3-ply lamicoid or engraved PVC.

Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

6.53.4 Light Control Switches

Light control switches of ratings and types, i.e. decorative shall be supplied. The switches shall be grid plate type/Piano Key type suitable for use on 240V, 1 Phase, 50 Hz supply.

Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The switch box/enclosure may be recessed into or mounted on a wall as per the requirements of project layouts.

The size of enclosure boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 18 gauge sheet steel stove-enamelled/galvanized. The enclosure box shall be covered with perspex/insulating cover. An enclosure intended for surface mounting shall not have holes or gaps in its sides mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

6.53.5 Receptacle Units

Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch or MCB shall be flush mounted within a stove enamelled/galvanized 18 gauge steel enclosure with perspex/insulating cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.

The receptacle units shall be suitable for 240V, 1 phase, 50 Hz/415V, 3 phase, 50 Hz supply as indicated.

Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in "ON" position.

The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

The types and current rating of receptacle units shall conform to the applicable standards.

Whenever required, receptacle units may be provided with MCBs instead of switch.

6.53.6 Lighting Wires

The wiring of lighting system shall be carried out through 650/1100V, PVC insulated, FRLS, unarmoured, stranded copper conductors, unless otherwise specified. The wires shall conform to the applicable standards.

The minimum area of conductors shall be 1.5 sq.mm for point wiring of light fittings and 5A receptacles and 4.0 sq.mm for receptacles rated 15A. The Circuit wiring for light fitting shall be with 2.5 sq.mm stranded copper conductors.

The wires shall be coated red, yellow, blue for R, Y, B phase and black for neutral and green for earthing.

The approximate quantities of wires shall be indicated by the Employer only when the same are not covered in the Contractor's "Point Wiring" work under lighting system installation work.

Unless otherwise specified, lighting cables shall be of 650/1100V grade, 3, 3½ and 4C, PVC insulated and armoured type for main distribution boards.

6.53.7 Conduits

MS or UPVC (Unplasticised PVC) conduits and their associated fittings as per sizes shall conform to applicable standards. The minimum size of conduit shall be 20 mm.

Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

6.53.8 Junction Boxes

Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.

The junction boxes shall be dust and vermin proof and shall be fabricated from 14 gauge sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather-proof when specified.

The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, HRC fuses, etc.

The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600V grade, one piece construction complete with terminals, insulation barriers, galvanized nuts, bolts and washers and provided with identification strips of UPVC/MS. The terminals shall be made of copper alloy and shall be of box clamp type.

The boxes shall be painted with one shop coat of Red oxide Zinc chromate primer followed by a finishing coat of paint as specified.

6.54 Lighting System Installation Work

6.54.1 General

This specification indicates the requirements of lighting system installation work. The installation, testing and commissioning of complete lighting system and power receptacles shall be carried out in accordance with the Lighting Installation Notes, the Employer's Drawings and as stipulated in this specification and Data Sheets. Separate Specifications when enclosed, cover the requirements of lighting equipment supply.

6.55 Ventilation System Equipment

6.55.1 Ceiling Fans

Ceiling fans shall be suitable for operating on 230V, 1 phase, 50 Hz supply and shall be complete with standard mounting accessories such as suspension rods, top and bottom caps etc.

Approximate size of the fan to be 1200mm. The minimum fan shall be of 80w and shall produce minimum of 215 cm. The fan shall be fixed at a minimum to height to ceiling of 1000mm and shall not be fixed at less than 3000mm from finished ground level. The fans shall be supplied with appropriate speed regulators, fixtures and with all other accessories.

6.55.2 Split AC

Minimum capacity of the AC to be 1.0T. The AC shall be wall mounted split ac with a rated capacity of 5stars. The AC shall include all the required fixtures, invertor and with all other accessories.

6.55.3 Codes and Standards

Electrical installation work shall comply with the latest applicable Standards, Regulations and Safety Codes of the locality where the equipment will be installed. Nothing in this Specification shall be constructed to relieve the Contractor of this responsibility.

Installation work shall conform to the latest applicable Code of Practice, Indian Electricity Rules, Fire Insurance Regulations and Standards.

6.55.4 Installation Work Scope

The installation work shall include storing, unpacking, fixing of all equipment associated with lighting system, routing and laying conduits, wiring, termination with copper lugs wherever required, testing, commissioning and all other work items necessary for completing the job.

The supply of all mounting accessories, earthing wires and incidental hardware and consumables like fixing saddles, spacer plates, junction boxes and conduits required for the fitting fixing/suspension points, point boxes and connectors, jointing ferrules, all fixing brackets, screws and studs, shall be deemed to be included as part of installation work. Mounting accessories like saddles, spacer plates, joint boxes, junction boxes and fixing hardware shall be of galvanized mild steel.

The Contractor shall be responsible if parts of panels, fittings, etc. are lost or damaged and fluorescent tubes/incandescent lamps/mercury vapour lamps/sodium vapour lamps enclosures of glass/plastic etc. are broken during installation. All damage and thefts shall be made good by the Contractor till the installation is handed over to the Employer.

The Contractor shall touch-up painting on lighting panels/boards if the same is damaged during installation handling.

6.55.5 Point Wiring

Whenever asked for, if installation is to be carried out on point wiring basis, the supply of following shall be deemed to be included as part of the installation work, in addition to the items mentioned earlier.

a) 650/1100V lighting wires for conduit wiring, minimum size of 1.5 sq.mm PVC insulated FRLS copper conductor.

b) UPVC/MS conduits with all relevant accessories and junction/inspection boxes. Minimum size 20 mm for exposed/concealed conduits respectively.

c) necessary 5A/15A light control switches of grid plate type on MS boxes.

d) Required switch and receptacles units in similar boxes as in item (d) above.

Wiring of each lighting fitting/receptacle unit/ceiling fan/bell etc. shall be considered as one point. However, when two or more receptacles are to be wired at the same location/in the same box. Wiring of first receptacle shall be considered as one point and wiring of each of subsequent receptacle at that location shall be considered as half point each.

6.55.6 Concealed Wiring

For installations requiring concealed conduit wiring, the supply, routing and laying of UPVC conduits of minimum size 20 mm in walls/ceiling, from lighting panels upto fittings, receptacles, inspection/junction boxes etc. shall be in the Contractor's scope. The Contractor shall closely co-ordinate his work with that of the Civil Contractor. The Contractor shall prepare and furnish drawings showing the location of the embedded conduits/junction boxes/inspection boxes and lighting layout drawings.

6.55.7 Wiring

All types of wiring concealed or unconcealed shall be capable of easy inspection. Unconcealed wiring when run along walls shall be as near the ceiling as possible. In all types of wiring, due consideration shall be given for neatness and good appearance.

Wherever specified, Emergency lighting shall be switched in through change-over Switch on AC mains failure, and manually switched in for testing, independently of normal lighting. Emergency lighting cables shall run in a separate conduit system.

In large rooms, the lighting system shall be distributed among three phases.

Wiring shall be colour coded so as to enable easy identification of phase and neutral conductors. The neutral shall be of the same size as the phase conductor.

There shall be a circuit breaker or a linked switch on each live conductor of supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in neutral wire in the form of switch or fuse unit.

Conductors not arranged for connection to the same system and circuit or supply different phases of the same supply, shall be kept a part throughout their entire run.

Receptacles and lighting fittings in general shall be fed from different circuits. Five amps receptacles for toilet or small change rooms can be fed from the lighting circuit with proper isolating arrangement.

Each final sub-circuit from a lighting panel shall be controlled by a single pole switch connected to the live conductor.

For long conduit wiring runs, inspection/pull boxes shall be provided at intervals not exceeding 5m. Such facilities shall also be provided at conduit bends.

6.55.8 General Practices

All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be wall or column mounted.

Ceiling roses shall not embody fuse terminals as an integral part of it. For voltages exceeding 250 volts, a ceiling rose, or any similar attachment shall not be used.

A socket outlet shall not embody fuse terminals as an integral part of it. The switch controlling the socket outlet shall be on the live side of the line.

All exposed metal parts of the plug, when the plug is in complete engagement with the socket outlet, shall be in effective electrical connection with the earthing pin.

6.55.9 Earthing

Conduits and fittings shall be earthed by 14 SWG Copper wires (unless otherwise stated, run along the length of the conduit and secured by means of suitable clamps efficiently fastened to conduit pipe. To achieve perfect electrical continuity, the conduits shall be bonded effectively on either end of a coupling and other joints. Earth bonding clips shall be provided.

Conduits shall be grounded at the ends adjacent to switch boards at which they originate or otherwise at the commencement of the run, by a earthing conductor connected at an earth clip, clamp or gland, in effective electrical contact with the conduit.

6.55.10 Testing and Commissioning

Before a completed installation or an extension to an existing installation is put into service, installation tests stipulated in applicable Standards and Codes of Practices shall be carried out by the Contractor in the presence of the Employer/Employer's representative.

6.56 Lighting Fitting and Accessories

6.56.1 General

This specification covers the design, material specification, manufacture, testing, inspection and delivery to site and installation & commissioning of lighting fittings and their associated accessories.

6.56.2 Applicable Codes & Standards

The lighting fittings and their associated accessories such as lamps/tubes, reflectors, housings, ballasts, etc. shall comply with the latest applicable standards as specified. Where no standards are available, the supply items shall be backed by test results, shall be of good quality and workmanship & any supply items which are bought out by the Contractor shall be procured from approved Contractors acceptable to the Employer.

6.56.3 Lighting Fittings - General Requirements

Fittings shall be designed for continuous trouble free operation under atmospheric conditions at site without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.

The fittings shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.

Connections between different components shall be made in such a way that they will not work loose by small vibration.

For each type of lighting fitting the Contractor shall supply the utilization factor to indicate the proportion of the light emitted by the bare lamas which falls on the working plane.

All fittings shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage.

The fittings and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant standards.

Outdoor type fittings shall be provided with outdoor type weather-proof box.

Each fitting shall have a terminal block suitable for loop-in, loop-out and T-off connection by 650/1100V, 3 core, PVC insulated Cu conductor cable of 2.5 sq.mm in size unless otherwise specified. The internal wiring should be completed by the Contractor by means of stranded copper wire and terminated on the terminal block.

The mounting facility and conduit knock-outs for the fixtures shall be as specified.

All hardware used in the luminaire shall be suitably plated or anodized and passivated for use in chemical industrial and power plants.

6.56.4 Earthing

Each lighting fitting shall be provided with an earthing terminal suitable for connection to the earthing conductor.

All metal or metal enclosed parts of the housing shall be bounded and connected to the earthing terminal so as to ensure satisfactory earthing continuity throughout the fixture.

6.56.5 Painting/Finish

All surfaces of the fittings shall be thoroughly cleaned and degreased. The fittings shall be free from scale, rust, sharp edges and burrs.

When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mills for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

The housing shall be stove-enamelled/epoxy stove-enamelled-vitreous enamelled or anodized as indicated on flame-proof fittings is prohibited.

The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90o over ½" dia mandrel.

The finish of the fittings shall be such that no bright spots are produced either by direct light source or by reflection.

6.56.6 Decorative Type Fittings

Decorative fittings shall be provided with mounting/housing channel cum reflectors of CRCA sheet steel, stove enamelled.

Diffusers or louvers shall be provided as required. Diffusers shall be of translucent white opal acrylic or depending upon the type of fitting.

Fittings shall be suitable for the number of lamps of specified wattage, for directly mounting on ceiling/conduit suspended or for recess mounting in false ceiling, as specified.

6.56.7 Industrial Type Fittings

These fittings shall be suitable for use with as per requirements

6.56.8 LED Light Fittings

For general industrial use in humid atmosphere, the fittings shall be provided with CRCA sheet steel mounting/housing channel vitreous enamelled and with vitreous enamelled reflector of minimum 20 SWG thicknesses.

For dusty and vapour prevalent atmosphere, the fittings shall be dust and drip proof type, totally enclosed in sheet steel housing with a heat resistant toughened glass cover or clear acrylic sheet. The housing shall be epoxy stove-enamelled and neoprene gaskets shall be provided for sealing.

For atmosphere where chemical vapours/fumes are corrosive, the material of fitting housing/mounting, reflectors and end-plates shall be of cast aluminium/aluminium sheet and finished in epoxy stove enamel to resist corrosion.

Fittings shall be suitable for the number of lamps of specified wattage, for directly mounting on ceiling/wall and or conduit suspended.

6.56.9 Building Type Fittings

6.56.9.1 LED Wraparound Light with Fixture

Approximate size to be 4ft. The LED light shall be of 50w and shall produce minimum of 5500 lumens. The wrap around LED light shall include the inbuilt fixtures and with all other accessories.

6.56.9.2 Bulkhead and Well-glass Type

Bulkhead, weather-proof type fittings for use in corridors, staircase landings, covered porches and low ceiling factories, shall be suitable for direct fixing to wall/ceiling and to accommodate upto 150 watts LED lamp. The fitting shall be provided with housing of cast aluminium alloy with stove enamelled finish, prismatic heat resistant glass cover hinged on to the housing and fixed by screws. Neoprene gaskets shall be provided to make the fitting weather-proof. For mechanical protection to glass cover, a protective wire-guard of 3 mm galvanized wire with stove enamelled finish paint shall be provided.

Wellglass, weather-proof type fittings for use in building exteriors and compound walls, shall be suitable for conduit mounting and to accommodate upto 200 watts LED lamps. The fitting shall be provided with stove-enamelled cast aluminium housing with top conduit entry, heat resistant clear glass cover unit hinged to the housing and fixed by screws. The fittings shall be provided with neoprene gaskets and wire guards as started in above item.

6.57 Accessories for Lighting Fittings

6.57.1 Reflectors

The reflectors shall be made of CRCA sheet steel/aluminium/silvered glass/chromium plated sheet copper as indicated for above mentioned fittings, unless otherwise specified.

The thickness of steel/aluminium shall comply with relevant standards specified. Reflectors made of steel shall have stove enamelled/vitreous enamelled/epoxy coating finish. Aluminium used for reflectors shall be anodized/epoxy stove enamelled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.

Aluminium paint on the reflectors of flame-proof lighting fittings is prohibited.

Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflection coefficient such as to ensure the overall light output specified by the Contractor.

Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

6.58 Lamps

6.58.1 Lamps shall be of LED type

6.58.1.1 Tests and Test Reports

Type tests, acceptance tests and routine tests for the lighting fittings and accessories covered by this specification shall be carried out as per the relevant standard for the respective fittings and their accessories.

The Manufacture's type and routine test certificates shall be submitted for tests conducted as per relevant standards for the fittings and accessories. The Contractor shall submit with his proposal copies of available test certificates of the fittings offered.

6.59 Earthing System

6.59.1 General

The earthing system shall comply with all currently applicable standards, regulations and safety codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

The installation work shall conform to the latest applicable Electricity Rules, standards (IS:3043) and codes of practice.

The earthing& electrodes shall be supplied by the Contractor when specifically indicated. Conductors shall be free from rust, scale and other electrical and mechanical defects and all materials used shall conform to relevant standards or approved by the Employer. The sizes, materials and quantity shall be as listed.

Steel earthing conductors above ground shall be hot-dip galvanized, unless otherwise stated, to prevent atmospheric corrosion.

6.59.2 Scope of Installation Work

The Contractor shall carry out the earthing of all equipment/panels/structures. Whether specifically shown in drawings or not, building columns, hand-rails, miscellaneous items such as junction/marshalling boxes, field switches, cable boxes etc., shall be earthed.

The Contractor shall install bare/insulated, copper/aluminium conductors, braids, etc., required for system and individual equipment earthing. All work such as cutting, bending, supporting, painting/coating drilling, brazing/soldering/welding, clamping, bolting and connecting onto structures, equipment frames, terminals, rails or other devices shall be in the Contractor's scope of work. All incidental hardware and consumable such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts,

washers, bitumastic compound, anti-corrosive paint as required for the complete work shall be deemed to be included by the Contractor as part of the installation work.

The quantities, sizes and material of earthing conductors and electrodes to be installed, and routes of the conductors and locations of electrodes shall be shown on the project drawings. The alignments of conductors are approximately shown in the earthing drawings and these may be suitably shifted/finalized in consultation with the site Employer to avoid any interference. If earth connection to any device is not shown specifically in the relevant earthing drawings, it shall be field routed.

The scope of installation of electrodes shall include installation of these electrodes such as (a) directly in earth, (b) in constructed earth pits, and connecting to main buried earth grid, as per enclosed drawings/relevant standards. The scope of work shall include excavation, construction of the earth pits including all materials required for construction of the earth pits, placing the rod, providing and fixing test links on those rods in test pits and connecting to main earth grid conductors.

The location of the earth electrodes will be such that the soil has reasonable chances of remaining moist, as far as possible. Entrances, pavements and roadways are definitely avoided for locating the earth electrodes.

The scope of installation of the test links shall include mounting of the same at specified height on wall/column by suitable brackets and connections of the test link to the earth electrode.

6.59.3 Work Details

Earthing conductors along their run on walls and columns shall be supported by cleating/welding at intervals of 750 mm and 1000 mm respectively.

Wherever earthing conductors cross underground service ducts and pipes, it will be laid 300 mm below, the earthing conductor shall be bounded to such service ducts/pipes.

Wherever main earthing conductor crosses cable trenches, they shall be buried below the trench floor.

Suitable earth risers approved by the Employer shall be provided above finished floor/ground level, if the equipment is not available at time of laying of the main earth conductors. The minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided shall be marked in project drawings.

Earth leads and risers between equipment earthing terminals and the earthing grid shall follow as direct and short a path as possible.

Neutral connection shall never be used for the equipment earthing.

Each neutral point of a transformer shall be earthed to two separate earth electrodes for connection with earthing system.

Shield wire in sub-stations shall be connected to the earthing grid through test links at every alternate switchyard portal tower.

An earthing pad as shown in the drawings shall be provided under each operating handle of the isolator and operating mechanism of HV breakers. Operating handle of the isolator and supporting structure shall be bonded together by a flexible connection and connected to the earthing grid.

A separate earth electrode bed shall be provided adjacent to structures supporting lightning arrestors and coupling capacitors. Earth connections shall be as short and as straight as practicable. For arrestors mounted near transformers, earth conductors shall be located clear of the tank and coolers.

