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BIDDINGDOCUMENT

National Open Competitive Procurement

for

Construction ofTerminal and Riverine Infrastructure at Guwahati Gateway Ghat, Assam

(Engineering, Procurement, Construction ("EPC") following two envelope Bidding Process with e-Procurement)

VOLUME–2

TECHNICAL SPECIFICATIONS

RFB:IN-IWT-244480-CW-RFB

NCB No. : AIWTDS/270/2021

Employer:
Assam Inland Water Transport Development Society, (AIWTDS)
Governmentof Assam

Country:India

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1 General Information and Employer's Requirements

1.1 General Information

1.1.1 Background

The Brahmaputra River with a length of 891 km between the Bangladesh Border and Sadiya, was declared National Waterway no. 2 by the Government of India in 1988, the development of its navigation infrastructure thereafter being the responsibility of the Inland Waterways Authority of India (IWAI).

The Directorate of Inland Waterway Transport Assam, established in 1958 and part of the Assam Transport Department, is responsible for developing, maintaining and regulating IWT services in the state.

In order to leverage the benefits of inland water transport, the Government of Assam wishes to transform the quality of inland water transport services and integrate high quality passenger and vehicle ferry services, and inland water freight transport into Assam's wider transport network system.

AIWTDS intends to develop ferry terminals on National Waterway-2 at Guwahati Gateway Ghat (GGG) in Guwahati, Assam.

This call for EPC bid being addressed to potential Contractors for Engineering, Procurement of Materials & Construction of "Ferry Terminal at Guwahati Gateway Ghat (GGG)".

1.1.2 Site Location

The proposed ferry terminals are located in the Indian state of Assam at Guwahati city. The terminal GGG is located on Brahmaputra River at $26^0$11'12.48" N, $91^0$43'17.50" E. Google image of the proposed terminals are shown in Figure-1.

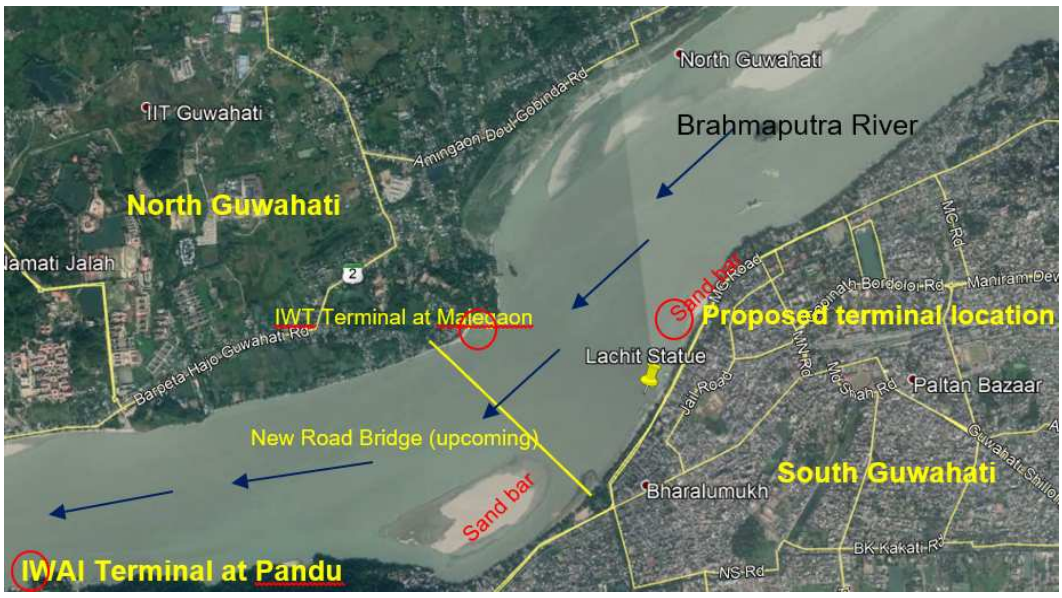


Figure 1: Google Image for ferry terminal site at Guwahati Gateway Ghat (GGG)

1.1.3 Site Information

The site information included in the following paragraphs are only for the guidance purpose to the Bidders. The Bidder shall conduct all necessary field tests and surveys to satisfy / verify himself regarding the correctness of the data furnished vis-à-vis actual condition. No claim whatsoever will be entertained for any variation between the actual site conditions met with during the execution of the work and those indicated herein.

1.1.3.1. Air Temperature

The climate in Guwahati Gateway Ghat (GGG) site is warm and temperate. The temperatures vary from 5℃ to 50℃. The highest and lowest temperature recorded at the Project Site is furnished below:

Recorded Temperature (Highest and Lowest Temperature at the Project Site)

Month	Recorded Temperature (^{O}C)		
	Mean Daily Maximum	Average	Mean Daily Minimum
January	22	19	15
February	26	22	17
March	32	28	21
April	32	30	23
May	32	29	24
June	31	29	25
July	29	28	25
August	32	30	26
September	30	28	25
October	30	28	24
November	26	23	19
December	24	21	16

Source: www.worldweatheronline.com

1.1.3.2. Wind

An Operational wind speed of 30 m/s and extreme wind speed of 50m/s shall be considered as per IS 875 (Part 3).

1.1.3.3. Rainfall

The rainfall data for Guwahati Gateway Ghat (GGG) is given below:

Rainfall Data (Monthly Average) for the Project Site (2020)

Month	Monthly Total (mm)	Number of Rainy Days
January	2.75	12
February	8.93	4
March	2.8	10
April	44.63	21
May	146.05	27
June	220.43	30
July	262.6	31
August	171.83	31
September	132.78	30
October	72.43	27
November	2.03	7
December	1.75	9

Source: www.worldweatheronline.com

The number of rainy days varies from 4 to 31 in a month and heavy rainfall (> 20 days in a month) varies in the range 45 mm – 263 mm.

1.1.3.4. Seismic Zone

The terminal falls under the seismic Zone V.

1.1.3.5. Currents

The design velocity of current in river Brahmaputra at Guwahati Gateway Ghat (GGG) is 4.0 m/s.

The movements of floating crafts during construction shall be influenced by available draft, current, dimensions of craft, width of channel, etc.

1.1.3.6. Water Level

The proposed sites at Guwahati Gateway Ghat (GGG) is subjected to following water levels with reference to mean sea level.

High Flood Level (HFL): 51.46 m

Low Water Level (LWL): 40.56 m

1.1.3.7. Topographic information

The topographical survey of the proposed terminal at Guwahati Gateway Ghat (GGG) was carried out in January 2019. The topographic details are presented in the Drawings P.013223-P-20312-201 for GGG site. The survey is only for the information to the bidder.

1.1.3.8. Hydrographic Information

The hydrographical survey of the proposed Terminal at Guwahati Gateway Ghat (GGG) was carried out in January 2019. The topographic details are presented in the Drawing P.013223-P-20312-201 for GGG. The survey is only for the information to the Bidder.

1.1.3.9. Geotechnical Information

The geotechnical investigations at the proposed Terminal locations were carried out by M/s SKM Geosurvey Ltd., Kolkata. The investigations included carrying out a borehole in Guwahati Gateway Ghat (GGG) location. The investigation report is included in Encloure-3 for reference. The investigations report is only for the information of the Bidder.

1.1.3.10. Environmental and Social Impact Assessment

The Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) were carried out for the Guwahati Gateway Ghat (GGG) site by M/s Arkitechno Consultants Pvt. Ltd. The study report along with the Environmental Management Plan (EMP)and requirements are included in Encloure-4 and Social management Plan (SMP) is included in Enclousre 5. The study report is only for the information to the Bidder.

1.2 Employer's Design Requirements

1.2.1 General

The Employer's Requirements are that Contractor would be solely and fully responsible to carry out the Detailed Planning, Detailed Engineering and Design, Prepare Good for Construciton including shop/fabrication drawings, Procurement of all materials, Construction / installation and successful commissioning of all the works listed below to meet the functional requirement of the Project as per the contract conditions and technical specifications followed by defects rectification during the defects liability period. The design drawings, plans, attached with this tender are for information purpose only and should be used as reference drawings only to develop it further in consultation with Employer and its Engineer. For this purpose, the Bidders are allowed to use the existing data to prepare their Bid but eventually will have to conduct all necessary field tests, latest bathymetric survey goetechncial investigations and any additional studies deemed necessary to verify the correctness of the data furnished vis-à-vis actual conditions. Such latest data collected by the Contractor shall only be used for Detail Engineering and design of the Project. No claim whatsoever will be entertained if revised site survey data varies from the data and reports shared by the Employer as part of the Biddig Documens.

OBJECTIVE AND PURPOSE OF THE TENDER

Plan, Design, Engineer, Procure, Build and Commission including defect liability the passenger ferry terminals at Guwahati Gateway Ghat (GGG) site as per Indian and relevant international applicable standards to ensure safe berthing of ferry vessels and safe boarding of passengers, sequential (one after the other) boarding of bikes and 3-wheeler vehicles on the ferry vessel throughout the year at all water levels.

The Contractor shall be fully and solely responsible for the Detailed Engineering and Design of all the riverine and terminal works and for the overall performance of the works to ensure safe and servicible terminal operations and responsible for successful commissioning at design capacity of terminal. Bidders should satisfy itself for the items of work listed below and should treat as minimum requirement. Any additional work required to be undertaken which has not been mentioned below should be included in its Bid or clarifications sought before Bid submission and any omission / missed out items will not relieve the Contractor of its overall responsibility from achieving the Objective and purpose of tender defined above. The Terminal design and dimensions of individual element sizing is to be verified and recomputed and has to meet the overall traffic and peak hour traffic demand considered in the DPR. All the facilities and criteria

considered in DPR are to be considered as a minimum requirement. The DPR is for reference and information only. Inspite of the proof checking and Employer's Engineer approval, the complete overall design liability of the Terminal works rests with the Contractor. All works are to be executed in accordance with the technical specifications for materials, workmanship provided in the tender and all such works also have to comply with applicable codes as provided in Tender.

In order to achieve the Objective and Purpose of this Tender, the successful Contractor is obliged and mandatorily required to perform following tasks in sequential manner.

a. Carry out all necessary site Surveys (topographic and bathymetric), geotechnical investigations, water quality and chlorides, sulphate content in soil and water. Conduct detailed hydrodynamic and morphological modelling for assessment of sedimentation and scouring at the proposed terminal site and at berthing pontoon position.

b. Prepare an overall Detailed Layout Plan (terminal building works and Riverine infrastructure works) and Detailed Design Basis document showing all minute details over and above the terminal plan contained in this tender. The Detailed layout plan should account for final topographic and bathymetric survey with global co-ordinates marked based on reference benchmarks.

c. Based on approval of Detailed Layout Plan and Design Basis, prepare a detailed Design, cross sections and detail engineering calculations, floating stability analysis through software (approved by Employer's Engineer), classification certification of linkspan bridges, intermediate and berthing pontoons and other connecting elements of the Terminal works.

d. Based on approval of Detail Design drawings and calculations, prepare the Good for Construction drawings.

e. Prepare and submit "As Built" drawings of all Terminal works.

For each of the tasks mentioned above (a-e), it is mandatory to submit the details in a timely manner to Employer's Engineer and seek written approval. The Contractor is obliged to prepare an overall schedule of works including the activities of planning, design, proof checking and approval. The time required for approval by Employer's Engineer may be considered as Fouteen (14) days for first review and seven (7) days for subsequent reviews. In no case, a written approval from Employer's Engineer relieves the Contractor of his overall and sole responsibility to timely deliver the works for fulfilment of the Overall Objective and Purpose of this Project.

Before appointing the Proof Checking Engineer, the successful Contractor should get approval from Employer's Engineer the agencies intended to be appointed for Proof Checking of Detail Design and Engineering, and classification certification body/organization. All submissions should be first submitted to Proof checking Engineer and approval obtained in writing with duly stamped design documents. Only documents approved by Proof checking Engineer should be submitted to Employer's Engineer for further approval.

The project involves construction of below mentioned works:

- Site Grading

- Riverine Structures – Berthing Dolphins, Intermediate Dolphins, Bankseat
- Linkspan and Pontoons
- Terminal Building and ancillary services including plumbing works, Electrical Works.
- Furniture inside the Terminal Building and Control Room
- Furniture on the Pontoons
- Electrical Works
- HVAC works
- Firefighting Works
- Water supply, Sewerage and Drainage Works
- Fenders, Bollards, Ladders, Lifebuoy rings, Handrails
- Solar Panels on top of the Linkspans
- Utilities and Control Room and Switchgear Room
- STP and solid waste segregation area
- Environmental Protection Works
- Landscape development
- Communication and IT systems – CCTVs, TV screens
- Preparation and implementation of Contractor's Environmental and Social Management plan, including an Environmental Monitoring Plan

1.2.2 Mobilizaiton and Site Grading

The Contractor shall bring to Site all the necessary equipment based on the nature and scope of work but not limited to a preliminary list included in the Bid.

The Contractor shall first clear the area assigned for development from any obstructions or old structures and carry out a detailed topographic survey of the whole area. Formation level shall be firmed up such that there shall be no flooding of the site.

1.2.3 Riverine Infrastructure Works

The riverine infrastructure comprises of the following components for the project development:

I) Guwahati Gateway Ghat (GGG)

a) Berthing pontoons – 60x15m (3 nos.)

b) Dolphins for berthing pontoons – 7.5x7.5m (6 nos.)

c) Steel linkspans – 32m span x 8m wide (4 nos.) and 20m span x 8m wide (1 no.). The total length of 172.9 m to be covered should meet the functional requirement to maintain the slope in extreme low water.

d) Intermediate pontoons – 20x9m (4 nos.)

e) Dolphins for intermediate pontoons – 19.0x11.5m (4 nos.)

f) Bankseat – 20x15.5 (1 no.)

The layout and general arrangement of the components of riverine infrastructure listed above are shown in drawing no. P.013223-P-20301-201.

1.2.4 Functional and operational requirements of the Riverine Infrastructure Works.

a) Berthing Pontoons:

The purpose of Steel Berthing pontoons should be to provide an interface between linkspan and ferry vessel for safe embarking/disembarking of passengers and vehicles of 7 Ton cargo capacity to/from landside terminal to/from ferry vessel. These pontoons should be completely restrained in horizontal plane but should be flexible to move in vertical plane with rise and fall of water level. The lowest level of berthing pontoons should be defined, and a suitable supporting corbel should restrict its further movement in downward direction. These pontoons should be equipped with suitable rubber fenders, pipe bollards, ladders, lifebuoy rings of adequate capacity as per safe mooring design requirements, overhead steel roof canopy, seating chairs, e-toilets, freshwater hydrants for supplyng water to vessel, washing and cleaning pontoon, electrical fittings, sockets, light fixtures, CCTVs, fans, etc as shown in reference drawings and/or as per specification requirements mentioned herein. The floating stability of pontoon should be computed using approved software by suitably qualified Naval Architect considering the loads arising out of its selfweight, passenger load, concentrated load arising out of 3 wheeled vehicular load, bike wheel loads, concentrated load from linkspan and all other loads arising out of operations. Parking on pontoon may lead to tilting of Pontoon and Bikes may fall. Specific area to be demarcated for keeping bikes and maximum number of bikes allowed to be declared after checking meta-center of Pontoon during loaded condition. All such loads should be mentioned in Design Basis. The freeboard, draught of the pontoons should be adjustable to ensure safe transfer of passengers from pontoon to ferry vessel. The pontoons should be painted with marine grade corrosion protection paint in accordance with the recommendations in ISO 12944 under exposure condition C5M and its design life should be specified clearly in Design Basis. The pontoons should be classified by approved certification body. Appropriate illumination is to be provided on berthing pontoons. The illumination requirement is to be specified in Design Basis. The maximum allowable draught of the berthing pontoons shall be 1.5m at all water level. The Berthing pontoons should be positioned in the water depth such that a minimum under keel clearance of 1.5 m is available at lowest water level at a maximum possible draught of pontoon and vessel.

b) Dolphins for Berthing Pontoons :

The main purpose of Dolphins is to ensure lateral restraint of intermediate and berthing pontoons. The Dolphins are to be built with piles and concrete deck. The concrete deck being above the Highest Flood level (1in 100 years). Berthing pontoons will be connected to pile(s) to ensure vertical movement of pontoons. The deflection at top of Dolphin deck should be defined in Design Basis and in accordance with relevant provisions of IS codes. The dolphin design and its pile design should comply with maximum potential scour in the area and accordingly the surrounding soil support should be neglected. Such scour should be determined through appropriate hydrodynamic modelling. The purpose of hydrodynamic modelling is to ascertain the siltation and scouring pattern likely to occur at and near the terminal and accordingly consider the pile design and positioning of berthing and intermediate pontoon to ensure they are always in floating condition wth the required underkeel clearance.

c) Steel Linkspan bridges :

In total five (5) linkspan bridges are proposed. The first linkspan bridge connects between the bankseat and first intermediate pontoon, the second linkspan bridge connects between the first and second intermediate pontoon, third linkspan bridge connects between the second and third intermediate pontoon, fourth linkspan bridge connects between the third and fourth intermediate pontoon and the fifth linkspan bridge connects between the fouth intermediate pontoon and berthing pontoon. These Steel link span bridges are to be provided to ensure safe passenger boarding at different water levels. The main operational and functional purpose of the linkspan bridge is to adjust in slope by being in contact with intermediate pontoons and the end linkspan's one end being hinged at bankseat and the fifth linkspan being in contact at berthing pontoon. The purpose is also to provide seamless and safe connectivity passage from the terminal to the berthing ponoon and back. The steepest allowed slope for linkspan bridges is 1:12 as per BS-6349 and beyond which the linkspan should not be steeper. Therefore, the lowest level of intermediate pontoons will need to be defined so that the further downward movement of intermdiate pontoons is restricted. The lowest level of both intermediate pontoons will be different and should be defined properly. The first linkspan should be connected to bankseat through a hinged support on other end on the pontoon (intermediate/berthing) through a roller/friction bearing. The moving mechanism of all three linkspans should be such that in case of highest water level all linkspans will be nearly horizontal and in lowest water level, none of the linspan bridges should have slope steeper than 1:12 and still remain connected to bankseat and the end of last linkspan bridge on the berthing pontoon. These linkspan bridges should be covered with appropriate roofing sheets along with solar panels and also allow natural lighting through translucent sheets. It is the sole responsibility of the Contractor to ensure that this mechanism works after installation and all necessary computations should be done before hand. Appropriate illumination is to be provided on linkspan bridges. The illumination requirement is to be specified in Design Basis.

d) Intermediate Pontoons :

The purpose of intermediate steel pontoons is to provide end support to linkspan bridges and capable of being afloat when the linkspan bridges are fully loaded as per design load conditions. The vertical movement of intermediate pontoons should be computed through floating stability computations derived through approved software and design carried out by suitably qualified Naval Architect. These intermediate pontoons should be painted with marine grade corrosion protection paint in accordance with the recommendations in ISO 12944 under exposure condition C5M and its design life should be specified clearly in Design Basis. The pontoons should be classified by approved certification body.

e) Dolphins for Intermediate Pontoons :

The main purpose of Dolphins is to ensure lateral restraint of intermediate pontoons. The Dolphins are to be built with steel piles and concrete deck. The concrete deck being above the Highest Flood level (1in 100 years). Intermediate pontoons will be connected to pile(s) to facilitate vertical movement of pontoons. The deflection at top of Dolphin deck should be defined in Design Basis and in accordance with relevant provisions of applicable IS code like IS-4651/IS-456. The dolphin design and its pile design should comply with maximum potential scour in the area and accordingly the surrounding soil support should be neglected. Such scour should be determined through appropriate hydrodynamic modelling.

f) Bankseat :

The Bankseat is a deck on pile structure with steel piles and concrete deck. Bankseat supports the steel linkspan at the hinged end.

1.2.5 Terminal Building

The Contractor shall plan, design and construct the terminal building with all ancillary facilities and provisions as listed below at the location identified in the layout:

- Waiting areas for passengers
- Emergency service facilities
- Toilet's facilities. The toilet facilities for each sex (M/F) and assisted use (differently abled) including nursing/creche area for women.
- Secuity check areas
- Ticketing booths
- Parking areas
- Drinking Water facility
- Open area
- Office, shop and Meal Room
- Entry exit routes
- Access to ferry services by disabled persons Including provision of signage of appropriate visibility and equipments for audio announcements, compatible with a variety of techniques or devices used by people with sensory limitations.
- Space for utilities / infrastructure requirements
- Control room for ferry services
- Storage Areas
- First aid room, Electric room, Baby care room, etc.

Safety of the users and the environment is the main objective of designing of any building. Safety of the intended users means provision of proper functional spaces, avoiding hidden / dark spots, provision of CCTV surveillance, signages. Avoid conflict between passengers and vehicles / vessels. Accessibility of the building by all age group of people (including differently abled). provision of safety alarm systems and emergency services. The building should be designed as environment friendly design with minimum disturbance with the natural features available at the site.

The GGG terminal building shall be constructed over RCC piles and concrete deck of size 56.625m (along the river) x 33.085m/29.065m (sides) as shown in drawing no. P-013223-P-20318-202.

The layout and general arrangement of the components of Terminal Building listed above are shown in drawing no.s P.013223-P-20318-201 to P.013223-P-20318-206 for GGG site.

The Terminal building works shall also include fire protection scheme and layout works. Refer drawing no.s P.013223-P-20318-250 and P.013223-P-20318-251 for fire

protection works in the GGG terminal building. Typical 3D views of the Building, linkspan and pontoons are shown in drawings.

1.2.6 Electrical Works

In order to meet the total power demand for river Terminal, power supply shall be provided by ASEB at 11 kV level. The Contractor is obliged to assess the exact location of the power tap off and consider the appropriate route to bring the power to terminal building site. The main electrical substation location shall be near the Terminal Building only. Cabling from power tap-off point to the substation shall be considered in scope of work. Further onward power transmission to the Terminal building area (through 415V LT Power cable) and all downstream distribution to Pontoons, pathways and associated facilities shall also be considered in the scope of work and shall be through 415V Switchgear.

Upon receiving the power at 11 kV level from ASEB tap-off point, power shall be taken up to main sub-station area through 11 kV cable and it will be stepped down to 415V level by means of 11/.415 kV step down transformer. It shall be connected with 415 V Switchgear for downstream LV power supply. Other necessary voltages below 415V shall be derived from thereon.

The 415V Switchgear consists of two bus sections i.e., normal and emergency, which are coupled by bus coupler & electrical interlock and shall be serving as normal-cum-emergency Switchgear. Emergency power required by emergency loads shall be made available by Emergency Diesel Generator (EDG) located in a separate room. EDG will be directly connected to emergency bus section of Switchgear and all emergency loads shall be fed from this bus section. Incomer breaker of EDG shall be Normally Open (NO). EDG shall start automatically after failure of normal power supply, however shut down of EDG shall be manual.

Under emergency condition normal load (fed from on normal bus section) from Switchgear shall be shed off due to under voltage and Emergency load shall be connected. Emergency load shall also be in operational condition even during availability of normal power supply.

The lighting load is fed from emergency bus of LT Switchgear through lighting transformer. The output of Lighting Transformer is fed to Main Lighting Distribution Board. A bus coupler is provided in bus section of MLDB and one more incomer is also provided to feed power from solar plant for lighting loads. When EDG incomer is closed, the bus coupler breaker of MLDB is tripped and thus power is restricted to emergency bus of MLDB and power is supplied to emergency lighting bus.

For basic conceptualization of power distribution within battery limit of GGG , refer drawing no P.013223-P-20318-240 . Illumination layout of the terminal building, outdoor area, pontoon area are given in drawing no.s P.013223-P-20318-241 to P.013223-P-20318-244 for GGG.

The electrical system shall be designed to provide;

- Safety to personnel and equipment both during operation and maintenance.
- Reliability of Service
- Minimal fire risk
- Ease of maintenance and convenience of operation
- Automatic protection of all electrical equipment through selective relaying system.

- Electrical supply to equipment and machinery within the design operating limits.
- Suitability for applicable environmental factors.
- Maximum interchangeability of equipment.

The IP protection shall generally follow as per below:

S. No.	Item Description	IP Class
1.	LT Switchgear	IP-54 (for indoor)
2.	DBs/Panels/Local control station	IP-54 (for indoor) IP-65 (for outdoor)
3.	Motor & MOV (indoor & outdoor use)	IP-55 (Outdoor motor shall be provided with FRP canopy)
4.	Lighting fixtures	IP-54 (for indoor) IP-65 (for outdoor)
5.	Welding receptacles/small receptacles	IP-41 (for indoor) IP-65 (for outdoor)

1.2.7 Firefighting Works

Fire System mainly comprises of the following sub-systems:

- Fire detection, alarm and control system.
- Fire protection system.

The Fire Detection and Protection System for the Pontoon / Pathway to Pontoon / Building / Parking area/ Transformer / DG set etc. shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / NFPA (National Fire Protection Association, an American national Standard) / LPA (Loss Prevention Association of India) Fire Protection Manual guideline.

Fire Detection System of following types shall be provided.

- Fire Detection System
- Fire Alarm System
- Control System
- Cables and Wires
- Public Address / Talk Back System

Fire protection systems of following types shall be provided.

- Water Filling Arrangement
- Jockey pumps and Hydro Pneumatic Tank
- Hydrant system

- High Velocity Water Spray System
- Automatic Water Spray System
- Inert gas system
- Portable fire extinguishers

In addition to this all-necessary ventilation and air conditioning facilities shall be provided in the terminal.

The layout and general arrangement of the components of firefighting system listed above are shown in drawing no. P.013223-P-20318-250 to P.013223-P-20318-252 for GGG.

1.2.8 Water Supply, Sewerage and Drainage Works

Water Supply:

The contractor shall plan, design, install and commission the water supply system to the terminal.

The broad classification of works is given below:

- Source of water
- Water Storage
- Water Treatment
- Distribution

Water treatment shall produce water as per CPHEEO and IS 10500 drinking water norms. The treatment process involves the following steps;

- Raw water is pumped (1 working + 1 standby)
- Pressure sand filter
- Activated carbon filter
- Filter Backwash System
- Disinfection - the chlorination shall be done for domestic water with displacement pump
- The system shall be designed for rated capacity with 16 hours operation.
- Hydropneumatic system

Sewerage:

A dedicated sewage treatment plan shall be proposed to treat the wastewater generation from terminal buildings. A package type STP shall be proposed to treat the sewage generation from terminal. The water shall be collected at sump near terminal building. The collected water shall be pumped to sewage treatment plant. The wastewater shall undergo several steps. In general, the process for treatment of domestic sewage involves:

- Primary Treatment (Screening, Grit Removal and Primary Settling Tank)

- Secondary Treatment (Aerobic /Anaerobic Biological Treatment and Secondary Settling Tank)
- Tertiary Treatment (Sand Filtration)
- Disinfection
- Sludge Treatment

The treated water shall be used to horticulture and Excess water shall be finally discharged. As per CPHEEO norms, the sewage generation is taken as 80% of the water demand.

Drainage Works:

Concrete deck surrounding the terminal building and Utility area shall be made with suitable slope to drain the rainwater directly into the River. Deck areas of dolphins and pontoons shall be made to slope to drain the rainwater directly into the River.

1.2.9 Internal Roads

The Contractor shall plan the internal roads and demark on concrete deck top for Terminal. All access roads shall be minimum 6 m wide that will also suffice for exigency vehicle routes, along parking, at drop off and approach in and out of concrete platform.

Layout of Road provision is shown in Drawing no P.013223-P-20318-201 for GGG .

1.2.10 Conractor's Environmental and Social Management plan, including EMP.

Based on the study of baseline environmental conditions and the assessment of potential impacts of the project, a contractor environment and social management plan (C-ESMP) shall be developed by the Contractor.

In order to effectively implement the ESMP, an institutional framework shall be developed and roles and responsibilities of various relevant agencies have to be worked out.

To ensure the effective implementation of ESMP, it is proposed to undertake environmental and social monitoring both during construction and operation period. A three-tier monitoring program shall be proposed as given below:

- Compliance monitoring,
- Effect's monitoring, and
- External monitoring.

The detailed environmental and social management and monitoring plan shall be provided by the Contractor with necessary mitigation measures to properly monitor the Health, Safety, Environmental and social issues.