Wherever earthing conductor passes through walls, galvanized iron sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Contractor by suitable water proof compound. Water stops shall be provided wherever earthing conductor enters the building from outside below grade level. Water stops and above mentioned sleeves shall be provided by the civil Contractor.

6.59.4 General Instruction on Electrical Pre-Commissioning Arrangement and Tests

All tests shall be carried out by the Contractor using his own instruments, testing equipment as well as qualified testing personnel.

The results of all tests shall conform to the specification requirements as well as any specific performance data guaranteed during finalisation of the Contract.

At site all equipment shall be energised only after certification by the personnel performing the test that the equipment is ready for energising and with concurrence of the Employer.

6.59.5 Cable Termination and Jointing

Termination and jointing of aluminium conductor power cables shall be by means of compression method using compression type aluminium lugs. Copper conductor control cables shall be terminated directly into screwed type terminals provided in the equipment. Wherever control cables are to be terminated by means of terminal lugs, the same shall be of tinned copper compression type.

6.60 Testing and Commissioning of Electrical Equipment & Installation

6.60.1 General

The testing and commissioning for all electrical equipment at site shall be according to the procedure laid down below.

All electrical equipment shall be tested, installed and commissioned in accordance with the latest relevant standards and codes of practices published by Indian Standards Institution wherever available and stipulations and in relevant general specifications.

In case where Indian Standards are not available these shall be carried out in accordance with the latest standards and codes of practice published by any other recognised National Standards Institution or latest publications of International Electro Technical Commission (IEC).

The testing of all electrical equipment as well as the system as a whole shall be carried out to ensure that the equipment and its components are in satisfactory condition and will successfully perform its functional operation. The inspection of the equipment shall be carried out to ensure that tall materials, workmanship and installation conform to the accepted design, engineering and construction standards as well as accepted codes of practice and stipulations.

6.60.2 Polarity Test of Switch

In a two wire installation a test shall be made to verify that all switches in every circuit have been fitted in the same conductor throughout and such conductor shall be labelled or marked for connection to the phase conductor or to the non earthed conductor of the supply.

A verification of polarity shall be made and shall be ensured that all fuses and single pole control devices are connected in the live conductor only and for socket outlets that the wiring is correctly connected.

i) Physical inspection for removal of any foreign bodies, external defects, such as damaged insulators, loose connecting bolts, loose foundation bolts etc.

ii) Check for the free movement of mechanism for the circuit-breakers, rotating parts of the rotating machines and devices.

iii) Check for tightness of all cable, busbars as well as earth connections in the main earthing network.

iv) Check for clearance of live busbars and conductors from the metal enclosure.

v) Continuity check in case of power and control cables.

vi) Checking of all mechanical and electrical interlocks including tripping of breakers using manual operation of relay.

vii) Check and calibrate devices requiring field adjustment/calibration like adjustment of relay setting etc.

viii) Check proper connection to earth network of all non-current carrying parts of the equipment and installation.

ix) Check for grease, insulating/lubricate oil leakage and proper charge.

x) Check for alignment of all draw out devices like drawout type circuit breakers, MCC cubicles etc.

xi) Checking of alarm and annunciation circuits by manual actuation of relevant relays.

The following tests shall be carried out on the equipment.

a) Earth Electrode Resistance Test

The earth resistance of the earth electrode is to be measured by an earth testing "Megger" provided with a direct reading ohmmeter. Readings obtained in ohms shall not be more than 1 ohms. If necessary, with the approval of Employer additional electrode shall be provided away from the resistance are and linked to the electrodes system. Payment for such additional electrode and interconnecting tape/wire will be paid on unit or linear basis.

b) Insulation Resistance Test

Insulation resistance test should be made before the installation is permanently connected to the electric supply. The insulation resistance is to be measured by using an approved portable hand operated insulation resistance tester reading directly in ohms. The voltage of this tester shall be about 500 volts. The insulation resistance to earth shall not be less than 1 meg. ohm when measured with

all fuse links in place, all switches closed and all poles place, all switches closed and all poles or phases of wires are electrically linked.

c) Earth Continuity Test

The earth continuity conductor should be tested for continuity to ensure that there is no breakage or loose connections in the system.

The Contractor shall furnish the complete filled in data sheet given in Annexure-I along with the proposal.

6.61 Fire Fighting Works

6.61.1 Brief Description of Proposed System

The design, installation & operation of fire protection systems and other safety measures are to comply with relevant local regulations and the requirements of the local authorities having jurisdiction. The systems proposed shall be generally as per the recommendation / guidelines given in the following codes / standards:

- TAC – Fire Protection Manual
- TAC – Rules for Fire Alarm System
- National Building Code

The scope of fire protection shall cover following buildings located in the Port:

1. Operations Building
2. Administration building

The above buildings will be classified as Light Hazard.

All the above buildings shall be provided with an addressable type smoke, Heat detector and Manual call point system for early detection of fire on the premises. The spacing, type and quantity of the detectors shall be as per the Codes.

The master fire alarm panel shall be placed at the reception of the Port Admin building. The master fire alarm panel shall be provided with auto dialler facility to alert the Fire station in case of fire alarm from any of the detectors. The master panel shall be provided with 2 nos. gas release modules for future use in case required at a later stage. The master fire alarm panel shall be provided with auto dialler facility to alert the building in case of fire alarm from any of the detectors.

Each floor of all the buildings shall be provided with portable fire extinguishers as per the rules. Each floor of all the buildings shall be provided with one hose reel which shall be connected to the fire water supply.

Fire extinguishers shall also be provided in Custom's Post, Gate complex, pumphouse and substations.

A brief description of each major component / system is given below:

6.61.2 Main Fire Alarm Panel

The main fire alarm panel shall be of Analogue addressable type with simple user friendly operations and mimic display. It shall consist of 2 loops with each loop having Isolated Power source and Data transfer via isolators. The loop voltage shall remain stable regardless of the system voltage so that in case of mains failure and even if battery voltage falls to 18 volts the loop supply shall be maintained at a stable 24V.

Each loop shall be capable of addressing at least 99 smoke detectors or MCP and at least 25 control or monitor modules.

The panel shall have built in Mimic floor wise drawing with LED indication for indicating the location of fire to enable fire fighters to respond immediately.

The panel shall have a minimum 500 event log with a 40 x 4 line LCD display with back lighting.

1. Communication to repeaters shall be in 2 wires with half duplex RS485 data communications. The repeaters shall be powered from the main panel for this an additional pair of cores shall be provided with the connecting cable.

2. The panel manufacturer / service center shall be located in India and have a certified ISO 9000 Quality system audited by UL, TUV, BVQI or other reputed certification agencies.

3. The panel manufacturer / dealer shall guarantee to repair and maintain spares for the panel supplied for minimum 10 years and shall repair and maintain the equipment if required at additional charges.

4. Dealers or Manufactures who do not have adequate spares / service facilities and depend on supply of spares / services from abroad shall not be preferred.

The fire alarm control panel shall be microprocessor based fully addressable analogue type and shall monitor & control all addressable devices connected to it. The panel shall be able to analyze all signals received from each device connected to it and be able to identify PRE FIRE CONDITION / FIRE / FAULT. The panel shall have the facility to set each detector's sensitivity from the panel. The panel shall have the facility to permit the engineer perform a WALK test to periodically check the condition of each addressable device. The programmable functions shall include assignment of alarm / fault indication, location address, alarm message, alarm / output setting etc. for each addressable device in the system. The panel shall have built in keypad, Liquid Crystal Display, Battery back up (48 hours) and Mimic. The panel enclosure shall be totally enclosed dust & vermin proof type and shall be UL listed. The panel shall use all solid-state circuitry and shall be of modular construction. The panel shall have EN54/ FM/ LPCB approval or shall be UL / Equivalent inspected.

6.61.3 Smoke Detector (Optical Addressable Type)

The mounting base of the detector shall be electronics free. The detector shall be plug-in type to permit easy installation & replacement. The mounting base shall be common for all detectors of the same make. The detector shall be suitable for connection in a 2- wire loop. The detector shall be suitably protected against dust ingression. The sensitivity of the detector can be set from the panel. The detector shall have EN 54/ FM/ UL/ LPCB approval.

Heat Detector (Fixed / Ror Addressable Type)

The mounting base of the detector shall be electronics free. The detector shall be plug-in type to permit easy installation & replacement. The mounting base shall be common for all detectors of the

same make. The detector shall be suitable for connection in a 2- wire loop. The detector shall be suitably protected against dust ingression. The detector shall have EN 54/ FM/ UL/ LPCB approval.

6.61.4 Manual Call Point (Addressable Type)

The manual call points shall be “Press” to break type and suitable for surface / flush mounting. The MC station shall have its own built-in addressable module and micro-switch that shall be monitored by the panel. The switch shall be normally OPEN and shall CLOSE when actuated. The contacts shall remain closed until it is manually reset.

6.61.5 Hooters (Addressable Type)

The hooter shall be addressable electronic type with a minimum sound level of 85 decibels. It shall be suitable for surface / flush mounting. The sounders shall be able to connect into the loop circuit.

6.61.6 Interconnection Cables

The interconnection cables shall have 4 cores, 1.5 sq.mm cross-section area, stranded copper conductor, armoured, FRLS PVC outer sheath, PVC insulated cores. The voltage rating shall be 650/1100V. Each cable section shall have cable glands at both ends and shall be fixed on a wiring box. Each device base shall be fixed on the wiring box.

6.61.7 DCP Fire Extinguishers

Dry chemical powder fire extinguishers shall be of 5 kg capacity and shall bear the ISI mark as per IS: 2171.

6.61.8 CO_2 Fire Extinguishers

CO_2 type fire extinguisher shall be of 4.5 kg capacity and shall bear the ISI mark as per IS: 2878.

6.61.9 Hose Reel

The system shall be connected to the fire water supply system and installed as per the provisions of Fire Protection Manual of Tariff Advisory Committee (TAC) codes & standards. One hose reel shall be provided for each floor of all the buildings in the scope of work as per specifications. The system shall be designed based on the occupancy classification for the buildings as LIGHT HAZARD. The hose reels shall be swinging wall mounting type, complete with 19mm bore, 36 meter long, high pressure braided rubber hose as per IS:444 Type II, 6mm bore PVC shutoff nozzle and 25mm gunmetal inlet valve. The hose reel assembly shall confirm to IS: 884.

6.61.10 Hydrants

The hydrant system shall consist of main fire-fighting pumps (1 working +1 standby) and jockey pumps to maintain the minimum pressure of 3.5 kg/sqcm in the remotest hydrant, all provided at the pump house. Pipelines connecting the hydrants shall be laid underground (1 m below the finished ground level). The fire water headers which are falling within the roads shall be routed underground through the hume pipes.

6.61.11 Workmanship

The fire protection system as a whole and each component in particular shall be of very good workmanship and conform to the latest relevant standards. The Contractor shall submit quality

assurance plans for each major component. All major and critical components shall be inspected during manufacturing stage at the manufacturer's works by approved inspection agency.

6.62 Testing

6.62.1 General

The Contractor shall give 15 days' advance notice for conducting the final commissioning tests at site. The final commissioning tests will be conducted in presence of Inspection Agency / Owner's Representative.

6.62.2 Shop Testing

All fire alarm panels shall be inspected at the manufacturer's works for proper functioning and specified features.

6.62.3 Site Testing

The entire fire-fighting system shall be tested at the site after installation.

6.62.4 Training

On completion of the works the Contractor shall prepare suitable training program of about 3 days for Engineers, Technicians and Operators covering all aspects of the fire-fighting system installed. The training shall stress on the operation and maintenance aspects of the system and its components.

The detailed training program shall be submitted to the client two months in advance for approval.

6.63 Water Supply & Distribution System

6.63.1 General

Contractor shall provide a Water supply system to meet the demand for various buildings, landscaping, greenery and firefighting system.

- Necessary arrangement for treatment of the raw water before transferring from main underground reservoir to the overhead tanks on respective buildings.
- A pump house shall be built on main reservoir with two pumps (including one standby) for supply of raw water
- Another pump house on main reservoir with two fire-fighting pumps (including one standby) and jockey pumps on a separate chamber for the supply of fire water to respective locations.

All pipelines of required size, fixtures, foundations, brackets, connectors, anchors etc. shall be provided.

6.64 Material

6.64.1 Pipe

Piping for supply and distribution lines shall be HDPE pipes conforming to IS: 4984.

6.64.2 Fittings and Specials

Fittings and specials shall be suitable for 10 bar pressure rating, unless otherwise specified. Fittings and specials shall conform to Indian standards.

6.65 Execution

6.65.1 Installation

6.65.1.1 Cutting of Pipe

Cutting of pipe shall be done in a neat and workmanlike manner without damage to the pipe. Unless otherwise recommended by the manufacturer and authorized by the Employer, cutting shall be done with an approved type cutter.

6.66 Adjacent Facilities

6.66.1 Water Lines

Water lines shall not be laid in the same trench with sewer lines, gas lines, fuel lines, or electric wiring.

6.66.2 Joint Deflection

The maximum allowable deflection shall be as per Indian standards. If the alignment requires deflection in excess of the above limitations, special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth.

6.66.3 Placing and Laying

Underground pipes shall be laid in accordance with IS:12288:1987. Pipe shall be laid to the grade calculated by the Contractor or as indicated by the Employer. Pipe alignment shall be straight between bends and curves within a tolerance of + 5mm.

All bends of 11¼ degrees and greater shall be made with the proper fittings. Joint deflection shall be limited to the maximum recommended by the manufacturer. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid. Pipe shall not be laid in water or when trench conditions are unsuitable for the work. Water shall be kept out of the trench until joints are complete. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no trench water, earth, or other substance will enter the pipes or fittings. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored.

6.66.4 Service Lines

Service lines shall include the pipeline connecting building piping to water distribution lines to the connections with the building service at a point approximately 1.5 m outside the building where such

building service exists. Where building services are not installed, the Contractor shall terminate the service lines approximately 1.5 m from the site of the proposed building at a point designated by the Employer. Such service lines shall be closed with plugs or caps.

6.66.5 Tests and Inspection

The mains shall be slowly filled with water to expel all air from the system and shall be left to stand full of water for a period of not less than 24 hours.

Test pressures shall be applied by means of a manually operated test pump or in the case of long mains by a power driven test pump, which shall not be left unattended. Adequate precautions shall be taken to ensure that the specified test pressure is not exceeded.

The specified test pressure shall be maintained for a period of 1 hour and if there is any leakage it shall be measured by the quantity of water pumped into the main.

The main shall be deemed to be satisfactory if the loss of water does not exceed 3.5 litres per 100 mm nominal bore, per kilometre, per bar of test pressure per 24 hours.

Any defect or visible individual leak observed during the hydrostatic pressure testing shall be repaired by the Contractor at his own expense in the manner directed by the Employer.

Should losses from the main exceed the specified amount, testing shall be repeated until the main is deemed satisfactory and is accepted by the Employer. All labour, material and equipment for testing shall be deemed to be included in the rates.

These tests shall be conducted on the entire water distribution system by sections of 500 meters as a maximum on the general circuit, and by building, for the distribution from the main network.

All of the installations must undergo the pressure tests.

6.66.6 Cleaning and Disinfection

After the water distribution system has been tested, the Contractor shall proceed to clean the system with water, followed by disinfecting of the entire network. This disinfecting shall be carried out according to a method proposed by the Contractor for approval by the Employer, and according to the provisions indicated above and the current regulation of the Government of India.

6.67 Sewerage Collection & Transfer System

6.67.1 General

The intent is to install a sewerage system in the port area to cater to the collection and transfer of sewage generated from Buildings.

6.67.2 Scope

The scope covers collection of all sewerage from all terminal buildings to the septic tank or STP and further disposal of treated sewage to storm water drain or soak pit in case of septic tank. The sewerage system within the buildings and to a distance of one meter from the buildings is included in the scope of respective building.

The scope of work shall include pipe and appurtenant structures and building sewers to points of connection with the building drains 1.5 m outside the building to which the sewer system is to be

connected and drain all sanitary sewerage to septic tanks and dispose off the effluent as given in IS:2470 (Part 2). The system includes furnishing and installing sanitary sewers systems and appurtenances complete for this Contract.

Systems of pipes and appurtenances are to be sized by the Contractor according to the standard usage for sanitary sewers. Scope also consists of furnishing transportation, labour, equipment, and materials to construct sewerage system in accordance with their own Design and Drawings. All products and execution shall be subject to prior approval by the Employer.

The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the Employer.

6.68 Material

6.68.1 Pipe

Sewer pipe and fittings shall be concrete NP3 grade conforming to IS: 458 Codes. All reinforced concrete pipes shall be class NP3 conforming to IS: 458. RCC pipe of class NP4 type shall be used below road. Before being laid, the pipe and fittings shall be carefully inspected for defects, those not meeting the foregoing specifications shall be rejected.

6.68.2 Manholes

The manholes shall be made of reinforced cement concrete of grade M25.

PVC encapsulated foot rests shall be built into the wall of the tank at 300 mm intervals below each of the manholes, they shall be set staggered in two vertical runs at 200 mm centers horizontally the top footrest shall be 450 mm below the manhole cover and the lowest not more than 300 mm above the floor of the tank.

It must be possible to install the pipe in the wall of the manhole without touching the walls perpendicular to that wall.

Manholes types and construction shall be submitted for the approval of the Employer.

The covers shall be equal to heavy roadway type made of ductile iron, with frame of cast iron Ft. 20 for closed manholes.

6.68.3 Septic Tank

A septic tank is a combined sedimentation and digestion tank where the sewage is held for one to two days. During this period the suspended solids settle down to the bottom. This is followed by anaerobic digestion of settled solids (sludge) and liquid, resulting in reasonable reduction in the volume of sludge, reduction in bio-degradable organic matter and release of gases like carbon-dioxide, methane and hydrogen sulphide. The effluent although clarified to a large extent, still contain appreciable amount of dissolved and suspended putrescible organic solids and pathogens.