1.2.11 Vendors/ Makes and Quantities

a) List of Approved vendors and List of Minimum Furnitures

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.

The Contractor shall use the following list of quantities as minimum required or tentative for the materials mentioned in the scope of works:

Terminal Building

Furniture			
Sl.NO.	**Items**	**Quantity (Nos)**	**Vendors**
1	Stainless Steel Chairs	94	Godrej, Featherlite, Ergo Furniture, Supreme, Nilkamal
2	Revolving Chairs	7	Godrej, Featherlite, Ergo Furniture, Supreme, Nilkamal
3	Dining Chairs	4	Godrej, Featherlite, Ergo Furniture, Supreme, Nilkamal
4	Working Table with Drawer	1	Godrej, Featherlite, Ergo Furniture, Supreme, Nilkamal
5	Dining Table	1	Godrej, Featherlite, Ergo Furniture, Supreme, Nilkamal
Electrical Fittings			
1	Down Lighter(18W) LED IP65	15	Philips, Bajaj, Havells
2	4 ft Tube light(36W) LED	27	Philips, Bajaj, Havells
3	Ceiling Fan	35	Usha, Bajaj, Orient, Crompton Greaves, Havells
4	Medium Bay Luminaire (50W) LED	32	Philips, Bajaj, Havells
5	Heavy Duty Exhaust Fan	3	Usha, Bajaj, Orient, Crompton Greaves, Havells
6	Exhaust Fan	10	Usha, Bajaj, Orient, Crompton Greaves, Havells
7	Lighting Feeder Pillar	3	Philips, Bajaj, Havells
8	Main Lighting Distribution Board	1	Popular Switchgear, Scoot Engineering, Sterling and Wilson
9	Emergency Lighting Feeder Pillar	1	Philips, Bajaj, Havells
10	6A, 5 pin Shuttered Socket	31	Siemens, Legrand, Crompton Greaves, Schneider Electric
11	6/16A, 3 pin shuttered Socket	30	Siemens, Legrand, Crompton Greaves, Schneider Electric

12	63A, 5 pin Shuttered Socket	1	Siemens, Legrand, Crompton Greaves, Schneider Electric
13	Desktop Telephone Set	09	
14	Wall Mounted Telephone Set	4	
15	Fixed Type CCTV Camera	2	Cp plus, Hikvision, Godrej, Panasonic, Zicom,
16	PTZ Type CCTV Camera	3	Cp plus, Hikvision, Godrej, Panasonic, ,Zicom
17	65" LED Screen	2	Samsung, Sony, LG, Panasonic
18	4 STAR rating split type air conditioner of 1.5 Ton capacity with cordless remote	4	Blue Star, Voltas, Samsung, LG, Lloyds, Panasonic

Outdoor Area

Electrical Fittings			
Sl.NO.	**Items**	**Quantity (Nos)**	**Vendors**
1	Streetlights	19	Philips, Wipro, Havells
2	Flood light	3	Philips, Wipro, Havells
3	High Mass Light	1	Philips, Wipro, Havells
4	Fixed Type CCTV Camera	2	Cp plus, Hikvision, Godrej, Panasonic, Zicom
5	PTZ Type CCTV Camera	3	Cp plus, Hikvision, Godrej, Panasonic, Zicom
6	Wall Mounted Telephone Set	3	
7	6/16A, 3 pin shuttered Socket	1	Siemens, Legrand, Crompton Greaves, Schneider Electric
8	63A, 5 pin Shuttered Socket	2	Siemens, Legrand, Crompton Greaves, Schneider Electric
9	Flood light (400W) LED IP 66	4	Philips, Wipro, Havells
10	LED type floor mounted Up lighter 5 W	5	Philips, Bajaj, Havells
11	LED type floor mounted Up lighter 10 W	5	Philips, Bajaj, Havells
12	LED type Spike Light 9 W	5	Philips, Bajaj, Havells

Control Room

Furniture			
Sl.NO.	**Items**	**Quantity (Nos)**	**Vendors**
1	Wood Restaurant Fine Chair	2	Godrej, Featherlite, Ergo Furniture, Supreme, Nilkamal
2	Dining Table	1	Godrej, Featherlite, Ergo Furniture, Supreme, Nilkamal
Electrical Fittings			
1	4 ft Tube light(36W) LEDIP65	2	Philips, Bajaj, Havells
2	4 ft Tube light(36W) LED	7	Philips, Bajaj, Havells
3	Ceiling Fan	4	Usha, Bajaj, Orient, Crompton Greaves, Havells
4	Exhaust Fan	2	Usha, Bajaj, Orient, Crompton Greaves, Havells
5	Lighting Feeder Pillar	1	Philips, Bajaj, Havells
6	Emergency Lighting Feeder Pillar	1	Philips, Bajaj, Havells
7	6A, 5 pin Shuttered Socket	2	Siemens, Legrand, Crompton Greaves, Schneider Electric
8	6/16A, 3 pin shuttered Socket	4	Siemens, Legrand, Crompton Greaves, Schneider Electric
9	63A, 5 pin Shuttered Socket	1	Siemens, Legrand, Crompton Greaves, Schneider Electric
10	65" LED Screen	1	Samsung, Sony, LG, Panasonic
11	4 STAR rating split type air conditioner of 1.5 Ton capacity with cordless remote	1	Blue Star, Voltas, Samsung, LG, Lloyds, Panasonic

Linkspan

Electrical Fittings			
Sl.NO.	**Items**	**Quantity (Nos)**	**Vendors**
1	Down Lighter(18W) LED IP65	24	Philips, Bajaj, Havells
2	4 ft Tube light(36W) LED	105	Philips, Bajaj, Havells
3	Ceiling Fan	4	Usha, Bajaj, Orient, Crompton Greaves, Havells
4	Lighting Feeder Pillar	1	Philips, Bajaj, Havells
5	Emergency Lighting Feeder Pillar	1	Philips, Bajaj, Havells
6	6/16A, 3 pin shuttered Socket	9	Siemens, Legrand, Crompton Greaves, Schneider Electric

7	63A, 5 pin Shuttered Socket	9	Siemens, Legrand, Crompton Greaves, Schneider Electric
8	Wall Mounted Telephone Set	1	
9	PTZ Type CCTV Camera	2	Cp plus, Hikvision, Godrej, Panasonic, Zicom.

Pontoon

Furniture			
Sl.NO.	**Items**	**Quantity (Nos)**	**Vendors**
1	Stainless Steel Chairs	412	Godrej, Featherlite, Ergo Furniture, Supreme, Nilkamal
Electrical Fittings			
1	Down Lighter(18W) LED IP65	42	Philips, Bajaj, Havells
2	4 ft Tube light(36W) LED	170	Philips, Bajaj, Havells
3	Ceiling Fan	60	Usha, Bajaj, Orient, Crompton Greaves, Havells
4	Lighting Feeder Pillar	2	Philips, Bajaj, Havells
5	Emergency Lighting Feeder Pillar	2	Philips, Bajaj, Havells
6	6A, 5 pin Shuttered Socket	12	Siemens, Legrand, Crompton Greaves, Schneider Electric
7	6/16A, 3 pin shuttered Socket	12	Siemens, Legrand, Crompton Greaves, Schneider Electric
8	Wall Mounted Telephone Set	3	
9	Fixed Type CCTV Camera	2	Cp plus, Hikvision, Godrej, Panasonic, Zicom,
10	PTZ Type CCTV Camera	2	Cp plus, Hikvision, Godrej, Panasonic, Zicom,
11	Floor Mounted Bollard Light 9 W	5	Philips, Bajaj, Havells

2 DESIGN CRITERIA

2.1 Civil

2.1.1 Codes and Standards

The codes and standards stated here below or elsewhere in these documents shall be the latest editions prevailing till July 2021. All materials, testing, design and execution shall be in conformity with these codes and standards unless otherwise stated in these specifications. It is well understood that when a brand name is given for a material, the Contractor has the right to propose any equivalent material of any other brand for approval of the Employer. In case multiple codes have different interpretations or differ in recommendations, the most relevant Indian Standard shall apply to the Project.

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.

a) British and Euro Standards

b) American Standards

c) General Standards

Wherever details for part of works are not defined adequately in Indian Standards, relevant acceptable International Standards shall be adopted. Codes and standards covering a major part of the works is included in the Tender Document and some of them are listed below:

IS 4651 Code of Practice for Planning and Design of Ports and Harbours

IS 1893 Criteria for Earthquake Resistant Design of Structures

IS 875 Code of Practice for Design Loads for Buildings and Structures – (Parts 1–5)
IS 456 Code of Practice for Plain and Reinforced Concrete

IS 800 Code of Practice for General Construction in Steel

IS 2911 Code of Practice for Design & Construction of Pile Foundations

IS 3370 Code of Practice for Concrete Structures for the Storage of Liquids

IRC 37 Guideline for the Design of Flexible Pavements

IS 13920 Ductile Detailing of Reinforced Concrete Structures subjected to Seismic

Forces – Code of Practice

IS 4326 Earthquake Resistant Design & Construction of Buildings – Code of Practice

National Building Code (2005)

IRC 24 Standard specifications and code of practice for Road Bridges (Section V - Steel Road Bridges)

IRC 83 Standard specifications and code of practice for Road Bridges (Section IX - Bearings)

IRC 58 Guidelines for the Design of Plain Jointed Rigid Pavements for Highways

IRC 73 Geometric Design Standards for Rural Highways

BS 449 The use of Structural Steel in Building (Permissible Stress) BS 648

Schedule of Weights and Building Materials

BS 5493 Protective Coating of Iron and Steel Structures against Corrosion

BS 5950 Structural Use of Steel work in Building (Limit State) BS 6031 Earthworks

BS 6367 Code of Practice for Drainage of Roads and Paved Areas

BS 6399 Loading for Buildings

BS 8002 Earth Retaining Structures

BS 8004 Foundations

BS 8110 Structural Use of Concrete

BS 5930 Site Investigation

BS 8000 Foundations

IRS Steel Bridge Code

MJ Tomlinson: Pile Design and Construction Practice

2.1.2 Design Life

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

Structural Component	**Design Life**
Reinforced concrete structures	50 years
Steel Piles	50 years
Steel for link spans and walkways	25 years
Intermediate and berthing pontoons	25 years
Fenders and bollards	8-10 years
Buildings	50 years

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

2.1.3 Ferry Dimensions

Dimensions of the largest ferry considered in the planning and design of the infrastructure are given below:

- Length : 30 m
- Beam : 12 m
- Laden Draft : 0.75 m

The proposed terminal design shall be capable to handle the list of the vessels enclosed in the Annexure -1

2.1.4 Water Levels

Recommended design HFL and LWL are 51.46m RL and 40.56m RL respectively for Guwahati Gateway Ghat (GGG).

Structural Levels (GGG)

Levels for structures to be used in design are as follows:

Top of deck of concrete Bankseat	+52.0 m RL
Top of deck of intermediate dolphins	+58.0m RL
Top of deck of berthing dolphins	+58.0 m RL

Link Span caters for differential flood levels in a slope of 1 in 12

Scour

Due to flooding and consequent currents, changes in the river morphology and the associated heavy transport of sediments are predominant along the Brahmaputra River. Scour protection may be assured either by choosing a greater / safe design depth or by adequate additional measures such as grouted stone fill or geotextile geo-bags / tubes.

Pile foundations of the riverine infrastructure shall be designed for safe design depth considering design scour level as determined based on the Contractor's modelling results and subsequent approval of Proof Checking Engineer and Employer's Engineer.

However, the Contractor must conduct the Hydraulics & Morphological Modelling study so as to ascertain the local scour and sedimentation along with its anticipated effects on the Riverine structures viz., piles, including the anticipated effects due to the structure positioning. This will be the basic criteria for DESIGN of the Riverine structures and work out the detailed design / engineering duly taking into consideration of the Loads and the Load distribution arrangements of the proposed structures. The Drawings are to be prepared and got approved by the Employer's Engineer before proceeding ahead with construction.

2.1.5 Materials of Construction

Concrete

The reinforced concrete member sizes considered for all the components of the riverine and building infrastructure works shall comply to minimum dimensions prescribed in Fig. 1 of IS 456-2000 for a fire resistance of 4 hours. The following grades of concrete shall be used for construction of precast / cast-in-situ concrete components:

Sr. No	Members / Components	Proposed Grade of concrete
1	Beams & Deck slab for superstructure of bankseat and dolphins	M35 (minimum)
2	Buildings	M35 (minimum)
3	Piles	M40 (minimum)

Partial Safety Factor γ_m for Material Strength

- Concrete $\gamma_m = 1.50$
- Reinforcement $\gamma_m = 1.15$

Reinforcement

Main reinforcement steel shall conform to [Fe 500 (IS 1786)] TMT, 500 S with low alloy steel grade. Strength parameters shall be as follows:

- Minimum yield stress (Main steel) : 500 N/mm²
- Elongation (min): 18 %
- Secondary steel shall be HYSD : 500 N/mm2 (confirming to IS 1786)

Cover to Reinforcement.

The nominal cover to reinforcement for all reinforced concrete members complies with Fig. 16A of IS 456-2000 for a fire resistance of 4 hours. Nominal cover to be followed are as shown below:

Riverine Structures:

Piles and Pile caps	75mm
Deck slab	75mm
Beams	75mm

Building Structures:

Superstructure	50mm

Structural steel

The grade of structural steel considered for pontoons, linkspans and other superstructures shall conform to provisions of the material specifications mentioned in under section 4. However, the structural steel shall conform to Grade E275BR as per IS: 2062 with minimum yield Strength of 275 N/mm^2 for steel tubular piles.

Method of design

All structural steel members shall be designed in accordance with IS 800 or as applicable.

Reinforced concrete members shall be designed using limit state design method as per IS 456:2000.

The suspended deck structures shall be analyzed by preparing a three-dimensional (3D) model in STAAD-Pro or similar software package. The 3D model shall be applied with all relevant load cases and load combinations complying Indian standards.

Based on the soil profile at the respective location, approximate fixity levels of piles can be calculated and the same shall be used in the analysis of structures.

Geotechnical Design Criteria

The foundation/substructure for all riverine structures consists of driven steel piles.