6.68.4 Design

Septic tank shall be water tight, single storeyed, underground, rectangular in shape, single or double tank having roof. In case of double tank, the first compartment is usually twice the size of the second. The liquid depth is 1 – 2 m and the length to breadth ration i.e. 2.3 to 1. Septic Tank shall be provided

for the below buildings and the size of septic tank shall be based on IS: 2470 (Part I) for following users:

- Gate House : 20 users
- Customs Post : 10 users
- Fire station : 10 users

6.68.5 Construction Details

The inlet and outlet should be located at different levels to avoid disturbance due to the force of water entering or leaving the tank. Every Septic tank should be provided with ventilation pipes, top being covered by mosquito proof wire mesh. The height of the pipe should extend at least 2 m above the top of the highest building within a radius of 20 m.

Septic tanks constructed in concrete cast in-situ shall be provided with watertight covers of adequate strength. Access manholes of adequate size shall also be provided for purpose of inspection and desludging of tanks. The floor of the tank should be sloped towards the sludge outlet.

6.68.6 Sludge Withdrawn and Disposal

Portable pumps may be used for desludging. Mechanical vacuum tankers may preferably be used to empty the septic tanks. Yearly desludging of septic tank is desirable while desludging a depth of 2.5 cm of well-digested sludge is left at the bottom of the tank for further anaerobic action

6.68.7 Secondary Treatment and Disposal of Effluent

The septic tank effluent contains sizable portion of dissolved organic content and pathogenic organisms and hence need to be treated before its final, safe disposal. Depending on the position of the sub-soil water level, soil and subsoil conditions, size of the installation, resource available etc. The extent and type of secondary treatment facility may vary from the most conventional land disposal methods like soak pits or dispersion trenches to additional secondary biological treatment system.

6.69 Execution

6.69.1 Installation of Pipe, Fittings and Appurtenances

Excavation, trenching, installation, compacting soil and finishing operations for all pipe and soil materials shall conform to the Indian standards. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe. Provide all required equipment for lowering pipe safely into the trenches.

6.69.2 Pipe Joints

All pipe joints shall be watertight and of such design as to remain sealed after possible settlement. The length of pipe shall be pressure tested as per Indian Standard.

6.69.3 Repair and Retesting

Sections of pipe not meeting the pressure test requirements shall have individual joints tested and sealed.

6.70 Masonry Boundary Wall

6.70.1 General

This section of the specifications includes the requirements for furnishing and installing of masonry boundary wall and barbed wire fencing Y shape on top of the wall and appurtenances as required providing a complete security system.

A 2.4 m high boundary wall with barbed wire fencing 0.9 m high over it shall be provided along the onshore port boundary. The approximate overall length of wall shall be 3400 m. Suitable foundation system (either Pile foundation or Strip foundation) for the boundary wall shall be provided by the Contractor based on his design to satisfy the Design Criteria.

6.70.2 Materials

Refer specifications under ‘Materials’.

6.70.3 Workmanship

The purpose of fencing is to provide a solid uninterrupted stone masonry boundary wall around the port area, and keeping only openings being the road.

Stone boundary wall shall be erected and installed by professional organization who are regularly engaged in this business, employing skill labour in this type of work to provide a complete security fencing system.

Refer to specifications under Plain and Reinforced Concrete for the different concretes and reinforcing steel for the construction of the boundary wall. Refer to specifications under Stone Masonry Work for the construction of the boundary wall. Refer to specifications under Structural Steel Work for the construction of the fence and appurtenances as required.

6.70.4 Construction

The Contractor shall submit for approval shop drawings of fencing, and appurtenances and shall not proceed with abreaction and installation thereof prior to approval by the Employer. The location and alignment of the boundary wall shall be planned by the Contractor with the approval of the Employer. The wall shall be able to withstand the collision of vehicle with a speed of 10 km/hr.

The masonry boundary wall shall have stone masonry foundation with cement mortar 1:4 (1 cement: 4 coarse sand) on lean mix concrete 1:3:6 (1 cement: 3 coarse sand: 6 aggregates) base. Minimum height of the wall shall be 2.4 m. Reinforced Concrete (Grade M-25) coping breams shall be constructed on top of stone masonry wall. Barbed wire fencing Y shape on top of the wall with minimum height of 1.0 m shall be provided. Expansion joints shall be provided at 30 m centre to centre.

Barbered wire shall be fastened to the Y angles with wire ties at adequate spacing. Painting to the masonry boundary wall and structural steel shall be as per specifications under painting.

6.70.5 Clean Up & Repair

Upon completion of the masonry boundary wall, the Contractor shall clean all soiled places and repair the damages if any to the satisfaction of the Employer.

6.71 Electrical Distribution System

6.71.1 HT Switchgear

6.71.1.1 General

This specification covers the requirements of 11kV Switchgear complete with all accessories. Continuous current rating of the Switchgear shall be based on the name plate rating of the connected equipment with 20% margin, rounded off to the next higher standard rating. 11kV Switchgear shall be rated for short circuit withstand capacity of 40kA for 1 seconds.

Busbars, breaker and other components shall be designed for continuous operation at rated current considering temperature inside the cubicle. The inside cubicle temperature shall be considered as design ambient temperature for maximum continuous operation rating of the equipment. For breaker control, 110 V DC supply shall be considered.

Each breaker module shall be provided with multifunction numerical relay for protection. Switchgear shall be provided with separate earthing trucks for cable earthing and bus earthing.

6.71.1.2 Switchgear Construction

Switchgear shall be indoor, single front, single tier, metal-clad, floor mounted, fully draw-out with VCB breaker. Design and construction shall be such as to allow extension at either end. Switchgear cubicle shall be so sized as to permit closing of the front access door when the breaker is pulled out to Test position. The working zone shall be restricted within 750 mm to 1800 mm as from floor level.

Circuit breakers, instrument transformers, bus-bars, cable compartment, auxiliary control devices etc., shall be housed in separate compartments within the cubicle. The design shall be such that failure of one equipment shall not affect the adjacent units. The circuit breaker and bus voltage transformers shall be mounted on withdrawable trucks. In case breaker truck rolls out on telescopic rails suitable trolley shall be provided. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on a control cabinet built on the front of the cubicle.

The trucks shall have distinct ‘Service’, ‘Test’ and ‘Isolated’ positions. The switchgear assembly shall be designed to achieve IP54 degree of protection, with the truck in any position ‘Service’, ‘Test’ and ‘Isolated’ and all doors and covers closed. Relaying and Metering compartment shall also have degree of protection IP54.

Enclosure shall be constructed with rolled steel sections / sheets of not less than 2mm. The switchgear shall be cooled by natural airflow. Forced cooling shall not be accepted. The Breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Breaker compartment doors shall have locking facility.

6.71.1.3 Bus and Bus Taps

Main buses and connections shall be of high conductivity aluminium, sized for specified current ratings with maximum temperature limited to 90°C. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm^2. The busbars shall be designed for a short circuit rating of 40kA for 1 sec. All bus connections shall be silver plated. Adequate contact pressure shall be ensured by means of two bolts connection with plain and spring washers and lock nuts. Bimetallic connectors shall be furnished for connections between dissimilar metals. Busbar insulators shall be epoxy cast resin type designed to withstand stresses due to maximum short circuit current.

Busbars and connection shall be fully insulated for working voltage with adequate phase/ground clearances. Insulating sleeves for busbars and cast-resin shrouds for joints shall be provided. Cross section of the main horizontal busbar shall be uniform throughout the switchboard and continuous in one transport unit. All buses and connection shall be supported and braced to withstand stresses due to maximum short circuit current and also to take care of any thermal expansion.

Busbars shall be colour coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from front of the switchgear assembly. The busbar chamber shall be provided with inter panel barrier with epoxy case seal-off bushings which the buses shall pass through so as to prevent fire from one panel to another.

6.71.1.4 Circuit Breaker

Circuit breaker shall be triple pole, single throw Sulphur Hexaflouride (SF_6) or Vacuum Circuit breaker. It shall be restrike free, trip free type. Breakers shall be suitable for switching transformers at any load. Rated operating duty shall be O-3min-CO-3min-CO. Short circuit withstand/interrupting capacity shall be 40kA. Circuit breaker shall have communication facility for communicating with the PLC.

Circuit breakers shall be draw-out type, having SERVICE, TEST and DISCONNECTED positions with mechanical positive indication for each position. Operating mechanism shall be stored energy type. Circuit breakers of identical rating shall be physically and electrically interchangeable.

Each breaker feeder shall be provided with the following:

- An anti-pumping relay.
- Motor charged spring operating mechanism.
- Manual spring charging
- Mechanical indication of spring charge
- Mechanical position indicator (to show whether the breaker / contactor is ‘ON’ or ‘OFF’ in the service, test and disconnected positions)
- Closing coil (100% continuous rated)
- Shunt trip (100% continuous rated)
- Manual trip push button
- Operation counter,
- Locking facility to prevent breaker/contactor from being closed when it is open.
- Pressure relief device
- Safety shutters for power contacts
- Inter-pole insulators
- SF6 gas pressure low alarm/trip relay (In case of SF6 type Switchgear)
- Auxiliary Signaling contacts

For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to the motor. SF_6 breakers shall be provided with SF_6 density / pressure switch with separate trip, alarm and blocking contacts.

Robust fail-safe mechanical and electrical interlocks shall be provided to prevent the following situations:

- Move the breaker unit from the service or disconnected position while the unit is closed.
- Move the breaker from the disconnected position to the service position while the earthing switch is closed.

- Close the earthing switch when the breaker unit is in service position or between the service and disconnected position.
- The operation of the circuit breaker while the truck is not properly installed in the service, test or disconnected position.

The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 80 and 110 percent of the rated voltage. The shunt trip coil shall operate satisfactorily at all values of control supply voltage between 70 and 110 percent of the rated voltage. For breakers spring charging motor shall be provided with overcurrent protection. Motor windings shall be provided with class B insulation or better.

Circuit breaker shall not produce any harmful over-voltage during switching off induction motors. Surge protective devices to limit over voltage shall be included in the scope of supply for all motor feeders.

6.71.1.5 Current Transformer (CT)

CTs shall be mounted on the switchgear stationary parts. CT secondary current shall be 1A. For metering separate core shall be provided. Core balance CT shall be provided for all the outgoing feeders. Accuracy class of the current transformer shall be:-

(a) Class PS/ 5P20 for differential relaying and REF protection (Based on type of relay)

(b) Class 5P20 for other relaying

(c) Class 0.5 and ISF < 5 for metering

(d) Class 0.2S for Energy Accounting & Audit meters

For metering separate core shall be provided. Core balance CT and associated relay combination shall be such as to ensure a pick up sensitivity of 10 A primary ground fault current for all the outgoing feeders. Facilities for easy shorting and grounding the terminals shall be provided at the terminal block. All terminal blocks shall be of stud type with marking strip.

6.71.1.6 Voltage Transformer

Voltage Transformer shall be cast-resin, draw-out type and shall have an accuracy class of 0.5. Voltage Transformer mounted on breaker carriage is not acceptable. Rated secondary voltage shall be 110V. Accuracy class for metering core shall be 0.5, protection core shall be 3P and 0.2 for energy accounting & audit meters. High voltage windings of voltage transformer shall be protected by current limiting fuses. Fuse failure relay shall be provided on the secondary side of all voltage transformers to monitor failure of fuses.

The following over voltage factor shall be considered for PT.

- 120% for continuous duty.
- 150% for 30 sec (for 415V solidly grounded system)

High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position.

Low voltage MCB's, sized to prevent overload, shall be installed in all ungrounded secondary leads. MCB's shall be suitably provided with auxiliary contacts. MCB's auxiliary contacts connected suitably through relay shall be provided on the secondary side of all voltage transformers to monitor failure or trip of MCB's. The relay shall initiate alarm and block the tripping etc. which shall operate in case of VT MCB trip or failure.

6.71.1.7 Relays

Numerical multifunction relays shall be provided for all feeders. Numerical relay shall have trip circuit supervision. All protective relays shall be of draw-out type, suitable for flush mounting and fitted with dust tight covers. All relays shall have built-in testing facilities. Small auxiliary relays may be of non-draw-out type and mounted within the cubicle. Relays shall have lock-out facility with manual reset. Each feeder shall be complete with necessary auxiliary relays, timers, etc., to meet the circuit requirement. Under voltage relays shall be provided in the bus PT circuit.

Relays shall be rated for operation on 110V VT secondary voltage and 1A CT secondary current. The switchgear shall be provided with DC fail relay and DC fail indication lamp for each DC control supply incomer. DC isolation switch for each feeder shall be provided with backup HRC fuse. Breaker auxiliary contacts used for interlocking purposes shall be multiplied using electrically latched relay.

Incomers and Outgoing transformer feeders shall have the following minimum protection relays.

- Numerical protection relay having Instantaneous over current protection (50) on all the three phases, IDMT Over current protection (51) on all the three phases, Instantaneous earth fault protection (50N)
- Instantaneous Ground fault protection through CBCT (50G)
- Backup earth fault protection connected to Transformer neutral CT (51N)
- Latched Lock out relay (86).
- Trip circuit supervision relay (95)
- DC Fail relay (80F)
- REF protection relay (For Transformers 2MVA & above)

Self-reset auxiliary relays with hand reset flag indicator shall be provided for contact multiplication (52X) of the following:

- Transformer winding temperature indicator alarm and trip contacts.
- Transformer pressure relief trip contacts.

Bus Coupler (Tie) feeders shall have the minimum following protection relays.

- Latched Lock out relay (86).
- Trip circuit supervision relay (95)
- DC Fail relay (80F)

Motor feeders shall have Numerical motor protection relay having as a minimum following protections.

- Instantaneous earth fault protection through CBCT (50 N).

- Latched Lock out relay (86).
- Under voltage protection
- Trip circuit supervision relay

Bus PT shall have the following protections.

- Under & Over voltage relay
- MCB trip or failure relay
- No voltage relay

6.71.1.8 Control Switches

Circuit breaker control switches shall be 3-position spring return to `neutral' from both close and trip positions. They shall have `Pistol Grip' handle.

Ammeter selector switches shall have make before break feature on its contacts. The selector switch shall generally have four positions, three for reading three phase currents and the fourth as off position. The voltmeter selector switch shall measure phase to phase voltages.

The contacts shall be of silver plated, air break type. The continuous current and breaking capacity of the contacts shall be adequate for the duty involved.

6.71.1.9 Indicating Lamps

Indicating lamps shall be of the panel mounting, LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary. Lamps shall have translucent lamp-covers of the following colours, as warranted by the application. Bulbs and lamp covers shall be easily replaceable from the front of the cubicles. Low Voltage Glow Prevention (LVGP) feature shall be provided for indicating lamps. The colour of indication lamps shall be as follows:

- GREEN : Breaker Open
- RED : Breaker Closed
- AMBER : Auto trip & all Alarm conditions
- BLUE : Spring Charged
- WHITE : For all healthy conditions (e.g. trip coil healthy & control supply healthy)

For each breaker feeder, Panel indication lamps shall be provided as follows:

- Breaker Open
- Breaker Closed
- Auto trip
- Motor Spring Charged
- Trip coil healthy

- Control supply healthy
- Breaker in service position
- Breaker in Test position
- Lockout relay healthy
- SF6 Gas Pressure Low (Alarm)
- SF6 Gas Pressure Low (Trip)
- Any other indication, as required

For incomer and Bus, indicating lamps for R, Y, B phase shall be provided.

6.71.1.10 Meters

All Indicating meters shall be digital type, 96 x 96 mm size, suitable for flush mounting with constant accuracy for the entire range of respective parameters with an inbuilt provision for calibration verification. The instruments shall have an accuracy class of 1.0. All Multifunction meters shall have digital display and communication port with true RMS measurement facility with minimum 1% accuracy level. All digital meters shall be with RS485 communication port.

For incomers following Meters and transducers shall be provided:

- Ammeter
- Voltmeter
- Current transducer on three phases
- Voltage transducer on three phases
- Multifunction meter with digital display and communication port for kW, kVAR, kWH and power factor measurement.

For outgoing transformer feeders following Meters and transducers shall be provided:

- Ammeter
- Current transducer on one phase
- Multifunction meter with digital display and communication port for kW, kVAR, kWH measurement.

For outgoing motor feeders following Meters and transducers shall be provided:

- Ammeter on one phase
- Current transducer on one phase
- Hour run meter

For Bus PT following Meters and transducers shall be provided:

- Voltmeter
- Voltage transducer on three phase

All the transducers shall have dual output of 4-20 mA range. For motor feeders, it shall be 4-20-24 mA to measure starting current also.

6.71.1.11 Secondary Wiring

The Switchgear shall be fully wired at the factory to ensure proper functioning of control, protection, transfer and inter locking schemes. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks. Wiring shall be done with flexible, 1100V grade, PVC insulated switchboard wires with stranded copper conductors of 2.5mm² for current circuits and 1.5 mm² for voltage circuits. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per Contractor's wiring Diagrams. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals. All external cable terminations shall be accessible while the breaker is in service position.

6.71.1.12 Terminal Blocks

Terminal blocks shall be 1100V grade box-clamp type with marking strips. CT shorting links, Drop link type terminals shall be provided for CT secondary leads. Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished. Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

6.71.1.13 Cable Termination

Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection. All provision and accessories shall be furnished for termination and connection of cables, including removable gland plates, cables supports and crimp type tinned copper lugs, brass compression glands with tapered washer and terminal blocks.

6.71.1.14 Name Plates

Name plates of approved design shall be furnished at each cubicle and at each instruments & device mounted on or inside the cubicle. The material shall be lamicoid or approved equal, 3 mm thick with white letter on black back ground. The material shall be held by self-tapping screws. Nameplate size shall be minimum 20 X 75 mm for instrument device and 40 X 150 mm for panels. Caution notice on suitable metal plate shall be affixed at the back of each vertical panel.

6.71.1.15 Space Heaters and Plug Sockets

Each cubicle shall be provided with thermostat controlled space heaters and cubicle lamp with door switch suitable for operation from 240 V, single phase AC supply and 5A, 3 pin plug socket. The space heater shall be located at the bottom of each switchgear compartment. Cubicle heater, Motor heater, Plug/socket circuits shall have individual MCB units. In addition, motor feeder cubicle shall be wired-up for feeding the motor space heater through suitable rated breaker auxiliary NC Contact and/or contactor.

6.71.1.16 Testing and Inspection

Switchgear and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Switchgear and its components shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

6.71.1.17 Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

6.71.1.18 Transformers

This specification covers the requirements of 11/0.433 KV distribution dry type transformers complete with all accessories. The Cast resin dry type transformers shall be capable of operating continuously at its rated output without exceeding the temperature limits specified.

The transformers shall be suitable for connection to the system having short circuit level and short circuit duration as specified. The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults. Calculation shall be submitted along with the offer to prove that thermal as well as mechanical withstand capacity of the transformer is as per Indian Standards in the event of short circuit to the specified duration. Transformers shall be designed to withstand the thermal and dynamic stresses due to Short circuit at the terminals for 5 seconds duration with respect to fault level specified.

The impedance of the transformer shall not be less than as stated in Indian Standard at a reference temperature of $75^{O}C$.

The transformers shall be capable of delivering the rated output at any particular tap without exceeding the specified temperature limits under the following operating conditions.

- Voltage variation of ± 10% of rated voltage of that particular tap.
- Frequency variation of $\pm$3% of rated frequency.
- Combined voltage and frequency variation of 10% (absolute sum).

The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage. The noise level at rated voltage and frequency shall be as per NEMA-TR1 standard.

The transformers shall be suitable for over-fluxing (due to combined effect of voltage & frequency) up to 10% on any tapping without injurious heating at full load condition. The maximum flux density in any part of core and yoke under such condition shall not exceed 1.9 Tesla.

Generally, the Transformer shall have total efficiency not less than 98% at full load condition. Transformer shall be fitted with diagram and rating plates. The diagram plate shall show the winding connections and tapings in tabulated form.

Salient parameters of the transformers are as follows:

- Nominal system voltage (HV / LV) : 11/0.433K V
- Vector group : Dyn11

- Temp rise in winding by resistance method: 60°C over 45°C ambient
- Parallel operation of transformer : Yes, only momentary
- Short circuit withstand duration : 2 seconds
- 11kV System fault level : 40kA for 1 sec
- 415V System fault level : 50kA for 1 sec

6.71.1.19 Windings

Transformers shall be connected as specified in design requirements. Winding shall comprise of high conductivity copper conductors completely impregnated and cast under vacuum in epoxy resin, fully insulated (with glass fibre reinforced epoxy insulation of very good electrical and mechanical quality), and shall be suitable for the highest system voltage. Winding shall be concentrically wound on the core, and shall be braced to withstand shocks, which may occur through rough handling during transport, switching and other transient condition during service, and also to reduce to a minimum the damage arising from stresses due to an internal fault. All windings shall be subjected to vacuum drying.

6.71.1.20 Core

Cores shall be built from best quality, low loss, cold-rolled, grain oriented electrical steel laminations conforming to relevant Indian Standard. All core sheets shall be to reduce the core loss to a minimum. The flux density in core shall not exceed 1.6 Tesla under over voltage conditions and to this effect calculations shall be submitted. Maximum current density shall not exceed 2.5A per sq.mm. All joints shall be interleaved, and the core shall be securely clamped so as to ensure that the noise level and the vibration are maintained at a minimum. All clamps shall be adequately insulated. The complete core shall be coated with special resin as a protection against corrosion.

6.71.1.21 Temperature Indicators

For measuring hot spot temperature in the winding, 150 mm dia dial type winding temperature indicator (WTI) with adjustable potential free alarm and trip contacts, maximum reading pointer and resetting device shall be provided. Temperature sensing element shall be complete with image coil, bushing CT etc. Accuracy class of WTI shall be +/- 2°C or better.

6.71.1.22 Bushings

All bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects complete with suitable terminal connectors of adequate capacity. Bushings located inside cable boxes / bus-duct flanges can be epoxy-moulded types. Bushing CTs shall be provided as per system requirement. Secondary leads of CTs shall be wired upto-marshalling box. The arrangement shall be such that the CT can be removed from the transformer without removing the tank cover. Current transformers shall be cast resin type with Class E or better insulation.

6.71.1.23 Terminal Arrangement

Type of terminal connection shall be by Cables on both HV & LV side. The cable box shall be suitable for the working pressure of cable with which it is associated and shall have adequate clearances for the specified voltage and cable termination kits. For cable termination, terminals of transformer shall be brought out through side wall mounted bushings to a detachable cable box with disconnect link.

The cable box shall be self-supporting, weather proof, air filled type complete with all hardware such as undrilled gland plates, etc.

The design of the box shall be such as to preclude the access of water to the box. An adequate space shall be provided within the box so that the cable cores may be formed into the lugs without undue bending or stress on the lugs, and adequate clearance shall be preserved between live metal and frame such that the electrical pressure tests specified in Indian Standard are satisfied. Flexible links shall be provided between transformer terminals and cable lugs. Cable box shall have IP 55 degree of protection.

6.71.1.24 Marshalling Box

Marshalling box shall be sheet steel enclosed with IP 55 degree of protection alarm & trip contacts of all the fittings & accessories and secondary leads of CTs shall be wired up to marshalling box. Cable gland plate shall be of removable type. The marshalling box shall have isolating switch & MCB for incoming power supply. Cubicle illumination lamp with door switch and space heater with thermostat and ON/OFF switch shall be provided. The marshalling box shall have 10% additional set of control terminals.

6.71.1.25 Grounding

Two grounding pads located on the opposite sides shall be provided for connection of station ground mat / overall earthing for each transformer. Grounding pads shall have clean buffed surface with tapped holes. M10 GI bolts, nuts and spring washers. Two ground terminals each shall be provided on marshalling box & cable box. For neutral connection, two ground copper conductors of specified size shall be provided, supported on pin insulators (provided on tank) from neutral bushing to the bottom of the tank for connection to station ground.

6.71.1.26 Off Circuit Tap Changer

Off Circuit tap changers shall be provided on HV winding with +/- 10% range of taps in steps of 2.5%. The tap changing shall be affected by an external 3 phase gang operated tap change switch. The operating handle shall be padlocked at any position. The mechanism shall be provided with a mechanical tap position indicator, mechanical stop to prevent over cranking of mechanism etc. A warning plate indicating 'For de-energised operation only' shall be fitted.

6.71.1.27 Wiring and Terminal Blocks

All control cabinets, marshalling boxes, etc. shall be fully wired at the factory to ensure proper functioning of the control, protection and interlock schemes. All spare contacts of switches, relays and other devices shall be wired upto the terminal block.

Wiring shall be done with flexible 1100V grade HR PVC cables with stranded copper conductor of minimum size 2.5 sq.mm. Wiring shall be identified at both ends with ferrules bearing wire numbers as per approved drawings. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

Terminal blocks shall be of 1100 V grade suitable for terminating required cable size. Terminals for CT secondary shall have provision for shorting. Not more than two wires shall be connected to any terminal. 20% spare terminals shall be provided. All devices and terminal blocks within the panel shall have identification numbers as per schematic diagram.

6.71.1.28 Nameplate

Each transformer shall be provided with a nameplate of weather-resistance material fitted in a visible position showing all the 'information and additional information' as per IS: 1117.

6.71.1.29 Fittings & Accessories

Each transformer shall be supplied with the following as a minimum:

- Two nos. Stainless steel Rating & Diagram (Hindi & English), terminal marking and danger plates.
- 3 earth terminals per transformer, each suitable for earth conductors of size 2 numbers 75x10mm GI strip for earthing of the body of the transformer and its enclosure.
- Lifting lugs for complete transformer and Core-coil assembly
- 6 numbers PT100 RTDs with Winding temperature indicator (WTI) display
- 4 nos. Jacking Pads
- 4 nos. Bi-directional Rollers / flanged wheels with stopper arrangement to lock transformer in required position
- 4 nos.Cover lifting eyes
- Marshalling box
- Cable box
- 1 no. off circuit tap changer
- 3 nos. HV Bushings with terminal connectors
- 3 nos. LV Bushings with terminal connectors
- 1 no. LV Neutral Bushings with terminal connectors
- Platform mounting channel
- 1 set LV Neutral Bushing CTs
- 2 nos. Inspection covers
- 2 nos. supports for HV cable box
- 1 Lot Interconnecting cables

6.71.1.30 Testing and Inspection

Transformer and all its fittings should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Transformer and all its fittings shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

6.71.1.31 Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

6.71.1.32 LT Switchgear

This specification covers the requirements of 415 V Power Control Centre, Motor Control Centre, Main Lighting Distribution Boards, AC Distribution Boards, Lighting / Welding Distribution Boards, Starters, Local Push button stations etc. complete with all accessories. The switchgear and its components shall be designed for design ambient temperature of 45^{O}C. Switchgear shall be designed for natural air cooling. No forced cooling is acceptable.

Auto/Manual/Planned Changeover scheme with synchronizing feature for various incomers and bus couplers shall be provided in Power Control Centre (PCC) / Motor Control Centre (MCC) for interlocking of Incomer breaker with upstream breaker. Incomer, bus-coupler & Outgoing breakers shall also be controlled from PLC (only provision to be provided since there is no PLC envisaged at this stage) in addition to Local operation from the panel.

- Short circuit withstands rating of the switchgear shall be as given in the attached SLD.
- 415V normal system shall be solidly grounded. 110V DC system shall be ungrounded.

Busbar, breaker and other components shall be designed for continuous operation at rated current considering temperature inside the cubicle. The continuous current rating of the bus bars, incomers, bus couplers of the MCC shall be the maximum load on the bus due to all the running auxiliaries during any operating condition plus 20% margin rounded off to the next higher standard rating. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm^2 and for Copper busbars as 1.25 Amps/mm^2.

Close & Open control of all the motors in PCC/MCC shall be provided in PLC (provision only at this stage) in addition to Local Push Button Station (in the field) and from the panel. Local operation of circuit breakers shall be possible in "Test" position. Remote indications / alarms shall be provided in the PLC (provision only at this stage). The control / interlock schemes for various types of feeders shall commensurate with their application.

PCC & MCC shall be of draw out type for all the modules including breaker modules/ Starter module/SFU module. Distribution boards shall be of fixed type. All PCC/MCC/DB shall be single front type. 220V control supply shall be derived from 415/220V control supply transformer located in respective module. 240V AC space heater supply provision shall be provided for motors rated above 30 kW. For breaker operated feeders, control supply voltage shall be 110V DC.

At least 20% of feeder modules covering the range of motors used subject to minimum of one module in each bus section shall be provided as spare. Spare modules shall be completely wired up.

All motors shall have direct on line starter. 90kW and above capacity motors shall be fed from ACBs. Less than 90kW capacity motors shall be fed by MCCBs and contactors. However, the duty of the drive/application, i.e. high impact loading, etc. to be considered as criteria for selecting ACB operated motors even for rating < 90kW. Wherever applicable, priority shall be given to the use of Motor Protection Circuit Breaker (MPCB) with Contactor.

Operating height of the handles/switches shall be limited to a maximum of 1800 mm and a minimum of 300 mm.

For PCC changeover shall be provided. If there is an under voltage (dipped to 30-40% voltage) on any one of the buses, sensed through under voltage relays, the respective incomer breaker shall trip automatically and the bus coupler shall close, if the voltage is available on the other bus section, thereby establishing voltage at 415V motor terminals before motor reaches standstill condition. The auto changeover shall be blocked if any of the following condition exists:

- Any of the involved breaker is in the test or withdrawn position.
- Source voltage is not available.
- Source breaker is tripped due to bus fault.

No release is acceptable for Breaker feeders. Only CT operated relays shall be provided for protection. MCCB, Contactor and overload relay shall meet type-2 co-ordination as per applicable standard.

6.72 Design and Construction

6.72.1 PCC / MCC

415 V panels shall be of metal enclosed, indoor, floor-mounted, free-standing type. Switchboard frames and load bearing members shall be fabricated using CRCA sheet steel of thickness not less than 2.0 mm. Doors and covers shall also be of CRCA sheet steel of thickness not less than 1.6 mm. Thickness of gland plates shall not be less than 3.0 mm for sheet steel & 4.0mm for non-magnetic material. All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with IP54 degree of protection. Outdoor switchgear enclosures should have minimum IP55 degree of protection for covered area and IP65 for uncovered area.

All switchboards shall be of uniform height not exceeding 2450 mm. Switchboards shall be easily extendable on both sides by the addition of vertical sections after removing the end covers. Module size of switchboards shall not be less than 200mm. Cable entry for PCCs/MCCs/DBs shall be from bottom.

Switchboards shall be divided into distinct vertical sections (panels), each comprising of the following compartments:

- Main busbar compartment:
- Switchgear / feeder compartment
- Cable alley
- Auxiliary busbar compartment
- Control compartment for relays for ACB feeder

The feeder compartment shall be sheet steel enclosed on all sides with the withdrawable units in position or removed. The front of the compartment shall be provided with the hinged single leaf door with captive screws for positive closure. All circuit-breaker panels shall be of single-front type. All single-front switchboards shall be provided with single-leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with “DANGER” labels.

All 415 V circuit-breaker modules and MCC modules shall be of fully draw-out type having distinct 'Service' and 'Test' positions. The equipment pertaining to a draw-out type module shall be mounted on a fully withdrawable chassis, which can be drawn out without having to unscrew any wire or cable connection. Suitable arrangement with cradle / rollers and guides shall be provided for smooth movement of the chassis.

6.72.2 Main Lighting Distribution Board (MLDB) / AC Distribution Board (ACDB)

MLDB shall be totally enclosed, sheet steel, indoor, dust tight, vermin proof and floor mounting type. The sheet metal thickness shall be 2mm. MLDBs shall be provided with separate chambers for (i) bus bars (ii) outgoing feeders (iii) incoming feeders (iv)cabling chamber. MLDBs shall have degree of protection of IP-54 for indoor and IP-55 for outdoor installation.

ACDB shall be totally enclosed, sheet steel, indoor, dust tight, vermin proof and floor mounting type. The sheet metal thickness shall be 2mm. ACDB shall be provided with separate chambers for (i) bus bars (ii) outgoing feeders (iii) incoming feeders (iv) Dry type transformer (v) cabling chamber. ACDB shall have degree of protection of IP-54 for indoor and IP-55 for outdoor installation. ACDB shall be provided with 415/415V, 3 phase dry type transformer of suitable capacity to obtain 3 phase, 4 wire system and to limit the fault level to 35KA. The capacity of the transformer shall be decided such that there is at least 20% margin over the total lighting load. Fault level required for ACDB bus & incomer shall be 35kA.

MLDB & ACDB shall be provided with one TPN MCCB for incomer feeder and required number of 3phase outgoing feeders with TPN MCB's and two Nos. Spare feeders. CT operated ammeters and Voltmeter and indicating lamps shall be provided for incomers.

6.72.3 Lighting Distribution Boards (LDB)/Power Distribution Board (PDB)/Control Distribution Board (CDB)

Distribution boards shall be metal enclosed, fixed type, single front, and compartmentalized construction. The Distribution board frame shall be fabricated using CRCA sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by CRCA sheet steel of thickness not less than 1.6 mm. Suitable synthetic rubber gaskets shall be provided to make boards completely dust and vermin-proof with a degree of protection of IP54 for indoor and IP55 for outdoor installation. The handle of incoming switch shall be mounted on the door of the board, with padlocking facility in both 'ON' and 'OFF' positions. Cable entry facilities shall be provided with removable gland plates of suitable thickness. All incoming and outgoing cables shall be terminated on suitable terminal blocks.

For lighting circuits, Lighting Distribution Boards (LDBs) shall be provided and for welding receptacle circuits, separate Power Distribution Boards (PDBs) shall be provided.

LDBs shall be provided with one 63 Amp TPN MCB for incomer and required number of 20 Amp SPN outgoing feeders with MCBs with neutral links for each circuit distributed over three phases. Maximum lighting load on any one circuit shall be restricted to 1500 watts.

PDBs shall be provided with one 63 Amp TPN MCB with ELCB for incomer and required number of 32 Amp TPN outgoing feeders with MCBs with neutral links for each circuit distributed over three phases. Maximum welding receptacle load on any one circuit shall be restricted to 2000 watts.

6.72.4 Air Circuit Breakers

Air Circuit breakers shall be (three pole for motor feeders and TPN for other feeders), air break, horizontal draw-out type, and shall have fault making and breaking capacities as specified. These shall be microprocessor based with RS 485 communication facility. There shall be “SERVICE”, “TEST” and “ISOLATED” positions for the breakers. In “Test” position, circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the “SERVICE”, “TEST” or “ISOLATED” position. It shall be possible to close the door in “Test” position.

Each breaker feeder shall be provided with the following as a minimum:

- Electrical anti-pumping feature
- Motor charged spring operating mechanism.
- Manual spring charging
- Mechanical indication of spring charge
- Mechanical position indicator
- Closing coil
- Shunt trip coil
- Manual trip push button
- Operation counter
- Phase barriers
- Shutter assembly
- Door interlock kit

The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 80 and 110 percent of the rated voltage. The closing coil & shunt trip coil shall be rated for 100% continuous duty. One Open-Close-Open operation of the circuit breaker shall be possible after failure of power supply to motor. For breakers spring charging motor shall be provided with over current protection. Motor windings shall be provided with class B insulation or better. The shunt trip coil shall operate satisfactorily, all the values of control supply voltage between 70 and 110 percent of the rated voltage.

Circuit breaker of the same type and ampere rating shall be wired alike and shall be mechanically interchangeable.

All Air Circuit Breakers shall be provided with the following interlocks:

- Movement of a circuit breaker between “SERVICE” and “TEST” position shall not be possible unless it is in open position.
- Closing of a circuit breaker shall not be possible unless it is in “SERVICE” position, “TEST” position or in “ISOLATED” position.

- Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.

Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle. The trolley shall be such that the topmost breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. ACBs shall have CT operated relays for over current and earth fault protection.

6.72.5 Moulded Case Circuit Breaker (MCCB)

MCCB shall in general conform to IS: 13947 Part-2. MCCBs shall be provided with thermo-magnetic type release for over current and short circuit protection. These shall be microprocessor based with RS 485 communication facility. The setting of the thermal release shall be adjustable from 75% to 100% of the rated current. The MCCB shall have breaking capacity not less than 50kA. MCCBs used for incomers and Bus coupler shall be equipped with stored energy mechanism for electrical closing and tripping. All other MCCBs shall be manually operated. The operating handle should give a clear trip indication.