Pile safety factor for axial pile capacity (tension and compression) shall be as per API guideline:

- 2.0 in axial compression and
- 1.5 in axial tension

The lateral load capacity, end-bearing and skin friction capacity shall be checked and the pile spacing shall be decided accordingly. Allowable bearing pressure for shallow foundation shall be based on permissible settlement provided in Table 1, IS1904 for dead plus live load conditions.

For Transient loading (wind / seismic forces), allowable bearing pressure of soils shall be increased as per the recommendation provided in Table 1, IS1893 (Part 1) for RCC foundations. While designing foundations at various levels, the bearing capacity at that particular level and also the effect of uplift /sub soil water table shall also be considered.

2.1.6 Loads

2.1.6.1. Dead Load

The specified dead load for a structural member consists of the weight of the member, the weight of all materials of construction incorporated in the structure to be supported permanently by that member and the weight of permanent equipment.

In assessing dead loads for the purpose of design, the following material unit weight shall be used:

Reinforced Concrete	25 kN/m^3
Plain Concrete	24 kN/m^3
Structural Steel	78.5 kN/m^3
Backfill Soil	18 kN/m^3
Water	10 kN/m^3
Water proofing	4 kN/m^2

The unit weights of other materials shall be considered as defined in IS 875 – Part 1.

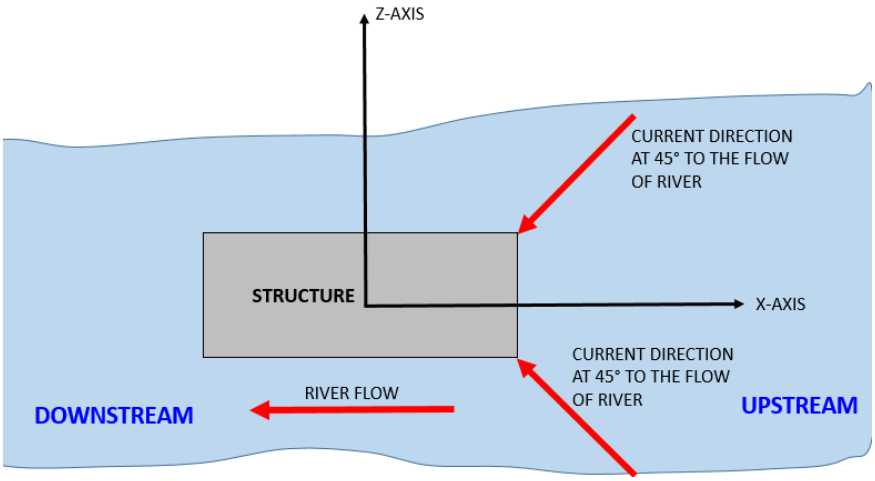
2.1.6.2. Live Load

A uniform live load of 5 kN/m^2 shall be considered for the design of bankseat, link spans, dolphins and intermediate pontoons. The live loads on the buildings shall be considered in accordance with IS 875 – Part 2.

Handrailing and kerb on approach roadway shall be designed in accordance with IRC-6 2014.

2.1.6.3. Current Load

The current loads have been evaluated based on the current velocity of 4.0 m/s. The current loads are considered at different directions with respect to the river flow. The predominant current load will be in the direction of the river flow. However, the current loads on the structures are also considered at 45° (maximum) from the direction of the river flow as shown in the figure below:



The current loads are resolved with respect to the X & Z axis of the structure as shown in the table below:

Degrees	X Component	Z Component
10	0.990	0.180
22.5	0.930	0.390
30	0.870	0.500
45	0.710	0.710

These factors are considered with the current loads in X & Z direction in the STAAD-Pro analysis of the structure.

2.1.6.4. Wind Load

An operational wind speed of 30 m/s and an extreme wind speed of 50 m/s shall be considered as per provisions of IS 875-2015. Suitable risk, terrain, height and topography factors (k1, k2 and k3) shall be considered as per site conditions. The following factors shall be considered for wind load analysis:

K1 = 1.00

K2 = 1.05

K3 =1.00

2.1.6.5. Earthquake Load

Earthquake forces as applicable for the site shall be evaluated and computed with reference to IS 1893 – 2002. Design horizontal seismic coefficient shall be evaluated as per procedure detailed in IS 1893-2002.

The parameters to be considered for seismic analysis are as follows:

- Seismic zone : V
- Design horizontal seismic coefficient, Ah : ZI (Sa/g)/ (2R)
- Zone Factor Z: 0.36
- Importance Factor I : 1.5
- Response Reduction Factor R: 4.00
- Damping : 5% for Reinforced concrete

Time period of specified structures shall be evaluated by STAAD analysis considering Dead load + Super imposed dead load + 50% Live load. Provisions of IS 13920 shall be considered for ductility detailing of reinforcement in reinforced concrete members.

2.1.6.6. Berthing Load

The berthing loads shall be computed in accordance with IS 4651 part III, considering following parameters.

- Berthing and site conditions: Sheltered and difficult
- Approach angle: 10 degrees
- Approach velocity: 0.5 m/s

- Maximum displacement of ferry vessel (100 seater + 50 bikes) : 95 Tons
- Maximum displacement of ferry vessel (50 seater + 25 bikes): 40 Tons

Suitable fender shall be chosen and fixed to the berthing pontoon. The berthing pontoons and the berthing dolphins shall be designed considering the reaction from the fender.

The friction force shall be considered 0.30 times the reaction of the fender in the longitudinal direction.

Surcharge Load

Surcharge load will be taken as minimum 10 kN/m^2 for design considered wherever applicable.

Load Combinations

The factors for load combinations shall be arrived with reference to Table 1 of IS 4651 (Part 4): 2014 for both limit state of collapse and limit state of serviceability for the riverine and building structures.

Increase in permissible stress

Increase in permissible stresses for members designed as per working stress design method will be as per Cl. 7 of IS 4651 (Part 4) – 2014.

The partial load factor for all the load cases shall be considered as 1.0 for use in working stress design. However, the permissible stress may exceed up to the limit as mentioned in Table 2 of IS 4651 (Part 4) – 2014.

Miscellaneous Components and Details

Handrails

All handrails shall be hot dip galvanized and painted. Horizontals of handrails shall be of at least 40 mm diameter. Toe plate of mild steel conforming to IS: 2062. Height of handrail shall be 1100 mm from deck.

Corrosion Protection

All structural steel surfaces exposed to the atmospheric zone shall be painted in accordance with the painting specifications. All concrete surfaces in contact with the soil shall be coated with 2 coats of Bituminous Paint in line with Manufacturer specification.

Serviceability Criteria

Deflection

The deflection criteria shall be so limited that it shall not produce difficulties in serviceability conditions nor shall it cause damage to the structures and its components.

Horizontal deflection of piles shall be limited to H/250 (H – unsupported length of pile).

Vertical deflection of link span members shall not exceed span/325.

The link span shall be designed to accommodate transverse and longitudinal differential movements between the intermediate pontoons and hinged support. One end of the structure shall be designed as a hinge support and the other end as a sliding/rolling support. The sliding support shall provide guide restrains in the vertical/lateral directions.

150% of the total calculated translation shall be allowed for in the end conditions and

bridge design. The hinge connection shall be designed to withstand 150% of the expected axial/horizontal thrust.

Crack Control

The structural concrete elements shall be checked for crack width for operating load combinations in accordance with provisions of IS: 456-2000. The crack width shall be limited to the values as defined in the table below:

Sr. No.	Item	Sustained Load Cases (mm)	Transient Load Cases (mm)
1	Above water zone	0.2	0.3
2	Splash zone	0.1	0.2
3	Submerged zone	0.2	0.3
4	Buried Zone	0.3	0.3

NOTE:

Sustained Load: Dead load, Live load and earth pressure load

Transient Load: Berthing, Mooring and Crane Loads (whatever applicable)

Building Works

All civil & structural steel structures shall be designed satisfying the Codal provisions. Loading shall be as per IS: 875 & IS:1893. The buildings shall be provided with adequate arrangements for plumbing, sanitary, electrical fittings, illumination, water distribution etc. Following minimum considerations shall be followed:

- Floor to floor height shall satisfy the bylaws of National Building Code.
- A 750 mm wide plinth protection shall be provided around each building.
- Finished floor level of buildings shall be 500 mm above the finished ground level unless specified otherwise.
- All external walls shall be of 230 mm thick, all partition walls shall be minimum 115 mm thick with 1:4 cement mortar.

All structures shall be analysed as framed structure using STAAD.Pro for the loads and their combinations. However, the design of the elements shall be carried out by either manually or standardized excel sheets or in-house software packages or using STAAD.Pro software design module.

All designs of RCC structures shall be carried out as per IS 456. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristics strength and characteristic loads as per IS 456.

All underground RCC structures other than liquid retaining structures shall be designed as per IS: 456 cracked section with limiting crack width as per codal provisions. All Liquid Retaining Structures shall be designed as per IS:3370.

Internal Roads and Vehicle Parking Area

Internal Roads shall be designed with the provision of relevant IRC codes with the following minimum requirement:

Geometric Parameters:

- Maximum longitudinal grade : 3.0%
- Cross slope : Unidirectional 2.5% for All Roads
- Maximum super elevation : 7%
- Sight Distance : Intermediate sight distance
- Turning Radius at junction : Min. 25 m

Storm Water Drainage System

Surface drainage shall be designed with the following basic consideration:

- The drainage system shall be planned to carry storm run-off from the proposed areas shown in the scope drawings.
- No allowance for sullage shall be kept.
- The storm water run-off shall be collected and stored for reuse using rainwater harvesting.
- A maximum velocity of 2.5 m/s shall be allowed for RCC channel with lined surface.
- Manning coefficient for different pipe material shall be adopted as follows:
  - Concrete surface in good condition - 0.015
  - Masonry surface with cement plaster - 0.015

All pipes shall be RCC NP3 except below the road. Pipe shall be of NP4 type below road.

Sewerage System

The pipelines of suitable size shall be laid for collection of the sewage from the buildings to a sump. The design and laying of the pipelines shall be carried out as per the provision of relevant IS codes.

Water Supply System

The combined capacity of the water tanks for Raw water and Clear water shall be 60 m^3 and the capacity of the Fire water tanks above platform deck shall be 152 m^3.

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

2.2 Electrical

2.2.1 General

The contractor shall work as per the drawings and designs described in the Tender document and the best current engineering practice. Particular attention should be paid to internal and external access to the electrical equipment in order to facilitate inspection, cleaning and maintenance. The contractor shall comply with latest code of practice published by the Bureau of Indian Standards as applicable. Care shall be taken so that materials and equipment supplied by contractor are the standard catalogued products of manufacturers regularly engaged in the manufacturer of such products and

shall be of the latest standard designs that conform to the specific requirements.

a) The essence of design shall be safety, simplicity and reliability in order to give long continuous service with high economy and low maintenance cost.

b) All equipment shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.

c) The design shall comply with relevant codes and regulations listed.

d) All apparatus, equipment and works shall be so designed that they provide satisfactory service without any harmful effects for prolonged and continuous periods in the worst climatic conditions, stated hereinbefore.

e) The reference design ambient temperature for all electrical equipment shall be taken as 45ºC and appropriate de-rating factors shall be considered for equipment as applicable.

f) Suitable de-rating shall be applied based on published data against the most severe conditions encountered in the site, by reducing the permissible temperature rise above the ambient level.

2.2.2 Errors, Omissions and discrepancies

In case of errors, omissions and discrepancies between technical specification, schedules and drawings the following order shall prevail:

a) MOM with Contractor in reverse chronological order.

b) Technical specifications

c) Tender drawings

d) Bureau of Indian Standards

e) International Standards

f) In all case of doubt or omissions or discrepancies noticed in any item of work any drawing, the decision of the Employer/Employer's Engineer shall be final and binding on the Contractor.

Other Technical Requirements

The Contractor shall arrange all the instruments, materials and labour involved in setting out the works to the satisfaction of the Employer/Employer's Engineer.

2.2.3 Standards and Regulations

The design and manufacture of the electrical equipment shall conform as a minimum to applicable codes, regulations and standards published by the following bodies:

BIS : Bureau of Indian Standards

IER : Indian Electricity Rules

BSI : British Standard Institution

ISO : International Organization for Standardization

IEC : International Electro-Technical Commission

IEEE : Institute of Electrical & Electronics Engineers

NFPA : National Fire Protection Association

NEC : National Electrical Code

Following is the list of some of the directly applicable Standards particular to the equipment. Any other relevant Indian Standard not covered shall also be applicable.

IS: 375	Marking and arrangement of Switchgear Bus
IS: 13118	Specification for high voltage alternating current circuit breaker
IS: 12729	Switchgear and Control gear for voltages exceeding 1000V – General Requirements
IS: 2705	Current transformers IS: 3156 Voltage Transformers IS: 335 New Insulating oils
IS: 2026	Power transformers
IS: 3639	Fittings and accessories for Power transformers
IS: 4257	Dimensions of clamping arrangement for porcelain transformer bushings
IS: 11171	Specification for Dry-Type Power transformer
IS: 10028	Code of Practice for selection, installation and maintenance of transformer
IS: 3427	A.C. Metal enclosed switchgear and control gear for rated voltages above 1kV and upto and including 52kV
IS: 8623	Specification for low voltage switchgear and control gear assemblies of switchgear & control gear for voltages not exceeding 1000V AC.
IS: 13703	Low Voltage fuses
IS: 13947	Low Voltage switchgear and control gear
IS: 1651	Stationary cells and batteries, Lead Acid Type (with tubular positive plates) – Specification
IS: 266	Specification for Sulphuric acid
IS: 3895	Mono crystalline Semi-conductor rectifier cells and stacks
IS: 4540	Mono–crystalline Semi-conductor rectifier assemblies and equipment
IEEE:484	Recommended Design for Installation design and installation of large lead storage batteries for generating stations and substations.
IEEE:485	Sizing large lead storage batteries for generating stations and substations.
IS: 1554	PVC insulated (heavy duty) electric cables for working voltages up to and including 1100 volts.
IS: 7098 -I	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to and including 1100 volts.