6.72.6 Control and Selector Switches

Control and selector switches shall be of rotary type, with escutcheon plates clearly marked to show the function and positions. Circuit breaker control switches shall have three positions and shall be spring return to “NEUTRAL” from “CLOSE” and “TRIP” positions and shall have pistol grip handles. Circuit breaker selector switches shall have three stay put positions marked `Test’, `Local’ and `Remote’, respectively. They shall have black spade handles. Selector switches for starter modules shall have ‘Test’, ‘Local’, ‘Remote’ positions as specified. Ammeter and voltmeter selector switches shall have four stay put positions with adequate number of contacts for 3-phase 4-wire system. These shall have oval handles. Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondary.

6.72.7 Contactors

Motor starter contactors shall be air break, electromagnetic type rated for uninterrupted duty. Contactors shall be double-break, non-gravity type and their main contacts shall be silver faced. Direct-on-line contactors shall be of utilization category AC3. Reversing starters shall comprise of Forward and Reverse contactors mechanically and electrically interlocked with each other. These contactors shall be of utilization category AC4. The contactor shall operate satisfactorily from 85% to 110% of the rated voltage. The contactor shall not drop out at 70% of the rated voltage but shall definitely drop out at 20% of the rated voltage.

6.72.8 Instrument Transformers

The CTs shall be mounted on the switchgear stationary parts. For metering separate core shall be provided. The CTs shall be of cast resin, bar primary type and of Class E or better insulation. CT secondary current shall be 1A. Accuracy class of Current Transformer shall be Class 5P20 for relaying and Class 0.5 and ISF < 5 for metering. CTs for current rating less than 50A shall be ‘Wound primary’ type and above 50A shall be ‘Bar primary’ type.

Voltage Transformer shall be cast-resin, draw-out type and shall have an accuracy class of 1.0. The bus VTs shall be housed in a separate compartment. All VTs shall have readily accessible fuse and MCBs on primary and secondary sides respectively.

6.72.9 Indicating Instruments

All Indicating meters shall be digital type, 96 x 96 mm size, suitable for flush mounting with constant accuracy for the entire range of respective parameters with an inbuilt provision for calibration verification. The instruments shall have an accuracy class of 1.0. All such meters shall be fed through suitable Current transformers for motors rated 10kW & above. All Multifunction meters shall have digital display and communication port with true RMS measurement facility with minimum 1% accuracy level.

6.72.10 Push Buttons

Push-buttons shall be of spring return, push-to-actuate type. Where specified push buttons shall be stay put type. Their contacts shall be rated to make, continuously carry and break 10A at 500 V AC. All push-buttons shall have two normally open and two normally closed contact, unless specified otherwise. The contact faces shall be of silver alloy. All push-buttons shall be provided with integral escutcheon plates marked with its function. All emergency push-buttons shall be stay put/latching type. To detach, master key provision shall be provided.

The colour of the button shall be as follows:

- Green for motor START, breaker CLOSE, valve / damper OPEN /CLOSE commands.
- Red for motor TRIP, breaker OPEN.
- Black for all annunciator functions, overloads reset and miscellaneous commands.

6.72.11 Indicating Lamps

Indicating lamps shall be of the panel mounting, LED type.The lamps shall have escutcheon plates marked with its function, wherever necessary. All indicating lamps shall be rated for continuous operation at 85% to 110% of their rated voltage. Low Voltage Glow Prevention (LVGP) feature shall be provided for indication lamps. Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

- Red for motor ON, breaker CLOSE.
- Green for motor OFF, breaker OPEN.
- Blue for Service
- White for Test, Spring Charged, Spring Discharged, Lockout Relay Healthy
- Amber for auto trip

6.72.12 Control Supply and Space Heater Supply

The breaker operated PCC/MCC shall receive two nos. 110V DC feeder for the control supply and distribute to each panel. Auto changeover arrangement shall be envisaged between two supplies. Each panel shall receive control supply through bus wires and shall be tapped off through switch & fuse provided in the respective panel. It shall be possible to isolate any panel without disturbing the power supply to other panels. Each sub circuit shall have separate fuse. An under voltage relay to monitor control supply shall be provided. A contact of the relay shall be wired to the terminal for external use. ‘Control Supply Failed’ indication shall be provided.

Each starter module of MCC shall derive 220V AC control supply through control supply transformer. The control transformers shall be of insulation class `B' or better. The sizing of control transformers shall be carried out by the contractor considering the actual load of power contactors, auxiliary contactors, indicating lamps and other equipment including remote auxiliary relays and lamps in the circuit.

For space heater circuits of motor rated more than 30kW and also for panel space heater, 240V AC supply shall be provided by tapping from the incomer before the main isolating switch/breaker. Necessary switch and MCB to isolate and distribute the supply to each panel shall be provided. For motor feeders, circuit for motor space heater shall be wired through NC contact of breaker/contactor and MCB.

Each panel of PCC/MCC/DB shall be equipped with the following as required:

- Thermostatically controlled space heater(s)
- Illumination lamp with door switch
- 5A 3pin socket with MCB protection

6.72.13 Wiring

All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables. All internal wiring shall be carried out with 1100 V grade, HR PVC/ XLPE insulated single core, copper conductor of minimum 2.5 sq.mm for CT circuits and 1.5 sq.mm for other circuits. All internal wiring terminations shall be made with solder less crimping type tinned copper lugs. Insulation sleeves shall be provided over the exposed parts of lugs. Engraved core identification plastic ferrules marked to correspond with panel wiring diagrams shall be fitted at both ends of each wire. Number 6 and 9 shall not be used for wire identification.

Control terminal blocks shall be of 1100 Volts grade, rated for 10 Amps and in one piece molding. It shall be complete with insulating barriers, clip-on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. Terminal blocks for CT & VT secondary leads shall be provided with test links & isolating facilities. CT secondary leads shall be provided with short circuiting & earthing facilities. In all the panels at least 20% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks.

6.72.14 Power Cable Termination

Cable termination compartment and arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, PVC / XLPE insulated, armoured and FRLS PVC sheathed cables. All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS:8309. All lugs shall be insulated / sleeved.

6.72.15 Nameplates and Labels

PCCs, MCCs, Distribution Boards, local push-button stations and local motor starters shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also. All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Suitable stenciled paint mark shall be provided inside the panel/module for identification of all equipment, in addition to the plastic sticker

labels, if provided. These labels shall be positioned so as to be clearly visible and shall have the device number, as mentioned in the module wiring drawings. Caution name plate “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.

6.72.16 Busbars and Insulators

Each PCC/MCC & DB shall be provided with three phase and neutral busbars. DC distribution boards shall have two busbars. All busbars and jumper connections shall be of high conductivity aluminium alloy for PCC/MCC and Copper for DB of adequate size. The cross-section of the busbars shall be uniform throughout the length of switchboard. Interleaving of PCC busbar arrangement shall be envisaged. All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fibre glass moulded insulators. All busbar joints shall be provided with high tensile steel bolts, belleville/ spring washers and nuts. All copper to aluminium joints shall be provided with suitable bi-metallic washers. All busbars shall have HRPVC sleeves and colour coded.

Contact surfaces at all joints shall be silver plated or properly cleaned and anti-oxide grease applied to ensure an efficient and trouble free connection. Suitable bimetallic connectors shall be used for dissimilar metal connections.

The continuous rating of the main busbars shall be same as that of the incomer breaker, and busbar shall carry this continuous current without exceeding the temperature of 90º C. For silver plated joints, temperature shall not exceed 105°C. All horizontal and vertical busbar joints shall be covered by insulating shrouds.

6.72.17 Earthing

A copper/ Aluminium earthing bus of adequate size shall be provided at the bottom and shall extend throughout the length of switchgear. It shall be bolted to the framework of each panel and each breaker earthing contact bar. The earth bus shall be sized to withstand specified short circuit current. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e., ‘Service’, ‘Test’ and ‘Isolated’ as well as throughout the intermediate travel.

All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. All hinged doors shall be earthed through flexible earthing braid. VT and CT secondary neutral point earthing shall be at one place only on the terminal block. All metallic cases of relays, instruments and other panel mounted equipment shall be effectively bonded to the earth bus by independent stranded copper wires of size not less than 2.5 sq.mm.

6.72.18 Local Push Button Stations

The local push buttons stations shall be with FRP enclosure, suitable for outdoor mounting on wall or steel structures. The local push button stations shall be dust and vermin proof and shall have a degree of protection of IP55 as per IS: 13947 Part-1. Local push button stations shall comprise Start/Stop push buttons as per drive control philosophy. Emergency stop Push-buttons shall be stay put/Latching type, requiring master key for de-latching.

Following shall be provided for each breaker feeders

- Electrical anti pumping feature (94)
- Hand reset High speed lockout relay (86)

- Trip circuit supervision relay (95)
- Aux relay for breaker contact multiplication (52X)
- Aux relays as required for contact multiplication
- Indicating lamps for ON, OFF, Auto trip, spring charged, Trip circuit healthy, DC supply fail etc.
- Breaker control switch
- Local / Remote / Test selector switch
- Test Terminal blocks

ACB incoming feeders for PCC from transformers shall be provided with the following as a minimum.

- TPN Air Circuit Breaker
- Current transformers for metering & protection
- Digital Ammeter & Ammeter transducer
- Fuse/MCBs for control circuits
- Voltage transformers, Digital voltmeter & voltage transducer
- Under voltage relay with timer
- Microprocessor based Multi-function meter with communication facility
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

ACB Bus coupler for PCC from transformers shall be provided with the following as a minimum:

- TPN air circuit breaker
- Current transformer for protection & metering
- Fuse/MCBs for control circuits
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

Unidirectional motor feeders rated less than 10 kW shall be provided with the following as a minimum:

- Triple pole motor protection circuit breaker (MPCB)
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit

- Interposing relays

Unidirectional motor feeders rated 10kW and up to 30kW shall be provided with the following as a minimum.

- Triple pole MPCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit
- Current transformer for metering
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated above 30kW and less than 125kW shall be provided with the following as a minimum.

- Triple pole MCCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons
- Indicating lamps LED cluster type
- Numerical Motor protection relay
- MCB for 240V AC space heater circuit
- MCB for control circuit
- Current transformer for metering
- Current transducer
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated 125 kW and above shall be provided with the following as a minimum.

- Triple pole Air Circuit Breaker
- Current Transformer for metering & Protection
- Numerical Motor protection relay
- Fuse/MCBs for control circuit
- Indicating lamps LED cluster type
- MCB for 240V AC space heater circuit
- MCB for control circuit
- Current transducer
- Digital Ammeter
- Interposing relay

Bi-directional Motor feeders shall be provided with the following as a minimum. (Not applicable for Integral Actuators)

- Triple pole MCCB
- Triple pole mechanically interlocked, open / close contactors
- Auxiliary contactors
- Local/Remote/Test switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons.
- Indicating lamps LED cluster type
- MCB for space heater circuit
- MCB for control circuit
- Interposing relays

6.72.19 Testing and Inspection

Switchgear and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Switchgear and its components shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

6.72.20 Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

6.72.21 110V DC System

This specification covers the requirements of 110V DC Batteries, Chargers and DC Distribution Board. The function of the 110V DC Power Supply System is to provide the normal source of power to the 110V DC loads, such as Control Supply to Switchgears / Panels.

The duty cycle imposed on the battery shall include the following:

- Continuous loads (indicating lights, continuously energized coils, Control Panels, Relays)
- Momentary loads (switchgear operation (Trip coil/Closing coil), which exist for a period of less than 1 min period)

110 VDC Power Supply System shall be operated as an ungrounded system; that is, the negative terminal or ground reference terminal is not connected to the station ground grid. A DC ground monitoring system on the DC systems shall be provided and any DC ground fault shall be alarmed.

Batteries shall be sized in accordance with IEEE-485. The battery shall be sized with a 10% design margin and an ageing factor of 1.25. 110V DC Power Supply System shall consist of 2x100% 110V batteries, 2x100% 110V battery chargers cum DC Distribution Board. End Cell Voltage of Lead Acid Plate battery shall be considered as 1.85 V / Cell and for Nickel cadmium battery as 1.14V / Cell. During Normal operating condition, batteries shall be supplied from two (2) 100 percent battery charger. The chargers are supplied power from PCC/ MCC. The battery charger shall supply power to 110V DC loads and, at the same time, shall continuously float charge fully charged batteries. Both the chargers shall have dedicated incoming AC supply from MCC/PCC. During Emergency operation the battery shall supply the DC load when there is a loss of all auxiliary AC power supplies and/or a loss of power from the battery chargers. Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency condition when AC supply is lost.

The Charger shall be float cum boost type suitable for float charging both the batteries and supply load simultaneously. Chargers shall boost charge fully discharged batteries in 12 hours. Design margin of minimum 20% shall be considered in charger sizing for either mode of operation. Charger protections such as DC-O/V & U/V, AC U/V, E/F, S/C protection etc. shall be considered.

6.72.22 Construction of Battery

Lead Acid (Valve regulated) sealed maintenance free Plate type batteries shall be float charged at 2.15 to 2.20 Volts per cell and chargers shall also be capable of boost charging the associated DC battery up to 2.7 Volts per cell at the desired rate. Batteries shall be rated for 10 hour discharge rate (C10) as per manufacturer data. Containers shall be made of suitable glass fibre reinforced plastics or Polypropylene. Containers shall be robust, heat resistant, leak proof, non-absorbent, acid/alkaline resistant, non-bulging type and free from flaws such as wrinkles, cracks, blisters, pin holes etc.

Batteries shall have thick plates designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminals shall be clearly marked. Each cell shall be separately supported on porcelain insulators fixed on to the racks with adequate clearance between adjacent cells. Breathers/Vent plugs etc. shall

be provided for each cell. It shall be anti-splash type and having more than one exit hole to allow the gases to escape freely but prevent the acid spray from the battery. Lead coated copper inter-cell connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. All the terminals and cells, interconnections shall be fully insulated or have insulation shrouds/covers.

End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC/XLPE insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 60 minute discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared. Anti-corrosive gel shall be applied at the Battery terminals.

Wooden racks shall be provided for batteries for multi-tier installation. These racks shall be made of good quality first class seasoned teak wood. They shall be free standing type mounted on porcelain insulators. Numbering tags, resistant to acid for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Following accessories shall be provided with batteries.

- Syringe type Hydrometer : 2 Nos per Battery
- Thermometer with specific gravity : 2 Nos per Battery
- correction scale
- Cell testing voltmeter 3-0-3 volts : 2 Nos per Battery
- Acid resistant funnel : 2 Nos per Battery
- Acid resistant jug. : 2 Nos per Battery
- Rubber apron and gloves : 2 sets per Battery
- Spanners : 2 sets per Battery
- Wall mounted teak wood rack for : 2 Nos per Battery
- above items

Following maintenance spares shall be provided as a minimum

- Inter cell connectors : 10 Nos.
- Inter row connectors : 2 Nos.
- Battery stand insulators : 2 Nos
- Cell insulators : 2 Nos
- Nuts, bolts & washers : 10 pieces each
- Vent plugs : 10 Nos.
- Spare dry cell : 4 Nos.

Fuse box for each battery shall be provided in the battery room and shall comprise the following:

- DP Fuse Switch unit
- HRC Fuses with striker pin & aux contact for remote alarm
- FRP enclosure.

Discharge resistor made of punched stainless steel grid enclosed in sheet steel enclosure shall be provided for discharge testing of Battery.

6.72.23 Construction of Battery Charger cum DCDB

During float charging, charger shall feed the respective DC Distribution board and as well as float charge its own batteries and maintain a DC voltage that shall pass the minimum current through the cells to keep them charged without overcharging. In case of mains failure to charger or charger failure, battery shall supply the full load. While boost charging of respective battery, DCDB shall be isolated from the Charger and shall be fed from other Charger. Each Battery charger should meet the Trickle requirement of both banks (under emergency) and boost requirement of each bank.

During boost charging, battery charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50 to 100 % of the rated output current for boost charging mode. During boost charging, the Boost charger shall recharge the completely discharged battery to full capacity in 12 hours.

When on automatic control mode during float charging, the charger output voltage shall remain within +/-1% of the set value for AC input voltage variation of +/-10%, frequency variation of + 3/-5%, a combined voltage and frequency (absolute sum) variation of 10 % and a continuous DC load variation from zero to full load. Uniform and step-less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire float charging output range specified. Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether float or boost charging.

All Battery chargers shall be provided with facilities such as automatic voltage regulator (AVR) for both automatic and manual control of output voltage and current. The chargers shall be self-regulating, natural air cooled, static type provided with suitable double wound transformer, full wave thyristor type rectifiers, filter circuits, DC & AC Switchgear. Chargers shall be metal enclosed, fixed type, suitable for indoor mounting on floor. Panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by cold rolled sheet steel of thickness not less than 2.0 mm. Suitable synthetic rubber gaskets shall be provided to achieve a degree of protection of IP54.

Rectifier transformer shall be continuously rated, dry type, class F insulation, epoxy resin impregnated, Air Natural (AN) cooling and with adequate number of taps. The rating of rectifier transformers shall correspond to the rating of the associated rectifier assembly.

All the Charger panels shall be provided with an illuminating CFL lamp, a 5 Amp socket and space heaters with thermostat. Toggle switches and MCB’s shall be provided separately for each of the above fittings. Space heaters “ON” indication to be provided. Two separate grounding pads shall be provided.

Locking facilities shall be for locking float / boost selector switch in the float position only.

Digital type Window annunciator shall be provided for alarm annunciation with acknowledge, test & reset push buttons and a buzzer for the following conditions:

- SCR fuse fail

- Battery / DC system under voltage
- DC system over voltage
- DC over load
- Output fuse blown
- AC supply fail
- AC under voltage
- Battery earth fault
- Filter fuse failure
- Battery on Float / Boost
- Charger fail/Battery on discharge
- Any other annunciation, as required

Remote alarm contacts for hooking up to PLC shall be provided. For each charger, current & voltage transducer shall be provided for remote monitoring of DC voltage and Current at PLC.

Protection features, indications, meters and alarms shall be provided for each charger. Protection features shall include the following as minimum.

- Overload Protection
- Phase failure protection
- Voltage unbalance protection
- Fuse failure protections for SCR and filter circuit

Suitable potential free contacts for remote indication of above abnormal conditions shall be provided. However the requirements / design shall be firmed up during the detailed engineering stage.

6.72.24 Testing and Inspection

Battery & Charger and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Battery & Charger shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

6.72.25 Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

6.72.26 Power and Control Cables

Power cables shall be sized to satisfy the following Criteria:

- Short circuit withstand capacity for applicable fault current and duration.

- Full load current carrying capacity under installation conditions considering Site ambient temperature & site installation (Grouping) conditions based on Manufacturer's recommendation.
- Permissible voltage drop limits under steady state/transient state as applicable.

Power cables shall withstand fault current of the circuit for the duration not less than the maximum time taken by the primary protective system to isolate the fault. Cables shall be sized for the following short circuit rating.

- Outgoing cables from 11kV Switchboards : 40 kA for 0.16 sec.
- Incoming cables to 415V PCC (Breaker operated) : 50 kA for 1 sec.
- Incoming cables to 415V MCC (Breaker operated) : 50 kA for 0.5 sec.
- Incoming cables to 415V MCC/DB (MCB protected) : Fuse cut-off current for 10m.sec
- Cables from 415 V MCC to Motors : 50 kA for 0.16 sec ACB operated
- Feeders from MCC/DB (MCB protected) : Fuse cut-off current for 10m.sec

To maintain voltage at motor terminals / equipment end with in desirable limit, it is proposed to limit the voltage drop in the cables within the following limits:

- Steady state Voltage drop (Continuous running condition) : 2.5%
- Transient state voltage drop (During Motor Starting) : 10 %

All cables shall be suitable for laying on racks, in ducts, trenches with chances of flooding by water and shall also be suitable for directly buried installation. All the cables shall be flame retardant low smoke (FRLS) type designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.

The minimum size of LV power cable shall be of 2.5 Sq.mm for Copper. Power cables shall have copper conductor for sizes up to 10 sq.mm. For higher sizes, aluminium conductor shall be provided. The minimum size of control cable shall be of 1.5 Sq.mm copper. For CT/VT circuits, minimum 2.5 sq.mm copper cable shall be provided. Conductor of Copper cables shall have plain annealed copper. All the conductors shall be multi-stranded.

Power cables shall be XLPE insulated. Control cables shall be PVC insulated. PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90°C and short circuit conductor temperature of 250°C.

The cable cores shall be laid up with fillers between the cores wherever necessary. All the cables shall have distinct extruded PVC inner sheath. For single core armoured cables, armouring shall be of aluminium wire. For multicore armoured cables, armouring shall be of galvanised steel strip/wire as per applicable IS.

Outer sheath shall be of PVC black in colour having following FRLS properties.

- Oxygen index of not less than 29.
- Acid gas emission of max. 20%
- Smoke density of not more than 60%

The cables shall meet flammability test as per IEEE-383. All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added in to the PVC compound of the outer sheath.

6.73 Construction

6.73.1 HT Cables

Cables shall be XLPE insulated, screened, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-II. 11kV cables shall be suitable for unearthed system. The conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process. The metallic screen of each core shall consist of copper tape with minimum overlap of 20% copper screen which shall be capable of carrying the system earth fault current for 2 seconds. Outer sheath shall be FRLS PVC.

6.73.2 LV Power Cables

LV Power cables shall be of 1.1 kV grade, XLPE insulated, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-I.

6.73.3 Control Cables

Control cables shall be of 1.1 kV grade, multicore, PVC insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed stranded copper conductor conforming to IS:1554 Part-I. Up to 5 cores it shall be colour coded and above 5 cores shall be numbered.

6.73.4 Trailing Cables (if applicable)

Trailing cables / Flexible cables shall be rubber insulated with copper conductor as per applicable standards. The minimum size of LV power cable shall be 4 Sq.mm for Copper.

6.73.5 Cable Identification System

In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed over outer sheath.

- Cable size and voltage grade.
- Word `FRLS' at every 5 metre.
- Sequential marking of length of the cable in meters at every one metre.

The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

6.73.6 Cable Drums

Cables shall be supplied in wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with waterproof layer. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/rubber caps, secured by `U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS 10418.

6.73.7 Testing and Inspection

Cables offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. Routine tests, Acceptance tests and all special tests for FRLS properties shall be carried out for all the cables as per applicable standards. The sample shall be drawn at the rate of one per type and size for every lot offered for inspection.

6.73.8 Special Tests

The following tests as applicable to FRLS sheathed cables shall be conducted as type tests on each size of each lot.

(a) Oxygen index test

(b) Temperature index test

(c) Acid gas generation during fire

(d) Smoke generation test under fire

(e) Swedish chimney test for class F3 as per SS : 424-14-75

(f) Under fire conditions for bunched cables as per IEEE std. 383 / 74

6.73.9 Spares List

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

6.73.10 Lighting System

This specification covers the requirements of Illumination system.

The lighting system includes

- 100% Normal AC lighting
- 20% High Mast Lighting and other Lightings 100% on DG set
- Emergency lighting through battery backed Portable lamps in selected areas of the plant during plant emergency conditions.

Normal AC Lighting shall be energised from 3-phase, 4-wire, 415 V main lighting distribution board. These MLDBs shall feed Lighting Distribution Boards (LDB) for each individual area. Dry type lighting transformers of voltage ratio 1:1 shall be provided for reducing fault level in MLDB. The single phase voltage level considered for lighting system & fixtures shall be optimally arrived to achieve energy

efficiency without sacrifice in the illumination level. Lighting transformer tap range & tap step to be designed accordingly.

Emergency lighting shall be provided in specific areas such as switchgear rooms, areas near local panels, staircases and other strategic areas during AC supply failure. Emergency lighting shall normally be “off,” and upon loss of normal AC supply, emergency lights shall be turned “on” in auto mode. Emergency lighting units with integral batteries shall be used. Emergency lighting unit shall provide light for one hour when the normal power source is lost. Each emergency light unit shall be provided with battery, battery charger and one number 5 watt LED lamps. Exit light fixtures shall be LED and provided in all the Building at exit doors.

LED lamps shall be used as light sources in the lighting system.

Fixtures considered shall be energy efficient type with low loss & low harmonics (less than 10%) and with higher lumen / watt.

Emergency lighting luminaries shall be supplied to ensure a safe exit in case of power failure. Emergency light shall be with dimming and SOS feature. Each shall be connected to the 240 V supply system and shall automatically switch to the battery in case of power supply failure. The battery shall be able to supply power to the lamps for a minimum of 1.0 hour.

Enclosure of all fittings shall be of weather & dust-proof construction and consist of cast aluminium body able to withstand direct hosting.

AC lighting fixtures and accessories shall be suitable for operation on 240 V AC, 50 Hz supply with supply voltage variation of ± 10%, frequency variation of +3% to –5% and combined voltage and frequency variation of absolute sum of 10%.

Lighting level design shall include a Maintenance factor as follows to account for lamp lumen depreciation, luminaries surface dirt and room surface dirt, etc.

- Air conditioned areas : 0.8
- Non-Air conditioned areas : 0.7
- Dust prone outdoor Areas : 0.6

Suitable number of 63 ampere, 3 phase, 415 volt AC welding receptacles shall be provided. Welding receptacles shall be placed near all major equipment and minimum 2 numbers on each floor in all the buildings.

20A, 240V, Single phase convenience receptacle with switch shall be provided in all the rooms. The convenience outlets shall be spaced to provide access to any point with a 15 meter extension cord. Receptacles shall be served from an earth leakage circuit breaker (ELCB).

Welding sockets shall be fed from ACDB / PDB. Number of receptacles per circuit shall not be more than 2. Each welding receptacle unit shall have dedicated MCB installed adjacent to the receptacle with IP55 type enclosure.

The light fixtures shall be circuited so that adjacent fixtures are connected to alternate phases of a 3-phase circuit. Auto-timed switching may be considered with manual bypass mode for indoor lighting system. The lighting for enclosed areas within the buildings shall be manually switched ‘on’ and ‘off’ at local light switches near personnel entrance doors. Wall mounted switches shall be provided at the entrance to battery room and equipment/office rooms.

Electric power to light fixtures located outdoors shall be switched with photoelectric controllers and timers. Outdoor lighting shall have auto/manual mode of operation. Provision shall be made to bypass the photoelectric controller and timer.

Switches shall be sized maximum of 80 percent of the light switch ampere rating with enclosures suitable for the location in which they are installed.

Load on each lighting circuit and single phase receptacle circuit shall be limited to 2000 W.

For areas illuminated by more than one circuit, the adjacent circuit shall be fed from different phase. Load balance on all the 3 phases to be envisaged for lighting as well as 1-ph power distribution circuit.

Wiring for indoor lighting installation shall be carried with PVC insulated wire with following sizes laid in conduit.

- Lighting Panel to lighting Fixtures : 2.5 sq.mm copper
- Switch box to lighting Fixtures : 2.5 sq.mm copper
- Lighting Panel to Sockets : 4 sq.mm copper

For Area lighting, PVC insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed Copper conductor cables shall be provided.

Wiring for lighting circuits of Normal AC system and DC system shall run in separate conduits. Wiring for Lighting fixtures and receptacle units shall be fed from different circuits and shall run in separate conduits. Two different phase circuits shall not be laid in the same conduit.

All conduits shall be surface mounted in general. In Office rooms & Control rooms conduit shall be concealed type. Conduit fill criteria shall be 40%. Conduits should have the minimum number of bends in their run with pull boxes at suitable locations. Conduits shall be sloped & drained to avoid water accumulation & draining into the equipment at its end. Conduits shall be galvanized steel except in corrosive areas, where it shall be epoxy painted.

Lighting and Welding Transformer shall be suitably accommodated alongwith other equipments in the final equipment layout prepared by EPC contractor.

6.73.11 Receptacles

3 phase Industrial type welding receptacles shall be rated for 415V, 63 Amps with interlocked switches, scrapping earth connection, male and female units and cover. Protection class shall be IP-65.

1 phase Industrial type receptacles shall be rated for 240V, 20A Amps with interlocked switches, scrapping earth connection, male and female units and cover. Protection class shall be IP-65. 1 phase receptacles with switches shall be provided at each emergency portable lamp fittings.

All receptacles shall be provided with matching plug-tops. All hardware shall be of Stainless steel type only including the mesh of well glass luminaries, nut, bolts, washers, etc.

6.74 High Mast Lighting System

6.74.1 General

High Mast at the proposed locations in the plant area shall have adequate height to achieve the required illumination. Top level of high-mast foundations shall be as per the approval from the engineer-in-charge. All High Mast of similar height shall be identical in construction to allow possible future relocation of High Masts within the area. A High Mast Switchboard is required to be installed at the base of each High Mast. The High Masts are expected to be fabricated out of steel.

The High Mast shall be designed for the number of light fittings determined by the Lighting Design based on the average 30 lux (with minimum 20 lux) of illumination plus two additional fittings to allow for possible future modifications/expansion. The High Mast shall be designed for the worst sail area resulting from the most adverse configuration. The High Mast shall be designed to withstand loads from fabrication, handling, erection, and for the dynamic loading outlined below.

6.74.2 Design Criteria

The lighting design shall be in accordance with IS:3646. The selection of lamps and luminaire types shall be based on high efficiency, good glare control and illuminance level required. Luminaires, mast and brackets shall be selected to suit the harsh environmental conditions specified. Luminaires shall have high power factor (0.85 or higher) control gear. Any apparatus, appliance or material or services which may be necessary to make the system complete and perfect in all respects even if not particularly specified shall be furnished, without any additional expense to the Employer. Details not usually shown or specified, but necessary for the proper installation and operation of the work shall be included.

6.74.3 Fittings

Lighting fittings selected shall be High Pressure Sodium type. Lighting fittings shall be full cut off type to prevent stray light above 90 deg. Light fixtures shall be provided with Power factor correction capacitor to achieve high power factor.

6.74.4 Light Switching Philosophy

Each High Mast shall have following separate circuits.

Security Lighting Circuit, controlling 20% of the light fittings on High Mast. This circuit shall be controlled by a photoelectric cell located in substation so that the security lights turn on automatically depending on preset solar radiation level. Manual over ride facility shall also be available in the switchboard located at the base of the high mast.

Main Lighting Circuit No. 1, controlling another 40% of the light fittings on High Mast. This circuit shall be push button controlled from the system control panel. Manual override facility shall be available in the Switch Board located at the base of the High Mast.

Main Lighting Circuit No. 2, controlling another 40% of the light fittings on High Mast. This circuit shall be push button controlled from the system control panel. Manual override facility shall be available in the Switch Board located at the base of the High Mast.

6.74.5 Location of High Masts

High Mast locations shall be as shown in the **Drawing 60636525-DPR-1023** attached with these specifications. High Mast number, height and location are indicative, final details as per the detailed design shall be submitted to the Employer for approval. It is anticipated that the high mast positions as shown on the Drawings will provide sufficient coverage to obtain the specified illumination.

6.74.6 Detailed Lighting Plan

Detailed lighting distribution plans of the entire area along with Lux level plot plan shall be provided for approval of the Employer by the successful contractor.

6.74.7 High Mast Head Frames

Each High Mast shall be fitted with a head frame, which shall be capable of being lowered and raised by means of a winch or other similar mechanical mechanism. The winch shall be able to be operated by use of a power tool. Each High Mast shall be provided with internal power tool complete with drive motor and drive assembly of suitable rating. The power for the drive motor of power tool shall be from the respective high mast switchboard. The head frame shall be of durable steel construction fitted with light and gear fixings and junction box. It shall be in single piece for maximum strength. The head frame shall also act as an electrical conduit with cable holes protected by grommets. The head frame shall incorporate arrangements to prevent damage to the galvanizing of the High Mast.

6.74.8 Mechanical Arrangement – Lowering and Raising Headframe (Ring) System

For installation and maintenance purpose, it is required that the headframe (ring) be able to be raised or lowered using a winch or approved lowering device to the base of the High Mast. The steel wire rope supporting the headframe shall be kept in balance and horizontal at all times. A device, suitably protected from corrosion, shall be incorporated to ensure that the tension rope cannot accidentally or manually be released without a service tool.

6.74.9 Top Pulley Assembly – Lowering and Raising Headframe (Ring) System

The pulleys for the lowering and raising of the headframe system shall be of non-corrodible material and shall run on self-lubricating bearings with stainless steel axles. They shall be of sufficient diameter so as to enable multicore flexible cables to be used. Arrangements shall be provided to ensure that the electric cables and steel wire ropes are separated before passing over their respective pulleys and close fitting guides shall protect the pulleys to prevent ropes and cables leaving the pulley grooves. It is intended that there will be 2 cables from the High Mast Distribution Board at the base of the High Mast to the junction box on the headframe. Individual cables will then run from the junction box to each light fitting. This cabling arrangement will need to be considered in the design.

The pulleys shall be housed in a chassis integral with a sleeve which slips over the top of the High Mast and is secured axially and in azimuth. Guides and stops shall be provided for locking the headframe and an anchor point shall be securely welded to the assembly to receive the safety maintenance equipment. The complete chassis assembly shall be hot dip galvanized after fabrication. The pulley assembly shall consist of safety brakes capable of immediate stopping of the raising and lowering device even in the extreme case of hoisting cables breaking.

The pulley assembly shall be protected by a galvanized steel/aluminium or other approved weatherproof cover.

6.74.10 Winches – Lowering and Raising Headframe System

Winches shall be completely self-sustaining without the need for brakes, springs or clutches which require adjustment and shall be designed to be installed or removed through the door opening. Termination of the winch ropes shall not involve distortion or twisting of the rope structure. A minimum of four turns of the rope shall remain on the drum when the lantern carriage is fully lowered. Winch drums shall be grooved to ensure a tidy rope lay. A test certificate issued by an independent test house shall be supplied with each winch. The capacity and operating speed of the winch shall be clearly marked on each winch on an indelible label together with the Specification of the recommended lubricant. Each winch shall be supplied with a fitted canvas cover.

6.74.11 Lightning Protection and Earthing System of High Mast

Each high mast shall be provided with lightning protection and earthing system which shall be installed and tested as per BS:6651, BS:7430 and TR7, ILE, UK, and IS:2309, IS: 3043 & IEEE:80-2000.

6.74.12 Openings

Any openings in High Mast for feeding of cables/stainless steel rope in and out of the High Mast require coverings/cappings so as to prevent the intrusion of rain water into the High Mast.

6.74.13 Dynamic Loading

All High Masts shall be designed for maximum reaction arising from basic wind speed of 180 km/hr and factors K1, K2, K3 as per IS:875 (Part III) for design wind speed. The minimum design life shall be 30 years. High Masts shall be designed in accordance with relevant Indian earthquake standard. The design shall be such that wind excited oscillations are damped as much as possible and an adequate allowance shall be made for the stress due to these oscillations. The method of damping shall be stated. Full calculations of the forces involved shall be submitted for approval. The analysis shall show the resultant loadings, deflection and stresses in all three principal axes at a minimum of 500 mm increments over the total length of the High Mast. In addition, High Mast structures shall have adequate strength to resist fabrication, handling and erection loads without becoming overstressed or deflecting excessively.

6.74.14 High Mast Construction

All steel used in the construction of the High Mast, including welding shall comply with relevant Indian or British standards for Structural Steelwork. High Mast shall be constructed from mild steel plates, of grade and thickness as determined in the design. The minimum steel plate thickness shall be 6 mm. An appropriate corrosion allowance shall be used in the design. High mast shall be cut and folded to form a polygonal/circular section. Adjoining sections of the High Mast shall be joined by taper slip fit jointing. No site welded joints will be permitted.

All High Masts shall have a close fitting weatherproof door at the base with hinges and a heavy duty lock. The lighting distribution board shall be placed inside the High Mast base at this location. The size of the door is expected to be approximately 1.00 m x 0.50 m in size but may vary according to each design. The bottom of the door shall be located at a height of 0.50 m from the underside of the base plate of the High Mast. The door opening shall be reinforced where required to prevent buckling. The reinforcement being designed to suit the width of the door opening under the designing loading specified. Ten (10) sets of keys shall be provided for each type of lock.