IS: 7098 -II	Cross linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 kV up to and including 33 kV.
IS: 10810	Methods of tests for cables.
IS: 418	Tungsten filament general service electric lamps
IS: 1777	Industrial luminaire with metal reflectors.
IS: 1947	Flood Lights
IS: 10322	Luminaires for street lighting.
IS: 1944	Code of practice for design of Street lighting
IS: 2206	Flame proof electric lighting fittings
IS: 2215	Starters for fluorescent lamps.
IS: 2418	Tubular fluorescent lamps for general lighting services
IS: 4013	Dust-light electric lighting fittings
IS: 8224	Specification for Electric Lighting fittings for Division 2 areas
IS: 9583	Emergency lighting units
IS: 9900	High-pressure mercury vapour lamps
IS: 9974	High Pressure sodium vapour lamps
IS: 2713	Specification for Tubular Steel Poles for Overhead Power Lines
IS: 1255	Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
IS: 732	Electrical wiring installation (system voltage not exceeding 1100 V). IS: 2309 Code of practice for the protection of building and allied structures against lightning.
IS: 3043	Code of practice for earthing.
IS:15885	
(Part2/Sec13) 2012	Safety of Lamp Control Gear, Part 2 Particular Requirements Section 13 d.c. or a.c., Supplied Electronic Control gear for LED Modules
IS:16101: 2012	General Lighting - LEDs and LED modules – Terms and Definitions
IS:16102 (Part 1) : 2012	Self- Ballasted LED Lamps for General Lighting Services Part 1 Safety Requirements
IS:16102 (Part 2) 2012	Self- Ballasted LED Lamps for General Lighting Services Part 2 Performance Requirements
IS:16103	Led Modules for General Lighting Part 1 Safety Requirements
(Part 1) : 2012	
IS:16103	Led Modules for General Lighting Part 2 Performance Requirements
(Part 2) : 2012	

IS:16104: 2012	D.C. or A.C. Supplied Electronic Control Gear for LED Modules - Performance Requirements
IS:16105: 2012	Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources
IS:16106: 2012	Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products
IS:16107 (Part 1)	Luminaires Performance Part 1 General Requirements
2012	
IS:16107-1: 2012	Luminaires Performance Part 2 Particular Requirements Section 1 LED Luminaire
IS:16108: 2012	Photo biological Safety of Lamps and Lamp Systems
IS:60470-2000	High-Voltage Alternating Current Contactors

In addition to Codes and standards, the installation works shall also conform to the requirements of following:

i) Indian Electricity Act

ii) Fire insurance regulations

iii) Regulations laid down by Chief Electrical Inspector of West Bengal

iv) Regulations laid down by the Factory Inspector

v) Regulations for the electrical equipment of Tariff Advisory committee

vi) Any other regulations laid down by the Employer

vii) Regulation of Pollution Control Board of West Bengal

2.2.3.1. Standardization

Care shall be taken so that the materials and equipment are standard catalogued products of manufacturers regularly engaged in manufacture of such products and shall be of the latest standard designs conforming to specification requirements. Design shall also be based on similar types of electrical equipment supplied from one manufacturer, utilizing interchangeable parts wherever practicable. Materials and equipment incorporated shall be of a type for which spare parts and replacements are readily available in India.

2.2.4 Earthing and Lightning Protection System

The complete earthing system shall conform to the provision of Indian Electricity Rules, and applicable code of practice for earthing IS: 3043, however for chemical earthing IEEE:80-2000 shall also be followed. Working layout drawings shall be prepared by the successful Contractor. Value of earth resistivity shall be considered as per the areas indicated in IS:3043 or the actual value as obtained from the site from previous records available with the employer, if any.

All Non-conducting structures shall be provided with Lightning protection consisting of Air termination network at the top and down conductors as per IS:2309. All Structures made of conducting material shall be protected by adequate earthing arrangements and air terminations at the top as per IS:2309. Conductors shall be Galvanized Iron (GI) of suitable size as per IS:2309. Buried lightning grid conductors of 75mm x 8mm size shall

be provided for interconnection of the Lightning earth pits around individual building. The same shall also be connected with the main plant earth grid at places through isolating link installed in Earth pits.

2.2.4.1. Earthing Below Ground

a) The main earthing grid shall be buried below ground unless required otherwise. For crossing any trench or under-ground pipe minimum earth coverage of 500 mm shall be provided over the earthing conductor.

b) Where the earthing conductor passes through reinforcement or steel plate it shall be bonded to the same.

c) All building steels and columns shall be bonded directly to the earthing grid.

d) The riser/pigtails from earthing grid shall project 600 mm above grade/concrete level unless shown otherwise.

e) All earthing conductor connections shall be made by electric arc welding or by nuts and bolts using plain washers and spring washers.

f) All arc welding shall be carried out with low hydrogen content electrode.

g) All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. No artificial cooling should be adopted to cool welded joints.

h) The welding required for earthing shall serve the following three purposes (i) sufficient mechanical strength between the jointing materials (ii) sufficient electrical area for the flow of system short circuit current and (iii) sufficient electrical area available after commissioning during the life time of the plant.

i) Before welding, the earth conductors shall be clamped tightly to ensure good surface contact at welding points.

j) Before applying bitumen compound two coats of red oxide primer shall be applied to risers and exposed portion of earth grid, if any. Construction joints shall be given treatment with Barium Chromate before applying red oxide paint and bitumen.

k) Earthing shall be mechanically robust and all joints shall be capable of retaining low resistance even after passages of many fault current.

l) All the connections are to be made carefully and properly. Improper/poor connections are to be remade at the cost of Contractor.

m) Welded areas of risers/pigtail shall be thickly coated with bitumen compound to prevent corrosion.

n) Earthing pits/conductors shall be laid in field to avoid fouling with concrete foundations and in consultation with the Employer at site.

o) Trenches shall be filled up with `Free of Stones' earth after laying earth conductor. After filling up of trenches the earth shall be rammed carefully.

p) The successful Contractor shall submit detailed working drawings of earthing grid for approval by Employer prior to construction of the grounding system.

q) The rate quoted shall be inclusive of cost of all materials, labour required for excavation, backfilling, welding, cutting, bending, placing of GI strips etc. complete as per specification.

r) All tests as per relevant standards shall be conducted to certify the effectiveness and other requirements of the earthing grid.

s) Depth of laying of earth conductor for earth grid, ring and inter-connections shall generally be min. 500 mm from ground level and 300 mm below all foundations.

t) Erection of earth pits shall include making of masonry enclosure and supply of chemical and other materials.

2.2.4.2. Earthing Above Ground

a) The successful Contractor shall lay the above ground earthing conductors inside the buildings and on various structures for connection to various equipment/ drives etc. These earthing conductors may be installed within the cable trays in the form of runway conductors. The connection to equipment shall be tapped from these runway conductors at suitable locations. One runway conductor shall be provided for each side of cable trench/tray.

b) The neutral points of all earthed system of different voltages, all equipment frame works, other non-current carrying metallic structures and equipment such as motor frame enclosures of MCCs, panel boards, cable armour, cable trays, sheaths etc. shall be earthed by a minimum of two separate and distinct connections.

c) Armour of all power and control cables shall be earthed at both ends through gland earth ring provided with the cable glands.

d) All cable trays and supporting structure are to be earthed. All cable tray sections shall be bonded with each other for continuity.

e) All earth leads and riser connections shall be as short as possible.

f) Metal pipes and conduits through which cables run shall be effectively bonded and earthed.

g) Neutral connection shall not be used for equipment earthing.

h) All connections to earth conductors shall be welded/bolted type. Earthing connections to all equipment shall be bolted type.

i) Earthing conductor along their run on steel columns, beams etc. shall be tack welded at intervals of 1000 mm.

j) All joints in earthing conductor shall be welded type. All joints shall be welded with an overlap of 65 mm. Joints shall be thoroughly cleaned before welding. Welding is to be done around joint completely. All joints shall be given two coats of anti-corrosive paint (Red Oxide) to a thickness of 3-5 mils, followed by a coat of bitumen paint. Joints shall be thoroughly cleaned before applying paints.

k) All nuts, bolts washers etc. shall be cadmium plated or zinc passivated. Generally, earthing studs and terminals shall be provided on all equipment. In such cases, where it is not provided the Contractor shall have to drill and tap the equipment for deriving earth terminals.

l) Connections of earthing conductors to the main earthing loops or to equipment shall generally be made by means of cable lugs in case of round conductors, solid or stranded and directly in case of strips. Devices like spring washers and lock washers must be used to ensure that the connections are vibration proof.

m) Laying of earthing conductor shall include fabrication and fixing of clamps, cleats and supply fixing device i.e. nuts, bolts, washers as also civil work such as preparation of floor surface and finishing them to the finished floor level after installation of earthing strips.

2.2.4.3. Earth Pits for Earthing and Lightning Protection Systems

Earth pits shall be based on High Conductivity Technology. In this technology of chemical earthing, a compound of high electrical conductivity shall be filled up in the space around the ground electrode, so that the earth resistance value would decrease appreciably. The high Conductive Compound shall be able to perform in any weather and soil Conditions and shall have following properties;

a) It shall have high electrical conductivity, which should remain constant and unaffected by changes in temperature & moisture.

b) It shall permanently remain embedded and should neither dissolve in and swept away by water.

c) It shall have an ability to absorb large amount of water and retain the same over a long periods of time.

d) It shall decreases earth pit resistance with passage of time.

e) Solubility: Shall be partly miscible; so that it does not dissolve fully like common salt and thus increasing the Earth Pit Life.

f) The pH value shall be near neutral so that it does not pollute soil or water and also does not corrode earth electrode.

g) It shall be maintenance free Compound so that there shall be no need of extra water pouring at regular interval as in conventional earthing material, because it should retain the moisture.

h) Chemical Compound shall be thermally conductive, in order to maintain a constant Earth resistance in temperature range of -50 to +60 degree Celsius.

i) The Compound shall have relatively High conductivity so that it can create very low resistance even in rocky areas.

j) It shall have low earth resistance, carries high peak current repeatedly.

k) It shall have a Long and reliable life.

l) It shall be easily installed in any soil conditions.

Minimum Electrode size shall be as per the latest amendments of IS:3043. Earth electrodes / plates for body earth, DG & transformer neutral, Instrumentation earthing and Lightning earth pits shall be selected as per the latest amendments / requirements of IS:3043.

All earth electrodes comprising an earth system shall be connected together with a continuous ring of earth tape. After installation, test shall be made to ascertain that the earthing resistance hereinafter specified is obtained. If the required resistance value cannot be obtained, a sufficient number of additional pipes shall be installed, until the resultant resistance not exceeding the specified value can be obtained.

In all cases the pipes shall be driven such that their zones of earthing do not overlap. Each earth electrode shall be connected to its associated earth tape through a linked connection. The link shall be installed as close to the earth electrode as possible.

Each earth electrode shall be enclosed together with the link in a reinforced concrete hand-hole with cast iron cover, which shall be set flush with the ground.

2.2.4.4. Earth System

The Contractor shall furnish and install a 75 x 8 mm GI strip as the main grid. The resistance between any point on each earthing system and the earth electrode shall not exceed 0.1 ohm. The overall resistance between the earthing installation and the general mass of earth shall be less than 1 ohm.

The main earthing bars shall be so placed that earthing terminals of major equipment and where required cable sheaths to be earthed, can be readily connected to them. Branch connections from the main earth bars shall be provided to all switchboards, power transformers, capacitors, Control Consoles, distribution boards, etc. The bonds shall be made to the cable glands on which the lead sheath shall be plumed and the armour clamped. All steelwork supporting electrical equipment shall be bounded to the main earthing bars.

The Sizes of GI earth bus and earth wires shall be as follows:

Main earthing grid	75 x 8 mm GI strips
Riser upto ground level	75x8 mm GI Strip
HT & LT switchboards, PCC/MCC panels, cable trays, LT motors above 30kW	40 x 6 mm GI strip
High Masts Earthing	40 x 6 mm GI strip
LT Motors > 3.7kW & upto 30kW	25 x 6 mm GI strips
Control desk/Panel, LDB, Weld socket	25 x 6 mm GI strips
Structures	25 x 6 mm GI strips
Lighting panels, Distribution Boards etc.	25 x 6 mm GI strips
LT motors below 3.7kW	8 SWG GI Wire
Junction boxes, field instruments, gland earthing Lighting fixtures, 15A switch sockets	8 SWG GI Wire
Air Conditioner	8 SWG GI Wire

Joints, termination, fixing of the earth bars and their protection from corrosion shall be in accordance with the recommendation given in the aforementioned code of practice subject to the additional requirements specified herein. GI tapes shall be secured at intervals not exceeding 1m by means of single-screw fixing purpose made gunmetal saddle of a pattern approved by the Employer. The tapes shall run in square and symmetrical lines. Links shall be provided in the system adjacent to all junctions to enable tests to be carried out from time to time. All links shall have high tensile steel bolts and the nuts shall be tightened by means of a torsion spanner. All joints in exposed sections shall be protected against moisture and corrosion by the application of two coats of anticorrosive paint and shall be taped with self-adhesive PVC tape.

2.2.4.5. Earthing of Equipment

a) All lighting panels, junction boxes, receptacles, fixtures, conduit etc. shall be grounded in compliance with the provision of I.E. rule.

b) Ground connections of sub-station and meter room shall be made from nearest available 75 x 8 mm ground grid. All connections to ground grid shall be done by arc welding.

c) Lighting panels shall be directly connected to ground system grid by two nos. 25 x 6 mm GI strip at two different locations.

d) A continuous ground conductor of 8 SWG G.I. wire shall be run all along each conduit run and bended at every 600mm by not less than two turns of the same size of wires. This conductor shall be connected to panel ground bus.

All junction boxes, receptacles, lighting fixtures, etc. shall be connected to this 8 SWG ground bus.

e) Earthing of High Mast light towers shall be done by connecting 2 nos. of 40x6 GI strip at two different places.

2.2.4.6. Lightning Protection System

Lightning protection system shall be provided for all the buildings and structures covered under the Scope as per the provisions contained in the latest issues of Indian Electricity Rules and IS 2309. Lightning protection system shall comprise of air terminations, down conductors, test links, earth terminations & earth electrodes.

Material for lightning protection conductor shall be as follows:

- 75 x 8 mm Galvanized steel strip for interconnection between the various earth pits and riser.
- 50 x 6 mm Galvanized steel strip for Horizontal Air termination & Down Conductors
- 20 mm dia 1000 mm long Galvanized steel rod for Vertical air termination
- 40 mm dia 3 m long Galvanized Steel pipe of 6mm thickness with earth pit for Earth termination
- 25 x 6 mm Galvanized steel strip for horizontal conductor on roof along the periphery on parapet wall.

Air termination network shall consist of vertical or horizontal conductors or combination of both. Down conductors should follow the most direct path possible between the air terminal network and the earth termination network. The down conductors should be arranged as evenly as practicable around the outside walls of the structure. Each down conductor shall be provided with a test link for testing. An earth electrode with treated earth pit shall be connected to each down conductor.

2.2.5 Lighting System

2.2.5.1. General

This specification covers design requirements, supply and installation of lighting system for the project including all buildings and structures.

All equipment and materials shall be suitable for the system voltage. All materials and works shall comply with IS code of practices, Indian Electricity Rules and regulations. The lighting system of particular area whether indoor or outdoor shall be designed in such a way that uniform illumination is achieved. As far as possible, dark spots shall be avoided. This requires careful placing of luminaires, selection of proper mounting heights and

provision of supplementary lighting, wherever required. The type of lighting adopted shall provide adequate level of glare-free illumination, without creating undesirable shadows. Design of lighting layout shall be based on the minimum lighting intensities at the working plane and the type of luminaire specified as under:

Location	**Average lux level**	**Type of Luminaire**
Approach and Pontoon Area	30	350W LED Flood Light, weather proof, Heavy duty High Mast light in die cast Aluminium alloy housing
Electrical Substation, Transformer, DG , Security Office, Sewage Treatment Plant, Waste Collection Center, Utilities area	200	General Purpose Industrial compact batten suitable for 2x20 W LED Tube Light fitted with Aluminium heat sink
Terminal Building & Control Room	300	34Watt LED Panel with ultra modern recess mounting luminaire suitable for armstrong/grid/POP ceiling complete with separate electronic driver & high brightness SMD LEDs
Electrical Substation, Control Room, Terminal Admin Building, Security Office, STP, Covered Shed, all exit / entry points etc.	10	Battery operated emergency lighting unit consist of aesthetically designed rechargeable 5 Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type & 5V DC Li-ion charger with 1 hour battery backup
Road Light	20	70 Watt LED with single / double arm 9 meter hexagonal GI pole with FRP J.B and required accessories

2.2.5.2. Luminaires

a) All luminaires shall be industrial/decorative type as specified. Where the specific type of luminaire is not indicated, the Contractor shall select suitable type of LED luminaires to meet the requirement. Special luminaires may be provided when required by the seeing task or architectural treatment. The number of different type of luminaires and their wattages shall be minimum consistent with the lighting requirements.

b) While using discharge lamps, stroboscopic effect shall be minimized by various methods, which should be considered while planning lighting installation. All fluorescent fittings shall be of rapid start type and shall be so arranged that the power factor will be 90% or higher.

c) All luminaries along with its terminal boxes shall have IP56 degree of enclosure protection for internal areas and IP65 degree of enclosure protection for external areas and battery room.

2.2.5.3. Emergency Lighting

For safety and protection of personnel and for shutdown of the equipment, battery operated lighting units shall be installed as a part of fixed wiring system. Battery operated lighting unit shall consist of aesthetically designed rechargeable 5 Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type with fully automatic

5V DC Li-ion charger, transfer switch to automatically transfer from main supply to the battery and vice versa. The charger shall be capable of recharging fully in 12 hours. The unit shall operate on 1 Ph 240 V 50 Hz. Emergency lighting shall be designed to ensure minimum 10 lux in all the areas to ensure safe evacuation of persons in case of failure of both mains and DG supply.

2.2.5.4. Lighting Installation

All installation shall be of rigid steel conduit executed to IS: 1653. Minimum diameter of conduit used shall not be less than 19 mm. Conduits shall be concealed wherever practicable. The number and size of wire in any conduit shall not exceed that stated in IS regulations. Not more than three (3) lighting circuits or two (2) socket circuits shall be bunched in the same conduit. The wiring from the lighting panel to the outdoor lighting fixtures shall be done by PVC armoured, 650/1100V grade cable. For control room lighting stranded Cu conductor shall be used. The minimum size of conductor shall be 2.5 sq. mm copper.

2.2.6 Switchgear

Design of the Switchgear shall be in accordance with the requirements of these specifications and the best current engineering practice, together with the following general requirements:

i) Switchgear shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire. Installation of timer in external lighting arrangement needs to be incorporated.

ii) All panels, boards, etc. shall be suitably labeled with labels of design approved by the Engineer.

iii) Equipment shall be installed indoor/outdoor in a hot, dry climate. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

iv) Maximum temperature rise in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in relevant standards. The de-rating, of the equipment shall be made taking 45℃ as an ambient temperature.

v) The rated peak short circuit current or the rated short time current carried by the equipment shall not cause:

- Mechanical damage to any part of the switchgear.
- separation of contacts
- insulation damage of "Current Carrying Part"

vi) Transformer primary circuit breakers and the secondary circuit breakers should be arranged for inter-tripping as follows:

- Tripping of transformer primary circuit breaker, either manually or automatically on fault shall intertrip the transformer secondary circuit breaker.
- Tripping of the transformer secondary circuit breaker on fault shall intertrip the transformer primary circuit breaker.
- Manual tripping of the transformer secondary circuit breaker will not intertrip the transformer primary circuit breaker.

vii) All controls shall be suitable for 240V AC / 110V DC.

viii) At least 20% spare with at least one number of each type of feeder shall be provided as spare on either side of the BUS for LT Panels. The spare feeders selected shall be with highest rating in the event of reoccurrence in same type.

2.2.7 Cables

2.2.7.1. Cable Selection Criteria

a) HT (11KV) Cables Fault level withstand KA:

- 1 sec. for Main incoming cables
- 0.5 sec. for outgoing feeder cables b) LV Cables Fault level withstand kA:
- 1 sec. for Main incoming cables from Transformer
- For outgoing feeder cables, withstand time based on fault clearance time of ACB/MCCB

b) Permissible Voltage drop in Cables:

- Transformer to Switchgear Busbars : 1%
- Switchgear, PCC to Motor : 3%
- Switchgear, PCC, ACDB, MLDB to Lighting DB (LDB) : 2%
- LDB to farthest lighting fixture In the circuit :- 2.5%
- Starting Voltage drop of Motor : 15%
- Running Voltage drop of Motor : 3%

c) Other factors to be considered:-

- Short circuit capacity to be considered while selecting HT cables
- Factor for Ambient temp. 45ºC
- Grouping Factor for Cables laid touching in single/ multitier racks.
- Grouping Factor for Cables laid Buried
- 10% reserve capacity in cable over the load current requirement.

The cable shall be laid on cable trays / in cable trenches in sub-station rooms. In some cases cables may also be laid buried.

2.2.7.2. Cable Laying and Terminations

The cables shall be laid using the following methods.

a) Laying direct in ground

b) Laying in pipes

c) Laying in Concrete trench

d) Laying in cable tray running along cable corridor

While laying the new cables or rerouting the existing cables, successful Contractor shall take all safety measures and manual excavation operations are preferred.

a) Laying Direct in the Ground

Laying and installation of directly buried cables in ground shall conform to the requirements of IS:1255. This shall consist of excavating suitably dimensioned trench in ground, and directly laying cable on a bedding of riddled soil free from potentially corrosive elements, or sand at the bottom of the trench encasing cable with half round cut pipes, covering cable with additional riddled soil or sand, and filling up the trench. Depth of laying and formation of cables shall be as per IS:1255. A minimum separation of 300 mm shall be maintained between power and communication cables.

b) Drawing into Pipes

This system shall consist of required number and size of double wall corrugated pipes conforming to applicable requirements of IS or BS with simplex joints. Conduits shall be completely enclosed in concrete. Clearance between conduits comprising a duct shall be 50 mm on the sides, bottom and top. Conduit joints in concrete encasement may be placed side by side horizontally but be staggered at least 15 cm vertically. Duct lines shall be laid to a minimum gradient of 1:300. Conduit shall be thoroughly cleaned before using or laying. Particular care shall be taken to keep the conduits clean of concrete, dirt and any substance during the course of construction.

The cable route shall be generally be indicated by painting the concrete slabs. Where ever applicable cable route markers circular in shape galvanized and route direction indicated by an arrow shall be provided. This system of cable laying shall be adopted while cable is to be laid across roads, railway lines, water ways, and in such situations where subsequent excavation of a trench is both expensive and inconvenient.

c) Laying in Concrete Trench

This system of cable laying shall be adopted inside electrical substation. Ladder type FRP cable trays shall be used for cables in the RCC trench. Successful Contractor shall prepare actual drawings as per the requirement and obtain approval from the Employer before executing the same.

2.2.8 Cable Trays and Fittings

The size of cable tray shall be to suit the cable requirement of the particular section. However, successful Contractor shall provide the number of cables and tray size required.

a) Design Requirements and Construction

Cable trays and accessories shall be Fibre Reinforced Plastics (FRP) as per NEMAFG 1 1984-1993 with minimum thickness of 3mm upto 200mm width and 4mm above that. Horizontal rung spacing shall be 250mm.

Cable trays shall be in piece length of 2.5 meters. Tray ends shall be connected to either other straight tray or horizontal elbow, vertical elbows, Tee, cross, reducer etc. by using coupler plates. The bending radius on minor side of bends shall be 600 mm. Bends of lesser/bigger radius shall be made if warranted. Cable trays shall be supplied complete with side coupler plate and necessary nuts and bolts. Required number of reducers, bends, crosses, tees shall also form part of the supply.

To facilitate assembly, all accessories at ends shall have 100 mm straight portion. The width and length of trays and accessories shall be within a tolerance of $\pm$3 mm. The Contractor shall have to secure racks and supports by suitable methods on available building/structural steel and the required accessories shall

form part of the supply. In some areas, the Contractor may have to secure the supports on wall, ceiling or floor by suitable anchoring.

Fifty (50) percent spare space shall be provided in the cable trays, racks and risers.

All welded joints shall be smooth enough to provide a good appearance and shall not cause any injury to working personnel or any damage to the cable laid directly on it. All welding work shall be carried out by electric arc welding method only. Necessary welding sets, all consumables etc. to be arranged for the Contractor.

Successful Contractor shall prepare the actual drawings as per the requirement and obtain approval from the Employer before executing the same.

b) Cable Clamps

Trefoil clamps for single core cables shall be pressure die cast aluminium (hot galvanized) or fibre glass or nylon "claw" type and shall include necessary fixing accessories like GI nuts, bolts, washers etc. Trefoil clamps shall have adequate mechanical withstand capability in case of a fault and shall be tested and proven type. For clamping the multicore cables self-locking, de-interlocking type nylon clamps shall be used.

c) Cable Glands and Lugs

Double compression type tinned, of coating thickness 20 microns, brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof sealing. Rubber components used in cable glands shall be neoprene or synthetic rubber and of tested quality.

Cable lugs shall be tinned copper of approved design/make, solderless crimping type conforming to IS. Cable lugs for control cables and special cables shall be suitable for copper cable. Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided on the equipment. Crimping tool used shall be of approved design and make.

2.3 Firefighting

2.3.1 General

Fire Detection & Protection system is provided to meet following requirements:

a) To detect Fire Situation

b) To Protect - Control and Extinguish Fire.

An effective Fire Detection & Protection System results in minimizing the loss of property, human-life and downtime. The system is proposed for the following

a) Transformer Area

b) DG Room Area

c) Switchgear & Control Room

d) Office Room

e) Ticketing Room

f) Store

g) Pathway to Pontoon

h) Pontoon

GENERAL CONDITIONS

ENVIRONMENTAL CONDITIONS

Electrical Equipment Design temperature 40 ℃

ELECTRICAL NETWORK DATA

Auxiliary power supplies

LV AC power supply:

- Rated Voltage 415/240 V AC
- Variation Range ± 10 %
- Rated Frequency 50 Hz +5 %
- Earthing Mode Solidly Earthed

DC Power 24 V DC

System Description

Fire Detection, Alarm and Control System

The fire detection, alarm and control system are proposed to consist of different types of fire detectors, fire alarm panels, repeater panel (in electrical room), local panels etc. Panels It shall be microprocessor based, analogue addressable type.

Fire Detection System

The system is suitable to detect the presence of fire's smoke / heat in the room or around the equipment. Following are the fire's smoke / heat detectors:

Ionization type Smoke Detector is proposed for automatic water sprinkler / Inert gas system in (a) Office room, Ticketing Room, Meal room, Security room, Store Electrical room, Control & switchgear room to be installed below the ceiling or below the false ceiling, as the case may be, depending on civil design

Quartzoid bulb heat detection system is proposed to be provided for 11/0.415kV Transformer protected by HVW spray.

Electrical type Heat Detector is proposed for Battery Room.

Manual Break Glass Boxes is proposed to have a push button element kept in pressed condition by the glass fitted in the front of the box. Break glass boxes shall be used as manual call points.

a) Fire Alarm System

The Fire alarm panel, which monitors the smoke / heat detectors line, fire / fault

condition in the “building (Office, Ticketing room, Electrical room, Store, etc.) & Transformer area, DG room, Control & Switchgear room, Battery room, etc.” is proposed to be provided. The Fire alarm system consist of following

Hooters, in the event of fire, shall raise pulsating audio alarm and lamp shall flash.

The panel is also proposed to consist of solid circuitry on a printed circuit board, a loudspeaker and flashing lamp housed in weatherproof dust tight, wall mounted type enclosure. Fire Alarm Panel and operate with DC supply.

Siren shall be industrial type of 2.5 km (min) against the wind direction.

In case of any Multi Sensor Detectors or Manual Call Points being actuated a signal is transmitted to the Fire Alarm Panel which in turn actuates an Audio / Visual alarm in the Fire alarm panel and simultaneously initiate the signal for external hooters at the various places - such as on Pontoon, Pathway to Pontoon, Security room, control & Switchgear room, etc.

b) Control System

The control system is proposed to be provided to offer total flexibility for effective fire protection operations on the Pontoon; pathway to Pontoon; Building; Auxiliary area. The system shall enable control / operation of all systems from the electrical-room (except the hydrant valves).

c) Cables and Wires

The cables are proposed to be braided sheathed and laid down in suitably sized conduits, electrical tubings, metal moulding or metallic race ways and shall offer protection against fire and mechanical injury as per relevant standards and specifications. The use of wire nut type construction for wiring shall be prohibited. Screw terminal boxes shall be preferably used. All the cables and wires shall be suitably tagged for proper identification by colour bands and by ferrules at junctions respectively.

d) Public Address / Talk Back System

The public address & talk back system proposed for the Pontoon, Building, etc., shall consist of a main communication console located in the control room and speaker / talk back units located along the above said area. The spacing proposed is two nos., one at FWPH, and one every 100 meters on the approach trestle.