The baseplate shall be free from laminations and the welded connection to the High Mast shall fully develop the strength of the section. In addition supplementary gussets shall be provided between bolt holes. On the completion of fabrication, all High Masts and headframes shall be hot dipped galvanized both internally and externally to a minimum thickness of 100 microns.

6.74.15 Foundations

The design and layout of each type of High Mast shall be furnished. The design shall be based on the foundations not resting on bedrock & shall be carried to a depth of at least 2.0 m below final grade. Settlement shall not exceed 25 mm, unless specified otherwise and the structural arrangement and design shall be such as to withstand such settlements. The top level of the concrete pedestal shall be as per the approval of the engineer-in-charge. The footings for the High Mast including holding down anchor bolts with nuts and washers shall be supplied and installed under this contract.

6.74.16 Wire Ropes

Wire rope system shall be suitable for maintaining the lighting fixtures/control gear from the ground level in spite of crash barriers around the mast. Wire ropes shall be flexible stainless steel type. Thimbles and terminals shall be of compatible material. Ropes with hemp cores will not be permitted. In the event of failure of one rope the other rope shall hold the lantern carriage.

6.74.17 Materials

All materials shall comply with relevant Indian or British Standards. All steel conduits, metal work, angle iron brackets, suspension rods etc. shall be hot dipped galvanized to a minimum thickness of 100 microns. Where galvanizing has been damaged this shall be repaired with an approved two pack zinc rich epoxy finish.

6.74.18 Luminaires

Luminaires shall be standard industrial type suitable for high pressure sodium vapour SON-T lamps of 2x400 W/1x1000 W/1x400 W and shall have not less than 55000 lumens per 400 W lamp. Lighting fixture shall be waterproof, dust proof and suitable for highly corrosive atmosphere. It shall be manufactured with die-cast aluminium, MBV treated reflector, electronically brightened and anodized, IP 54 degree of protection and confirm to relevant IS specifications. The lamp shall be easily replaced from rear without disturbing the aiming position. It shall be provided with stainless steel toggles, heat resistant & toughened glass cover. Hardware used to install the fittings, control gearboxes and for other purposes shall be of stainless steel. The luminaires shall be tested as per Indian Standard and shall be suitable for installation on high mast.

6.74.19 Aviation Light

LED type aviation light shall be provided at each mast.

6.74.20 Power Tools

This is a geared motor with suitable torque limiter, industrial duty type. The motor is mounted on MS hot-dip galvanized plate inside the mast with a possibility of adjusting its position. However, the adjustment shall be so arranged that it cannot be altered easily during normal use of tool at site.

6.74.21 High Mast Switch Boards (HMSB)

These boards shall be free standing pad mounted type. The boards shall be designed for the number of circuits as required. The boards shall include miniature circuit breakers/ELCB, Contactor, ON-OFF Control Switch and all other required accessories as required. The cubicle shall be designed for mounting over RCC pad of 300 mm thickness minimum and shall be capable of withstanding the vibrations normally experienced due to vehicular traffic. The top cover of the enclosure shall have slope to prevent accumulation of rainwater. A gland plate shall be provided at the bottom of the switchboard. An incandescent lamp shall be provided inside the switchboard, with door switches on both doors, so as to switch 'ON' when the door is open.

The circuit wiring shall be as required. System control panel shall be fabricated out of CRCA sheets – 2 mm thick for structural components and 1.6 mm thick for covers and doors & hot dip galvanized after fabrication. HMSB shall be fabricated out of stainless steel of grade 316 to prevent corrosion. HMSB shall be sized to allow for heat generated and design includes for dissipation of heat and shall be IP 65 degree of protection plus canopy, whereas system control panel shall have minimum IP54 degree of protection. Each board/panel shall be provided with hinged door with gaskets.

230V AC auxiliary and control supply aluminium bus bars shall be provided through control transformer of adequate capacity in HMSB. The Board/Panel shall have earth bus bar running through the whole length of the board. All equipment mounted in the board shall be directly connected to this earth bus.

6.74.22 Wiring

Wiring shall be complete in all respects so as to ensure proper functioning of control, protection and interlocking schemes. Control wiring shall be PVC insulated stranded, copper conductor of 2.5 sq.mm cross section. Each control wire shall be identified at both ends with wire designations in accordance with the relevant Indian Standards. All wire terminals shall be with compression or clamp type connectors. Wires shall not be spliced or tapped between terminal points. Designation ferrules shall be interlocking type with designation engraved with indelible ink. Not more than two wires shall be connected to one terminal. Power and control wires shall be neatly bunched, separately and adequately supported so as to prevent sagging and strain on termination. Terminal blocks for power and control wiring shall be provided with adequate clearances.

6.75 Component Specification of HMSB

6.75.1 Contactors

Contactors for AC shall be 3 pole air-break electromagnetic type suitable for making and breaking locked rotor current of the motor which is equal to around six (6) times the full load current. Contactor shall have minimum 2 Nos. auxiliary contacts. Minimum rating of power contactor shall be 16 Amps. Contactors shall be suitable for uninterrupted duty as per IS 2959 and utilization category shall be AC3 as per IS:4064. The contact material of the contactors shall have anti-weld properties. Insulation class of the operating coils shall be class E or better. Operating coils of AC contactors shall be suitable for 240 V $\pm$10%, 50 $\pm$3% Hz, AC supply. The contactors in general shall not drop out at voltage on and above 65% rated control supply voltage.

6.75.2 Photo Electric Switch

A photo electric cell/switch operating on 240 Volt AC shall be provided for automatic group control switching operation based on solar radiation levels.

6.75.3 Auxiliary Contactors

The auxiliary contactors and no volt relay will be provided as per circuit requirement. The contact rating shall be 10 Amp for AC. The auxiliary contactors shall have at least 8 contacts in contact combinations as per the requirement.

6.75.4 Control Terminal Blocks

Control terminal blocks shall be of 650 volts grade, rated for 10 amps and in one piece moulding. It shall be complete with insulation barriers, clip on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. At least 20% spare terminals for connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks. All terminal blocks shall be suitable for terminating on each side, two (2) Nos. of 2.5 mm2 size stranded copper conductors. All terminals shall be numbered for identification and grouped according to the function. Engraved white-in-black labels shall be provided on the terminal blocks. Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links. Self-aligning, spring loaded, silver plated, sliding contacts for proven design shall be provided as control terminals for withdrawable / drawout modules. Detachable plug and socket type control terminals shall also be acceptable.

6.75.5 Indicating Lamps

The indicating lamps shall be panel mounting large industrial cluster LED type and shall be interchangeable. Indicating lamps shall be with translucent lamp covers. The lamp covers shall be mounted flush on the front panel door and shall be replaceable from the front of the cubicle.

6.75.6 Installation of Light Fittings

Mounting height of center-line of the various lighting equipment from FFL/Working platforms or finished grade level shall be as noted below unless otherwise specified in corresponding lighting layout drawings:

- Lighting panels/control gear boxes : 1500 mm
- Switch boxes : 1500 mm
- Receptacle boxes (Indoor) : 500 mm
- Receptacle boxes (Outdoor) : 1000 mm
- JB on poles/Masts : 750 mm

Lighting fixtures to be mounted on ceiling/platforms having considerable vibrations which can cause damage to the fixtures shall be suitably supported with rubber pads to limit vibrations in the fixtures. Where conduit wiring is adopted, an earth continuity conductor of 12 SWG galvanized steel wire shall be provided for earthing the lighting fixtures, switch boxes, etc. The earthing conductors shall be run along the entire length of the conduits and shall be securely connected and terminated at the junction boxes/control gear boxes/lighting panels. The earth connection shall be properly secured with bolts, nuts and washers. For outdoor lighting installations, an earth continuity conductor of atleast 25 x 3 mm galvanized steel flat shall be used for earthing the lighting masts/poles.

While designing the lighting circuit, the cables shall be sized such that the farthest loop from the supply receives no less than 95% of its nominal voltage, in addition it must be assumed that all the light fittings are energized while this design calculation is made. LED lights should be chosen &

located carefully where they illuminate rotating shafts, so as to avoid stroboscopic effect. Fittings made from Aluminium and its alloys should be avoided because the oxide that invariably forms after a time is considered as a potential source of sparks caused by mechanical impact. All fittings shall be installed at a safe height for maintenance & effective illumination. All lighting controls shall be from a non-hazardous area, using double pole, switches, the supply neutral should be switchable along with the phase.

6.75.7 Testing and Inspection

Equipment of Illumination system should be type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Equipment shall be subjected to routine tests as per applicable Indian Standard. Test reports shall be submitted for approval.

6.75.8 Spares List

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

6.75.9 Cable Trays and Accessories

This specification covers the requirements of cable trays, support structures, cable laying, termination, earthing and lightning protection system.

While finalizing Cable routing layouts, consideration shall be given to the requirements of Safety, Reliability and Convenience of cable laying and termination. Where duplicate drives/auxiliaries are provided for reliability, cable routing shall be segregated to the extent practically possible.

In cable trenches, distance between bottom most tier and bottom of trench shall be 150 mm and clearance from top most tray to top of trench cover shall be 400 mm. Distance between two tiers shall be minimum 250 mm. PCC flooring of built-up trenches shall be sloped in longitudinal and also in transverse direction for effective drainage system. Cables should not be laid directly in the trench floor. Cables trenches should be provided with strong & effective covers with water & fire proof sealing arrangement at trench entry & exit points.

Other than cable vault & cable trenches, Cable trays shall be laid in vertical formation to avoid dust accumulation. In cable spreader room a clear access passage of at-least 800 mm wide shall be provided along the cable ways. Wherever passage is through cable routes, a clear height of not less than 2.0 M shall be provided.

Cables of different voltages shall be laid in separate racks. Minimum distance of 250 mm shall be maintained along the routes between various types of cables. In case of horizontal formation, the highest voltage cables shall be laid in the top most position in the tray stack followed by other grades as follows in the descending order.

- 11 kV Power cables (Top Tier)
- 1.1kV Power cables (Below HT Tier)
- Electrical Control Cables (Below LT Tier)
- Instrumentation/Signal cables (Bottom most tier)

On cable trays all the multicore power cables can be laid in touching formation. Single core cables shall be laid in trefoil formation with the spacing equal to twice the diameter of the cable. Control

cables shall be laid in not more than two layers. Power & Control cables shall be laid on ladder type trays. Instrumentation & Signal cables shall be laid on perforated type trays. Cable trays shall be supported at an interval of 1500 mm approximately. Vertical runs shall be supported at an interval of 1000 mm approximately. Cable tray support system shall be site fabricated, welded and painted steel supports. Cable tray support system shall consist of ISMC channel as vertical support & ISA as horizontal arm. Horizontal arm is welded to the vertical support MS channel.

Cables shall be terminated using double compression cable glands suitable for the voltage grade of cables. Cable glands shall be heavy duty brass. Cable lugs for power and control cables shall be tinned copper solderless crimping type conforming to IS 8309. 11 kV cable terminations shall preferably be of heat shrinkable type kits.

Fire barriers/ Fire stops shall be provided for all fire rated wall and floor penetrations and for all direct cable entries into electrical Switchgear / Panels from Cable Vault. Fire barriers/ Fire stops shall provide a fire endurance rating of at least 2 hours. The fire sealing material shall be non-hygroscopic, mechanically steady, non-toxic and physically & chemically stable under fire conditions.

Fire barriers/ Fire stops shall be either of the following methods:

(a) Panel sealing method comprising Encasing Panels, Cavity fill material & Sealant

(b) Mortar Sealing method comprising Mixing Mortar curing with water

6.75.10 Design and Construction of Cable Trays

Cable trays shall be ladder/perforated type as specified prefabricated made out of Fibre Reinforced Plastics (FRP) complete with matching fittings (like elbows, bends, reducers, tees, crosses, etc.), accessories (like side coupler plates, Tray cover etc.) and hardware (like bolts, nuts, washers, GI strap, hook etc.) as required. The size of the trays shall be selected on the basis of maximum 50% fill criteria. Cable trays shall be standard width of 150mm, 300mm, 450mm & 600mm. Thickness of side coupler plates shall be minimum 2.5mm and of tray covers shall be minimum 1.6mm. Cable Trough shall be required for branching out few cables from main cable route. These shall also be fabricated of FRP of minimum thickness 3mm. Troughs shall be of standard width of 50mm & 75mm and 25mm height.

6.75.11 Design and Construction of Conduits/Pipes, Fittings & Accessories

Conduits/pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.). The size of the conduit/pipe shall be selected on the basis of maximum 40% fill criteria. Hume pipes shall be of reinforced concrete conforming to class NP3 for road crossings as per IS: 458. GI pipes shall be of medium duty as per IS: 1239.

Rigid steel conduits conforming to IS: 9537 Part-I & II shall be suitable for heavy mechanical stresses, threaded on both sides and threaded length shall be protected by zinc rich paint. Conduits shall be smooth from inside and outside. Fittings and accessories shall also be hot dip galvanized.

Flexible conduits where required, near equipment terminations, shall be made with bright, cold rolled, annealed and electro-galvanized mild steel strips. Flexible conduits shall be supplied with suitable end coupler nipple and check nut. In corrosive areas, epoxy coated conduits shall be provided.

6.75.12 Cabling Installation

The work shall be carried out in the best workman like manner in conformity with relevant specifications / code of practices of the Bureau of Indian Standards. In addition, work shall also confirm to the requirements of latest editions / amendments of the following:

- Indian Electricity Act and rules framed thereunder
- Fire Insurance Regulations
- Regulations laid by the office of the Chief Electrical Inspector to Government
- Any other regulations laid down by the local authorities

Support system shall be so designed that it is able to withstand weight of the cable trays, Weight of the cables, concentrated load of 75 Kg between every support span without any permanent deflection. Factors of safety of at-least 1.5 shall be considered. Cable tray mounting structure shall be welded/bolted to the plate inserts or to steel structure and the type of welding shall be of fillet type of at least 6mm size.

All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor. Tray covers shall be provided for overhead cable trays on top most tier. The cable risers or vertical raceways shall also be covered by cable tray covers upto 1.5 metres from respective floor for mechanical protection. The sheet cover shall be of removable type.

6.75.13 Testing and Inspection

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.

6.75.14 Spares List

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

6.75.15 415 V Diesel Generator Set

The output from the unit shall be 140KVA (at alternator output), 415 volts, 3 ph, 50 Hz, 0.8 power factor.

DG set shall be required to operate as standby unit under the following environmental conditions:

- Ambient temperature : $45^{O}C$
- Relative humidity : Above 90%
- Altitude : Sea-level

6.75.16 Diesel Engine

The engine shall comply with the requirements of relevant BS 649/BS 5514. Engine shall be designed for maximum reliability ensuring uninterrupted operations. Engine shall be capable of delivering 10% overload for a period of one hour in any consecutive twelve (12) hour period. The values of rating, rotative speed and brake mean effective pressure (BMEP) for a specific engine design will not be accepted unless they are published as catalogue data.

Engine shall be heavy duty, industrial type four stroke delivering matching BHP at 1500 rpm, turbo charged radiator coded suitable for standby duty. Engine and auxiliary system shall be designed for safe start, stop and running on high speed diesel (HSD). Engine performance shall confirm to ISO:3046/BS:5574.

Engine Governor shall be electronic.

The set shall be capable of accepting at least 60% of rated load in a single step from an initial startup condition.

Filters of the replacement element type shall be provided on the engine for fuel oil, lubrication oil and air intake.

Engine Starting shall be 24 V DC battery system designed so that at least two separate attempts can be made, to prevent complete loss of starting capacity in one attempted engine start. Sizing of starting system should be in accordance with the engine manufacturer's recommendations, but in no case should the storage capacity be less than 30 seconds of cranking. An automatic static battery charger which possesses characteristics of "Zero-float" and positive charging shall be used. An engine-driven battery-charging generator is not acceptable. Batteries shall be maintained in a warm (20^{O}F to 110^{O}F) atmosphere to assist in quick starting. The battery system shall be of lead acid automotive type.

Flywheel Guards shall be provided as required.

An **engine control unit** free from vibrations comprising of the following devices with sensors (mounted at engine) shall be provided as minimum:

- Water temperature gauges for jacket water temperature
- Water pressure gauge
- Tachometer for engine speed
- Lubricating oil, pressure and temperature gauges
- Automatic shutdown and indication for low lubricating oil pressure, over crank, low coolant level, high cooling water temperature and engine over speed.

6.76 Engine Auxiliaries

6.76.1 Cooling System

Cooling system shall be radiator type. Anti-freeze liquids and corrosion inhibitor as recommended by engine manufacturer shall be used to obviate the danger of damage occurring from the use of incompatible or improper liquids or inhibitors.

6.76.2 Intake and Exhaust System

(a) A residential type exhaust silencer of suitable size for exhaust run shall be provided complete with all support frames etc. to reduce engine exhaust noise. It should be kept as straight as possible.

(b) Dry type air-inlet filter, exhaust manifold, mufflers shall be used. Type of filter selected shall be to fit the environmental conditions at the site.

(c) Combustion air shall be taken directly from outside.

(d) The air-intake and exhaust shall be so located as to preclude the contamination of fresh air with exhaust gases.

(e) To dispose of the radiant heat given off by the exhaust pipe, sheet metal ductwork shall be supplied with 50 mm of space between the ductwork and the exhaust pipe.

6.76.3 Fuel Oil System

(a) The fuel-injection system shall be complete with PT fuel pump, injectors, fuel filters and self-contained piping.

(b) The system shall generally comprise of

- Day tank capacity for 10 hour running at 75% load.
- Pumps required for conveying fuel from day tank to engine. Critical pumps should be provided in sets (1 working + 1 standby)
- The day tank shall also act as a relief and by-pass tank for fuel oil that is circulated to the injectors whereupon any excess fuel is by-passed back to the day tank.

6.76.4 Fuel Filtering System

The primary filtering system shall be located at day tank inlet. In addition the engine shall have secondary filtering system. Both filters shall be capable of absorbing water.

6.76.5 Lubricating Oil System

The pressure lubrication system shall be used. The filter shall be of simplex type with paper element. The full flow lubricating oil filter can be mounted on the lubricating pump or remote mounted with flexible lines.