Fire Protection System

Fire protection layout and Fire protection scheme are described in drawing numbers “P.013223-P-20318-251 & 252” and “P.013223-P-20318-250”.

Fire protection systems of following types (as applicable) is proposed to be provided.

- Water Filling Arrangement
- Jockey pumps and Hydro Pneumatic Tank
- Hydrant system and Water Spray system

- Inert gas system
- Portable fire extinguishers
- Piping layout and schematics

a) Water Filling Arrangement

Firefighting water storage tank is proposed to be filled by water drawn from Primary sump. The water-filling pump-motor sets shall be of two Nos (One main and other as standby) of vertical type, each of approximate 145 m^3/hr capacity.

Filling water from the primary-sump to fire-water-storage-tank is proposed to be filtered and thus routed through the duplex-filter, necessary piping, valves, fasteners and instruments, as required, shall be provided

This fire water is proposed to be drown from water storage tank through a set of fire pump-motor sets each of 137 m^3/hr @ 7 kg/cm^2. The fire water is proposed to be discharged through hydrants & piping distribution system.

The water storage tank is proposed, as per NFPA 15 Clause 4.3.3.1.3, for one (1) hours water supply for the single largest hydrant.

The fire-water-storage tank is proposed to have level switches for automatic starting and stopping of fire pumps provided in primary-sump. When the water level in the water-storage tank goes beyond the pre-determined level then the water level indicator drives the signal to the panel and thereby stopping the operation of primary pumps.

b) Jockey pumps and Hydro-pneumatic tank

Pressurization of water feeding lines/mains of both (1) hydrant system and (2) water spraying / sprinkling system is proposed to be done through the combination of hydro-pneumatic tank and Jockey pumps, of 15m3/hr capacity, two (2) numbers (1 working and 1 stand-by, both electric motors driven) and air compressors (2x100% capacity, 1 working and 1 stand-by, both electric motors driven).

Hydro-pneumatic (HP) tank is proposed to be filled up with water up to 2/3rd portion of its height. Air space will be kept above the water-filled portion. The HP tank will be equipped with necessary level switches and pressure switches and other instruments as required. Minor leakage in the pressurised fire water system will be replenished from hydro-pneumatic tank. When the level of hydro-pneumatic tank will be low, jockey pump will be started automatically to replenish the level of water in the tank. Jockey pump will be cut-out automatically when the level of water in the hydro-pneumatic tank reaches its higher pre-determined limit. Pressure switches provided in the hydro-pneumatic tank will be inter locked with the cut-in / cut-out operation of compressors, which will be used to maintain a constant pressure in the hydro-pneumatic tank.

In the event of fire, pressure in the hydrant or spray system will drop due to water flow. In this event, water loss in the system will be replenished by jockey pump. However, if this is inadequate to meet the demand and results in drop in pressure

further to pre-set low pressure in the mains, first electric driven pump of the respective system will start automatically. In case of failure of starting of fire pump or due to increased demand of flow, the system pressure will reduce further, this will enable starting of subsequent (second) fire pumps in a sequential manner through means of various pressure switches. Failure to start the fire pump will be indicated as an alarm.

c) Hydrant System and Water spray system

The System comprises of a reliable source of water supply; network of pipe, combination of underground and above ground piping throughout the project. The system includes Hydrant arrangement, water mains network, hydrant valves, landing valves at each landing locations, water monitors. Hose cabinets with hoses, branch pipes, nozzles, hose boxes, central hose houses etc, at strategic locations.

The Hydrant system, along with Hose Reel and wet riser, is proposed to be provided for the complete project, including at least the following:

- Transformer (Oil Type) area
- DG set / Switchgear Rooms and Control rooms etc.
- Around Building area
- Pontoon Area
- Pathway to Pontoon

The hydrants shall be preferably double-headed type mounted on a 150 NB (Nominal Bore) dia. stand post connected to the fire mains. Each stand post shall be provided with an isolating valve & orifice plate and a Hose box.

Hose box containing 2 Nos hoses (each of 15-meter-long & 63 mm size) branch pipe and nozzle is proposed to be provided along with hydrant valve on each Pontoon, Pathway to Pontoon, around building area, around auxiliary equipments / rooms.

Fire hydrants shall normally in closed position & can be opened manually during occurrence of fire. Whenever there is a fire, the number of hydrant-valve is to be opened and depending upon the magnitude and location of fire. In this case water is directed towards the seat of fire through the hoses and branch pipes.

Line pressure will continue to drop due to opening of hydrants / monitors. The amount of water required will be catered from the storage water tank through fire pumps.

d) Sprinkler System

Automated water spray through sprinkler system comprises of network of underground and above ground piping, control valve, deluge valve), sprinkler bulbs, nozzles / projectors.

This system is proposed for Office, Security room, Baby Care room, First-aid room, Dining room, Shop, Janitor room.

e) High Velocity Water Spray (HVWS) System

Water spray systems are most commonly used for locations where liquids with flash point of 65 degree C and higher constitute fire hazard. Typical example here is Oil-Type Transformer.

The system comprises of network of underground and above ground piping, control valve, deluge valve,HVW Spray Nozzles / Projectors.

In HVWS system the deluge Valve which is normally in closed position. Whenever the fire breaks down and temperature around the protected equipment goes beyond the temperature rating of Q.B. detector (79 ℃), installed around the equipment), then Q.B. detector will collapse, and it reduces the pressure in the detection line by draining the water, which results in opening of deluge valve and water will rush to spray water network, through the opened Deluge Valve. The DV operation makes the diaphragm in action to spray the water on protected transformer. Deluge valve shall also be provided with a local panel for manual electrical operation.

In addition to above, HVWS system will also be actuated by Transformer PRD (Pressure relief device) status from transformer marshalling box by the transformer manufaturer. If PRD in transformer reaches its predefined set pressure, FAP will receive this signal through DV panel. FAP will give command to solenoid valve of DV through DV panel for spraying through its respective control module. Operation of DV shall initiate unit shut down through command from control system.

Water motor alarm gong shall be provided to sound a continuous alarm while spray system is in operation.

Deluge Valve shall be manually reset to initial position after completion of entire operation. Each deluge valve shall be provided with a local panel for manual electrical operation of valve.

Butterfly valve with limit switches are provided on the inlet and outlet of DV for isolation at the time of maintenance. These valves shall be normally open. Gate valve shall be provided at bypass line.

f) Inert gas-based Fire Extinguishing System

This system is proposed for Control and Switchgear room, Electrical room, Ticketing Room.

This system comprises of gas cylinders, piping and control system. The inert gas (Nitrogen, etc), as recommended in NFPA 2001, is released in a controlled manner to dilute the oxygen content and consequently to control fire.

g) Portable Fire Extinguisher

Portable Fire Extinguishers, fire suit and first aid box are proposed to be provided, as per NFPA / LPA guidelines, at all strategic points of the building / DG Set &

Transformer Area / Electrical Room / Battery Room / Pathway to Pontoon/ Pontoon, etc..

h) Piping Layout and Schematic

Piping for all the protection systems will generally be laid over ground, on RCC pedestals, except in locations such as road or in main plant area where it may not be feasible to route over ground.

3 GENERAL REQUIREMENTS

3.1 Site Acceptance and Mobilization/Demobilization

3.1.1 Acceptance of Site

In accordance with these specifications, the Contractor shall have examined the site and familiarized himself with all existing conditions. He shall accept the site in its existing condition at the time of award of contract.

3.1.2 Mobilization

Upon award of the Contract and within a reasonable time but not exceeding 1 month the Contractor shall mobilize all such labour, equipment and materials that are necessary to complete the Project in due time.

3.1.3 Demobilization

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

3.1.4 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.

3.1.5 Permits and Licenses

Except as expressly stated in the Employer's Requirements, 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. The Contractor shall also give the Employer a copy of all relevant correspondence and other documents relating to the Contractor's permits and licenses.

3.2 Temporary Works

The Contractor shall design, install and maintain all temporary facilities required for the construction of facilities under this Contract, 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 plan for temporary works to the Employer/Employer's Engineer, for approval, within 30 days of award of the Contract.

Temporary construction shall be adequate for intended uses and for all loads imposed without excessive settlement, deflection or deformation. All parts and members shall be properly strengthened to prevent displacement or failure.

Before or upon completion of work, unless otherwise required or directed, preparatory structures, installations and utility services shall be disconnected and removed from the Site.

3.2.1 Utilities

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.

3.2.1.1. 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.

3.2.1.2. 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 additional Project requirements.

The Contractor shall make his own arrangements as outlined hereunder: Distribution of adequate capacity for power, lighting and other construction needs.

As necessary to properly and safely perform work at enclosed spaces or under hazardous conditions. Likewise, providing lights for night work/ protection as necessary.

Temporary electrical systems shall comply with the local codes and regulations.

3.2.2 Waste and Rubbish

The Contractor shall provide regular daily clean-up and removal of trash, waste, scraps, construction debris, etc. from site and temporary work yard and shall arrange for disposal of waste and rubbish to disposal areas approved by the Employer/Employer's Engineer.

3.2.3 First Aid and Fire Protection

3.2.3.1. 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.

3.2.3.2. Fire Protection

The Contractor shall establish and submit the following measures to the Employer/ Employer's Engineer..

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 sterilized materials for first aid treatment of minor injuries at the Contractor's Site Office.

3.2.4 Construction Safeguards

3.2.4.1. 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. Specific care has to be taken by contractor to protect the existing embankment works. Any damage to existing embankment works due to excavation will have to be made good and reinstated as per original condition by the Contractor at no extra cost to the Employer. The Contractor is obliged to take adequate and appropriate measures to prevent flooding at site, any damages arising due to flooding shall be rectified by Contractor at no additional cost to Employer. protected by barricades or railings.

3.2.4.2. Access

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

3.2.4.3. 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.

3.2.5 Protection of the Public

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

3.2.6 Contractor's Laboratory & Equipment

The Contractor shall provide site laboratory in order to carry out the specified tests. This laboratory shall be completely staffed and properly equipped to the satisfaction of the Employer to carry out the tests as specified.

The Contractor's site laboratory shall be available for the use of or inspection by the Employer as required by him. The Employer may require his representative to be present at any test and at any time during the working hours of the laboratory.

The Contractor shall furnish and maintain the laboratory, apparatus and supplies necessary to permit execution of the tests required by the Specifications. The Contractor shall submit to the Employer for his approval, within 28 days after award of work, a complete list of the equipment, apparatus and supplies he proposes to furnish the laboratory. The list shall include the manufacturer's name and descriptive literature.

List of instruments, tools & tackles required for Material testing laboratory /QA facility at project site to be submitted by the Contractor for Employer approval.

3.3 Submission of Documents During Project Execution

3.3.1 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 showing the various activities of the Work using MS Project along with a detailed Work Breakdown Structure (WBS).

- 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.

3.3.2 Work Schedules, Survey Data & Drawings

The Contractor shall prepare and submit construction schedules, 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 two sets of paper prints, maximum size 610 mm x 810 mm and on CD (in AutoCAD format).

3.3.3 Maintenance Plan

3.3.3.1. 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.

3.3.3.2. 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.

3.3.4 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 labourers 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 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.

3.3.5 Design & Drawing Submissions

3.3.5.1. Design Submissions – 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 and submit the same for approval to the Employer/Engineer. Detailed Engineering shall be done by the Contractor. 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 Employer/Engineer, without submitting such revised designs and drawings for the review of the Employer.

The Contractor shall submit for the approval of the Employer, progressively from the date of receipt of the Letter of Award, Five (5) copies of the following:

- Layout of Terminal
- General arrangement of all structures
- Cross sections and other details showing important particulars such as overall dimensions, clearances, etc.
- Specification/catalogues of all standard bought-out items.
- All drawings other than shop fabrication/manufacturing drawings. These will include, but not be limited to assembly, sub-assembly, key components, etc. However, one week prior to fabrication, fabrication and part drawings shall be made available to the Employer.
- Power Requirement (installed and peak demand loads)
- Wiring drawings and equipment inter-connection diagrams of local control panels & Single
- Line Diagram of facility power distribution.
- All detail design calculations pertaining to all structures and works but not limited to pontoons, firefighting, plumbing, terminal building, linkspans, dolphins and all other works that form complete scope of works.
- A further digital copy (in AutoCAD format) of the submission shall be given on compact disc. This digital copy shall include the full submission with scanned copies of any documents prepared by hand.

The list of submission will however be discussed with the Contractor after the award.

3.3.5.2. Submission of Calculations

All calculations submitted for the Employer's approval shall comply with the following:

a) Each calculation page shall be uniquely numbered.

b) 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 Standards, books and drawings which are the basis of the calculations.

c) Each section of calculations shall have a Table of Contents, including page numbers.

d) Calculations shall be accompanied by all necessary sketches or extracts from drawings.

e) 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.

f) Equations and values from International Standards and Codes of Practice are to be clearly referenced which are used in the design shall be attached to the submission.

g) Where values used in the calculations are brought forward from previous calculation pages, the page reference shall be included.

h) At the end of each section there shall be a summary, listing the conclusions of the calculations, and referring to construction drawings.

i) 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.

j) All calculations shall be signed / initialled by the designer and design verification engineer.

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

3.3.5.3. Submission of Drawings

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

a) All drawings shall be in metric millimetre dimensions and be finally prepared in ink with legible lettering on either A0 1189mm x 841mm using AutoCAD format compatible with AutoCAD 2014 or lower version. The submitted prints shall be clearly legible throughout and there shall be no ambiguity.

b) All drawings shall be submitted in digital format on compact disc, as well as three paper prints.

c) Drafting Standards employed in the preparation of all drawings shall be sufficient to produce legible 297mm x 420mm (A3) reduced drawings.

d) 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.

e) 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.

f) All drawings shall clearly identify the drafts-person responsible together with the identity of the drawings checker.