6.76.6 Piping and other Associated Connections

All piping, flexible connections, flange valves, seals, fittings etc. shall be supplied by the Contractor for all the associated auxiliaries of equipment.

6.76.7 Alternator

Alternator shall be air cooled, brushless, 3 phase, fan ventilated, synchronous type fitted with heavy duty, long life ball or roller bearing with forced lubrication or lubricant packed for approximately 4000 hours of running without attention. The alternator shall be manufactured in accordance with BS 2613 IEE-341 or as per relevant BIS, ISO, DIN, NEMA, standard. The unit shall be horizontally mounted.

Enclosure shall possess minimum IP23 degree of protection.

Insulation throughout shall be class H, temperature rise by resistance. All windings shall be impregnated to allow operation in climatic conditions specified in this volume.

The Alternator shall be provided with following minimum accessories:

- Resistance temperature detectors
- Bearing temperature detectors
- Space heaters.

The basic ratings of the Alternator shall be as follows:

(a)	Rated voltage	:	415 Volts
(b)	Speed	:	1500 rpm
(c)	Rated power output	:	As specified (Continuous rating)
(d)	Frequency	:	50 Hz

(e)	Number of phases	:	Three
(f)	Power factor	:	0.8
(g)	Type	:	Brushless, synchronous, self-excited self-regulated
(h)	Neutral earthing	:	Solid grounding
(i)	Voltage regulation	:	+1% of rated voltage from no load to full load at any power factor between 0.8 lagging and unity
(j)	Type of cooling	:	Self cooled fan ventilated

6.76.8 Metering and AMF Control Panel

This is intended for operation of DG set in auto mode. The panel shall be sheet steel construction and arranged for free standing, floor mounting and bottom entry with front and rear access. The interior wiring of the cubicle shall be looped and clipped and all wire ends are to be clearly identified. Any printed circuit boards shall be tropicalized.

Following metering and protection devices as a minimum requirement shall be included in each panel:

A) Metering Instruments (Digital)

- Voltmeter
- Ammeter
- Frequency meter
- KW meter
- Battery voltmeter
- Power factor meter
- Hours run indicator
- KWH meter
- KVAR meter
- Excitation current ammeter
- Excitation voltmeter
- Engine Speed Indicator

B) Push Buttons

- Engine start PB
- Engine Stop PB
- Lamp Test PB

- Reset PB
- Emergency Trip PB

C) Indication Lamps (Cluster LED type)

- DG set on
- Load on DG set
- Set running
- Mains available
- Mains failure
- Start failure
- Generator over current
- Generator high voltage
- Generator low voltage
- Earth fault
- High engine speed
- Low engine speed
- Low fuel level
- High fuel level
- Charge failure
- Generator winding temperature high
- High bearing temp
- Low lubricating oil pressure
- High lubricating oil temperature
- Engine jacket water temperature high
- Engine jacket water pressure low
- Reverse power
- Low fuel oil pressure
- Rotor diode failure

D) Protective Relays

- IDMT relay (Over current and earth fault)

- Over voltage relay
- Under voltage relay
- Reverse power relay
- Field failure relay
- Differential relay
- Phase failure relay

E) Multi-function Meter with Transducer

- Voltage – Ph-to-Ph & Ph-to-N
- Current – line to neutral
- Power – kW, kVAH, kVAR (Avg. & Ph. wise)
- Energy – kWH, kVAH, kVARH
- Power Factor – Average & Ph. wise.
- System frequency
- Import & export kWH & kVARH.
- RS 485 MOD BUS

6.76.9 11 KV Capacitor Bank with Automatic Power Factor (PF) Correction Control Panels

11 kV Automatic Power Factor Control Panels shall comprise of 11 kV circuit breaker, sets of Fuse & Vacuum Contactors for each capacitor bank, PF Meter, Automatic PF Correction Relay, Capacitor Banks (Heavy Duty, Star connection) with series reactors, discharge resistance, residual voltage transformer & neutral displacement protection relay of suitable rating as indicated in the attached Single Line Diagram. Rating shown in the SLDs are indicative. Contractor shall perform their own calculations to verify the size and submit the same to Employer for verification. Number of steps shall be based on 5kVAR power step minimum. The capacitor banks ratings shall be finally selected to provide a power factor of 0.95 lag on the bus. Zero step shall also be provided. Capacitor bank shall be double layer construction (film + paper + foil) gas impregnated type. 11 KV Capacitor panel shall be suitably accommodated alongwith other equipments in the final equipment layout prepared by EPC contractor.

6.76.10 Makes of Components

Make of the equipment under supply items shall be selected as per the list specified in **Section 2 of Volume-II**. Employer, however, reserves, the right to select the particular make during detailed engineering for uniform design and inventory. Approval of makes for items not mentioned in this list shall be obtained from Employer before initiating procurement action.

6.77 Communication System

6.77.1 EPABX System

The system envisaged is an Electronic private automatic telephone exchange (EPABX) with a capacity of 100 Lines and connection to public switched telephone network. The unit shall be installed in the control room of the port operations building, which shall be air-conditioned by a split type air conditioner of suitable capacity.

The system shall conform to relevant telecommunication standards and shall operate on power drawn from single phase AC mains. The system shall operate with DC power drawn from Batteries on float charge such that the performance of the system shall not deteriorate in anyway on failure of electricity mains supply.

The system shall include provision of telephone instruments in all the rooms of all the buildings provided in the contract and also in the electrical substation, pump rooms, gate house and Watch towers.

The telephones shall be robust yet sleek and aesthetic and shall have all necessary features like Dial tone, ring tone for external call, ring tone for internal call with distinct and different tones, Busy tone, congestion tone, intrusion warning tone, number unobtainable tone etc.

The numbering scheme shall be in three digits starting from 200. The system shall have conferencing facility. The system shall be capable being connected to public telephone network.

6.78 Public Address System

6.78.1 General

i) The system shall be distributed amplifier type for indoor/outdoor usages

ii) The nominal voltage of the system shall be 240V, single phase 50 Hz except that power supply of reduced voltage is specified for certain purposes. All the equipments and materials shall be suitable for the system voltage unless otherwise specified.

iii) The design of the Communication System shall be in accordance with the requirements of this specification and the best current engineering practice, together with the following general requirements:

iv) The minimum enclosure protection degree of the system components shall be in accordance with IEC 529 as follows:

- Outdoor IP 55.
- Indoor IP 41

6.78.2 Operational Feature

The basic system shall incorporate the following operational features:

(a) It shall be possible to make announcements by lifting any of the microphone handsets and speaking into the mouth piece. The announcement shall be heard over all the speakers within the area.

(b) It shall be possible for the called party to reply by moving to the nearest microphone hand set station and lifting the microphone hand set off the hook switch. The conversation now shall proceed between the caller and called party over the channel. This shall be heard over all the loud speakers. The system shall be of common talking type allowing any hand set station to take part in the conversation.

(c) Lifting of a handset off the hook shall automatically mute the adjacent loudspeaker. This is required to prevent the acoustic coupling and feed back to the local handset mouthpiece transmitter.

(d) Facilities shall be provided to generate a 400 Cycles signal which will be used as siren during emergency. This tone signal shall also be used to test all amplifiers and loudspeakers circuits. A tone/test switch shall be provided on the amplifiers rack to initiate the siren. Provision shall be made for testing all microphones and associated circuits.

(e) The Contractor shall propose a suitable scheme to overcome the problems generally associated with long distance propagation of voice signal and paging and shall submit the details of offered scheme showing schematic diagram, system write-up and other necessary details.

6.78.3 Component Specification

(a) Amplifier

The rated output power of the inbuilt amplifiers in any handset station shall be adequate to cater to microphone handset and specified number of loudspeakers. If the amplifier has sensitivity sufficient to operate only from the highest input voltage likely to be met with, the same has to be supplemented with pre-amplifier for use with source at lower voltage. The frequency response, harmonic distortion and the signal to noise ratio shall be as per the relevant standards. Amplifiers shall incorporate safeguards against excessive voltage or current rise in case of open circuit conditions or short circuit conditions respectively, in the output circuit. Volume and tone control shall be provided.

(b) Loudspeakers

The loudspeakers shall be of high efficiency, high peak power drive units in weather-proof design of rugged metal construction designed for non-ringing and shall deliver clear, faithful voice reproduction through any degree of noise level.

Facilities shall be provided for easy orientation of the speaker units over wide horizontal and vertical plane after the assembly has been mounted. Suitable means for locking in any position shall be provided on each speaker. Electrical filter at the line matching transformer shall be incorporated to cut off low frequencies to avoid damage to the voice coil at lower frequencies. The power handling capacity of the transformer shall be not less than the power to be absorbed by the speaker.

The transformer primary and secondary shall have suitable caps to match the voltage tap at the amplifier output transformer and loudspeaker impedance respectively. Volume control shall be provided in horn type and cone type loudspeakers; no provision shall be kept in bidirectional horn type loudspeakers.

Loudspeakers shall preferably be rated for 15 W and shall be suitable for outdoor operation in areas with high ambient noise level. These speakers shall have good directional properties and high acoustical efficiency. The driver impedance matching transformer and all other accessories shall be housed in steel enclosure designed for wall or steel structure mounting. All necessary accessories shall be dust, vermin and weather-proof provided with neoprene gasket covers. Necessary provision shall be made for terminating incoming cable. Loudspeakers suitable for indoor use shall be rated for 6 watts. These shall be cone type and suitable for wall mounting. These shall be provided with buffer of thick plywood. Enclosure interior shall be padded with suitable lining for damping.

(c) Hand Set Station

Each hand set station shall comprise of a microphone hand set unit. Handset station shall be wall mounting / Desk type as shown in the attached riser diagram.

Handset microphones shall be of low impedance, dynamic type, with highly directional characteristic designed for close talking, minimum acoustic coupling and feedback. The handset shall pick up only the operator's voice and shall shield out extraneous noise.

Handset shall be provided with special neoprene covered shielded, retroactive coiled core type cable of length not less than 3 metres to provide freedom of movement.

Handset mouth pieces shall be protected from dirt and other foreign particles by means of filters.

The handset shall be equipped with locking type plug and socket to permit easy removal and replacement of handset when desired, without disturbing the soldered connection.

Handset stations and all associated equipment shall be completely assembled and wired at factory on a conduit core ready for mounting on conduit box and attached directly to field conduit. In case of handset stations for outdoor locations robust, weather-proof enclosures designed for direct connection to field conduit shall be provided.

(d) Signal Cable

The signal cable shall be annealed, high conductivity bunched copper conductor, twisted, PVC insulated, colour coded, PVC sheathed and armoured cables.

6.78.4 CCTV Surveillance System

Surveillance CCTV system is required to ensure surveillance of required locations as well as create secured record for post event analysis. The system shall provide an online display of video images on TFT/LCD monitors located in Control Room at Common Service Building and cameras at various locations likewise Gate Complex, Custom Buildings etc.

System shall facilitate viewing of live and recorded images and controlling of all IP cameras by the authenticated/authorized personnel. The core of the surveillance system shall be NVR servers. System shall also have operating systems, appropriate software, networking equipment and other essential components.

The communication between the cameras and the Camera Control Room shall take place wirelessly and hence the necessary hardware has to be implemented in order to ensure the maximum availability, Real time Delivery of the Datagrams and further maximize determinism. In addition to the Wireless, Backbone of the network an additional fibre optic as optional backbone has to be built in order to ensure the failsafe working of the CCTV surveillance in the event of unexpected failure of the system components such as wireless routers etc.

System shall have expansion possibility with the available hardware (system shall have the facility of additional camera installations beyond the originally planned capacity). It shall be an open standard based integrated system with IP network aimed at providing high-speed automatic operation for best performance. It shall use video signals from various types of indoor/outdoor cameras installed at different locations. Joystick and mouse-keyboard controller shall be used for Pan, Tilt, Zoom, and other functions. System shall have a combination of Digital colour video cameras with individual IP address. It shall also have raid backup device of recording, application software, colour video monitors and keyboards. CCTV system shall also be equipped with workstation for System Administration / Maintenance.

Camera server shall be NVR server based with appropriate Audio and Video Management System backup system and software. Each camera server shall handle 60 or more cameras. CCTV system shall ensure that once recorded, the video cannot be altered; ensuring the audit trail is intact for evidential purposes. System shall provide sufficient storage of all the camera recordings for a sufficient period. The recording resolution and frame rate for each camera shall be user programmable.

6.79 Equipment Specifications

6.79.1 Server

The NVR shall have enterprise class reliability with a RAID 5 hard drive configuration and the option for redundant power supplies. In addition, both the hard drives and the power supplies shall be hot-swappable for online repairs. The NVR shall have upto 10 TB effective recording capacity that is expandable using a storage expansion unit. Quality Video Resolution: 640 x 480, 320 x 240 (default), 192 x 144. The Image Quality shall be of JPEG (favour clarity, standard, and favour motion) and MPEG4. It shall support a Frame Rate of 30 frames/sec (640 x 480, 320 x 240 or 192 x 144).

It shall support IPv4/v6 Dual Stack Supported Network Protocols. It shall support Simultaneous Viewing with simultaneous accesses with Image Transfer via E-Mail (SMTP) or FTP, SMTP, FTP, and HTTP etc. It shall be complete with standard keyboard, 21 inch XVGA TFT colour monitor, mouse controller, CD/DVD drives, network cards.

6.79.2 Workstations

Data terminal computers shall have high computing power, suitable for communication equipment networking. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking. They shall be complete with standard keyboards, 21 inch XVGA TFT colour monitors, mouse controllers, CD/DVD drives, network cards.

6.79.3 Optical Fibre Cables

Multimode, armoured optic cable (62.5/125) standard cable shall be used. It shall have rugged design for industrial applications indoors and outdoors. It shall have high immunity to noise and electro-magnetic fields and shall be Tap-proof and radiation shall be limited to applicable standards. It shall also be silicon free and free from varnish-moistening substances.

6.79.4 Radio Modem

A radio modem with suitable range (at least 5 Km), transmission power, antennae gain and other attributes shall be chosen as per requirements. The radio frequency band for operation shall be considered as per site conditions / rules. All help shall be rendered to the client for obtaining the necessary licensing for the usage radio frequency bands if required, from local authorities. The Modem shall establish a point to point connection with the surveillance cameras.

6.79.5 Network Switches (Manageable)

The Ethernet switch shall be optimized for VPN services and shall provide both high availability and service flexibility for Carrier Ethernet access deployments. It shall have Layer 2 VPN service features and the option to upgrade to Layer 3 VPN services. It shall have 24 Ethernet 10/100 ports, two dual-purpose (10/100/1000 and SFP) uplinks.

6.79.6 Ethernet Cable (Cat 6)

Category 6 cables shall be built tough enough to withstand the harsh environmental conditions and mechanical stresses. The cable shall also provide more stable electrical performance with less attenuation and greater resistance to EMI/RFI.

6.79.7 Cameras

All the cameras shall be IP based. They shall have an enclosure of minimum of IP-67 while outdoor cameras to be of IP-67. They shall also be outdoor ready with day/night functionality

1) 35x (Optical Zoom) PTZ Camera and an Image Sensor with CCD sensor, approx. with wireless capability.

2) 29x (Optical Zoom) PTZ Camera and an Image Sensor with CCD sensor, approx. with wireless capability.

6.79.8 Joystick/Keyboard

Video Surveillance Joystick shall give a responsive and accurate control of all PTZ cameras. It shall enable with the use of keypad the user to quickly navigate between workspaces, cameras, views and PTZ presets. There shall also be a Jog Dial for navigating through recorded video.

6.79.9 Mounts

All the cameras shall have appropriate mounts based on the camera design and the functional requirement of the same.

6.79.10 Enclosures

All the cameras shall have IP-67 appropriate dust tight enclosures ready for use in small Particle and dusty environments it shall also include Heater, Blower, Air Funnel Kit, Sun Shield and Sun Visor depending on the mounting location and requirement.

6.79.11 Video Management Software

The software shall be IP-Surveillance software that works with the network cameras to provide video monitoring, recording and event management functions. It shall enable recording of video continuously, on schedule, on alarm and/or on motion detection. The software shall have multiple search functions for recorded events. Remote viewing and playback shall also be possible with the use of the client software.

7.0 DRAWINGS

7.1 Drawing List

60636525-DPR-1001	Overall Site Plan
60636525-DPR-1002	Bathymetry Survey
60636525-DPR-1003	Topographic Survey
60636525-DPR-1004	Borelog Profiles
60636525-DPR-1005	Layout of The Terminal – Phase 1
60636525-DPR-1006	Layout of The Terminal – Phase 1A
60636525-DPR-1007	Layout of The Terminal – Phase 1B
60636525-DPR-1008	General Arrangement of Berth and Approach Trestle
60636525-DPR-1009	Details of Shore Protection Work
60636525-DPR-1010	Details of Terminal Administration Building
60636525-DPR-1011	Details of Covered Storage Sheds
60636525-DPR-1012	Details of Guard Room
60636525-DPR-1013	Details of Sub-Station
60636525-DPR-1014	Details of Canteen and Rest Room
60636525-DPR-1015	Details of Underground Water Tank & Pumphouse
60636525-DPR-1016	Details of Elevated Water Storage Tank
60636525-DPR-1017	Details of Fuel Bunkering System
60636525-DPR-1018	Details of Custom Office Building
60636525-DPR-1019	Details of Port in Call Office Building
60636525-DPR-1020	Plan and Section of Boundary Wall
60636525-DPR-1021	Layout of Internal Roads and Sections
60636525-DPR-1022	Layout of Storm Water Drainage and Sewerage
60636525-DPR-1023	Schematic Layout of Water Supply and Fire Water System
60636525-DPR-1024	Layout Plan of High Mast & Lighting Poles
60636525-DPR-1025	Layout of Road Connectivity
60636525-DPR-1026	Power Distribution Single Line Diagram (SLD)
60636525-DPR-1027	Dredging Areas and Profiles

AECOM India Private Limited
3rdFloor, Tower A, Building No. 8
DLF Cyber City, DLF Phase II
Gurgaon 122002, Haryana, India

T: +91 124 4830250

aecom.com