Each drawing shall show the scale(s) of the components illustrated by the drawing related to the original drawing size, A0, A1, A3 etc.

3.3.5.4. Inspection of Drawings at Site

The Employer shall have the right at all reasonable times to inspect all drawings

at the premises of the Contractor or call for any drawing to be given to Employer's office.

3.3.5.5. Manuals and Technical Data

a) Manuals

The Contractor shall supply Five (5) hard copies along with One (1) soft copy (in editable format) of Erection & Installation Manuals, Operation Manuals, Spare Parts Manuals and Inspection and Maintenance Manuals prior to the starting of erection. Recommendations of the manufacturer in respect of preventive maintenance, trouble shooting, and breakdown maintenance and over haul shall be brought out in the inspection and maintenance manuals. Soft copies of all drawings shall be supplied.

Operating instruction manuals shall be provided at the time of shipment with adequate information pertaining to the following:

i) Programming procedures; System specifications;

ii) Electrical power requirements; Expansion of internal fault diagnostics; Troubleshooting procedures;

iii) Powering up procedures;

iv) Shut down procedures

b) Technical Data

i) On completion of the works and before handing over possession to Employer, the Contractor shall supply Five (5) hard copies together with One (1) soft copy of the following:

ii) Shop drawings of all wearing parts and also major assemblies and minor assemblies which require unit replacement;

iii) All "As Built" Drawings of equipment, civil / structural, electrical items etc.

iv) ii) Complete technical data and dimensional drawings of all bought out product/ items in the system, shall be furnished - Six (6) hard copies together with One (1) soft copy of the following:

v) List of recommended spare parts.

vi) Parts catalogues in the case of all equipment /assemblies illustrated with part numbers in drawings both for electrical and mechanical items.

3.3.5.6. Tools and Maintenance Equipment

A list of complete set of tools/tackles and instruments required to be provided for satisfactory maintenance of the Works shall be furnished.

3.3.5.7. Maintenance Plan

The Contractor shall prepare maintenance plan covering all aspects of the works for the review of the Employer as per the requirement of this tender document. This plan shall be prepared to ensure that the design life periods stated in Tender are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life. Contractor shall also furnish list of estimated manpower required to perform monthly plan.

3.3.5.8. As Built Drawings, Design and Final Construction Report

Before submitting a request for Taking over Certificate, the Contractor shall ensure that it has furnished to the Employer all required documents including but not limited to two (2) sets of as-built drawings, final design in the supporting of as-built drawings and a final construction report as draft. And within thirty (30) calendar days after receipt of comments from the Employer, the Contractor shall submit five (5) sets of the Final Construction Report and five (5) sets of Final As-built drawings & Design documents. As-built drawings of the works consists of two (2) sets of original size copies (white print) and six (6) sets of bound copies reduced to A3 size. All documents and drawings shall be also delivered on CDs (drawings in Auto-CAD format, documents in other required formats and soft copy of the file used in software on which design was carried out).

Before submitting a request for Taking over Certificate, the Contractor shall ensure that it has furnished to the Employer all required documents including but not limited to five copies of manuals for installation, commissioning, operation and maintenance and the drawings/ documents etc., 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. In the event the Contractor makes any changes effecting such submission the Contractor shall submit afresh such document duly revising to that extent.

3.4 Quality Control and Assurance

3.4.1 General

The Contractor will be required to adopt a system of self-certification in accordance with his general quality plan and the appropriate detailed quality procedures. The quality system shall comply with Standards of ISO 9001.

The Contractor shall monitor his performance of executing his Works against two levels of certification:

The completion of individual work items

The completion of activities listed in the Programme.

In addition to the certification of the completion of work items and activities, the Contractor shall be required to issue the Quality Assurance (QA) certificates concerning the Quality Plan, Quality Procedures and Construction Documents.

The Employer may monitor the Contractor's work against the Contractor's Quality Plan and Quality procedures. The Employer may do this by spot checks, and/or by continuous monitoring of the work. The Employer may also do this by carrying out compliance audits periodically against the Contractors Quality Procedures. The frequency and intensity of such checks will depend on the proven reliability of the Contractor as work progresses. Each non- compliance with the Quality Plan shall be notified promptly to the Employer by the Contractor, together with proposals for remedy of the non-compliance. The absence of monitoring of or commenting on quality aspects as above by the Employer shall not absolve the Contractor from any of its contractual obligations and/or shall not entitle the Contractor for any claim.

3.4.2 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 currency of 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 terminating the Contract. In addition to termination of contract there shall be recovery amount from contractor.

3.4.3 Quality Plan and Quality Procedures

The Contractor will be required to submit his complete General Quality Plan to the Employer within four weeks of the Commencement Date. A designer's quality plan will be accepted as an interim measure to permit design work to be started in advance of the preparation of the General Quality Plan.

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.

3.4.4 Submission and Certification of Construction Documents

The Contractor shall submit a Design Certificate (in duplicate) and Design Check Certificate from proof check consultant of the Contractor whenever the Contractor is submitting Design and Construction Documents to the Employer for review. Construction Documents submitted without the relevant Design Certificates 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.

3.4.5 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 that 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 currency of 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 the 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.

3.4.6 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.

3.5 Field Surveys, Studies and Investigations

3.5.1 General

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

The Contractor may 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.

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.

3.5.2 Setting Out

After taking the possession of site, the Contractor should establish permanent benchmark near the entrance of terminal as per the norms of survey of India after taking 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.

3.5.3 Hydrographic Survey

3.5.3.1. General

Hydrographic surveys shall be performed by using Multi beam echo sounding equipment and an electronic Differential Global Positioning System (DGPS), both with an accuracy

which ensures that the requirements of the Contract are achieved. These surveys shall only be carried out if weather and river conditions, condition of equipment and methods of execution and interpretation are, in the opinion of the PMC Engineer, satisfactory for this purpose. The PMC Engineer or his Representative may resolve to check echo soundings by means of other methods to measure water depths, such as sounding poles or lead lines. The PMC Engineer may also order calibration checks of the equipment as and when considered necessary. The CONTRACTOR shall cooperate in this respect and supply any manpower, boats and equipment that may be reasonably required for this verification. The position, whether determined by electronic or optical methods, should be regularly checked by reference to onshore transit marks at some point along the survey line.

3.5.3.2. Scope of hydrographic survey

The hydrographic survey shall be carried out to the accuracy described in this specification based on WGS-84 Datum using UTM coordinate grid. The hydrographic survey is required to identify and record the water level and riverbed levels. Survey shall be carried out in an area of 500m X 500m with a grid spacing of 25m covering the Jetty area and approach area. The survey shall be extended towards the landside point until the water line is obtained to record water depths of at least 1.5m during the survey period.

3.5.3.3. Calibration of Sounding Equipment

Echo sounding equipment shall be checked and calibrated at least daily before and after use, by means of a bar or plate suspended at known depth below the water surface. Checking shall be performed at the actual location of the survey and the PMC Engineer may require additional checks during surveying. Adjustments to the recordings/readings taken shall be made accordingly. Records of bar checks shall be retained at the start and end of the echo sounder record for the day of survey. The echo sounder should maintain a repeatable accuracy of better than 10 cms. In case of Multibeam Echo sounder, a calibration procedure (Patch Test) shall be integrated with sub systems prior to actual survey.

3.5.3.4. Field Books

All field books, calculations, maps, original records, survey tracks and as-run plots etc. of all survey activities shall be kept on site available for the PMC Engineer study or checking for the duration of the Contract.

3.5.3.5. Accuracy of Surveys

The accuracy of surveys in the horizontal plane, related to the relevant triangulation stations for the projects should be within 1.0m. The accuracy of surveys in the vertical plane includes:

• The echo sounder which should maintain a repeatable accuracy of better than 10 cm for measurements of distances between seabed and survey vessel waterline.

• The registration of water levels by means of temporary tide gauges which should be within 5 cm. The water level plane between the tide gauges and the survey location can be assumed horizontal.

Survey Track lines on consecutive surveys should be sailed in the same direction. The survey lines shall be run at 20.0 m so as to have an overlap of minimum 20 m in between the lines for better accuracy. The coverage shall be managed in such a way to provide 100% in sonification of the Seabed. If at the end of the survey any gap is observed, additional survey lines shall be run to fill up the gaps.

However, the Sounding grid shall be followed as shown on the drawings.

All specified surveys shall be carried out jointly by the CONTRACTOR and the PMC Engineer/Owner.

3.5.3.6. Digital recording and plotting

Interpretation of echo rolls, reduction of sounded depths for tidal heights obtained from tide gauges, corrections for squat and wave motions (to be made using appropriate observed data and/or compensating devices) and definition of bottom levels on the echograms are to be done to the satisfaction of the PMC Engineer. Each fix on the echo roll shall be annotated on the track plot chart of the survey vessel, and there should be at least one fix for every 10 m of cross section or as approved by the PMC Engineer and the interpreted data shall be plotted.

3.5.3.7. Tide gauges

The CONTRACTOR shall, at the commencement of the Contract install one number automatic self- controlled and self-recording tide Level Gauge to monitor and measure continuously the tides with respect to the Chart Datum at an approved location near the shore and maintain and keep daily records of the tide levels throughout the Contract period. These gauges shall be placed and calibrated at least 15 days before sounding is foreseen to commence. The area where the tide gauges are to be installed shall be properly illuminated. The existing two tide gauges are required to be operational. The Tide Gauge installed by the CONTRACTOR shall continue to remain with the OWNER even after completion of the project.

3.5.3.8. Reduction of sounded depths

The CONTRACTOR shall place special stress on the accurate reduction of sounded depth in relation to the prevailing tidal levels.

All the drawings shall be plotted on 1:2000 scale or as specified by the PMC Engineer and these shall be constructed on UTM or WGS84.

On completion of the survey, the CONTRACTOR or the external agency shall prepare within 72 hours, survey charts and cross sections showing the full results of the survey. Drawings in Auto-cad should be submitted in soft and hard copies. On completion and agreement of the contents of the drawings, the CONTRACTOR, PMC Engineer/Owner and Hydrographic Surveyor of external agency, in case survey conducted by external agency shall sign the drawings, which shall form the basis for all the further measurement of the works undertaken in the course of the Contract.

3.5.4 Geotechnical Investigations

3.5.4.1. Scope

The scope of geotechnical investigation includes the following for the purpose foundation design for the jetty structures and terminal building.

- 15 number of geotechnical boreholes covering Dolphins at Berthing pontoon and Intermediate pontoon, bankseat and terminal building area to a minimum termination level of -10.0m with respect to MSL or upto the refusal.

The detailed scope of work for each bore includes the activities as specified below:

1. Mobilization of jack up barge, drilling rig, other rig, other drilling tools and accessories including personnel for carrying out Geotechnical investigation work.
2. De-mobilization of jackup barge, Drilling rig, other drilling tools & accessories and personnel for carrying out Geotechnical investigation work.
3. Setting up of jack up barge at each borehole location as per the location coordinates provided by PMC
4. Boring through soils of various strengths
5. Drilling through all kinds of weathered rock, and hard rock
6. Collection of 90mm / 100mm dia meter, 450mm long undisturbed samples from bore holes and sealing the tube with molten wax.
7. Conducting standard penetration test (SPT) in soil
8. Laboratory Experiments and studies
9. Preparation and submission of factual report during the progress of boring and testing in draft form for comments.
10. Preparation and submission of geotechnical investigation report including detailed results of laboratory studies, recommendation for foundation design etc for comments and incorporating the same and final submission.

3.5.4.2. Technical Requirements

A. Boring / Drilling and Rock Coring

The activities comprise of borehole drilling and either

a) In-situ testing in borehole and

b) Sampling and sample handling.

Boreholes of 150mm/100mm diameter boreholes in soil using open hole rotary drilling rig may be undertaken. In case rock is encountered, rock core drilling using diamond bit with double tube NX size core barrel and N type drill rod shall be undertaken. The borehole will be terminated at specified depth below the existing seabed level. The measurements for core recovery, RQD, weathering index, fracture index shall be carried out at site.

Typical borehole drilling apparatus shall have the various components as minimum.

a) Drilling equipment: Any equipment that provides a suitable clean open hole before insertion of down hole sampling and / or testing apparatus and ensures that sampling and / or testing is performed in undisturbed ground.

b) Drill Rig: Machine capable of providing rotation, feed and retraction, to drill pipe casting and or auger. Drill fluid pumping capacity shall be as required to promote return of drilling fluid.

c) Drill casing: cylindrical pipe with one or more of the following purposes:

i. To support the sides of the boreholes.

ii. To support drill pipe above ground surface in case of over water drilling

iii. To promise return of drilling fluid.

d) Drill pipe: Cylindrical pipe connecting drill rig and drill bit.

e) Drill Bit: Device attached to drill pipe and used as cutting tool to drill into the ground.

i. Core drilling is a ground investigation technique comprising simultaneous drilling and sampling.

ii. Core bit: Device attached to the core barrel and used as a cutting tool to drill the ground.

iii. Core catcher: Device that assists retention of core in the core barrel.

iv. Core Box: Box with longitudinal separators for the protection and storage of core.

B. Sampling

The description of the sampling apparatus is as follows:

a) Push sampling will be undertaken in highly sensitive clays or is the clay encountered is soft to firm is accomplished by

b) Sampler insertion equipment: apparatus providing relatively rapid continuous penetration force.

c) Reaction equipment: reaction for the sampler insertion equipment

d) Sampling rods: Rods that connect the sampler insertion equipment to the sampler head.

C. Conducting standard penetration test (SPT)

The standard penetration test shall be conducted as per the general specification suggested by IS/BS code of practice. The test shall be conducted using auto trip SPT set at specified interval of 1.5m at a depth where there is a stratigraphic change, whichever occurs earlier. SPT shall be terminated on recording 100 blows per 30cm or less penetration for three consecutive tests. The disturbed samples obtained from the split spoon sampler shall be visually classified, labeled for identification and reserved for laboratory testing.

D. Sampling Requirement

The feasibility of a particular laboratory test relates to the sampling practice and sample handling for a particular soil and depends on factors such as soil type, available amount of sample material and sample quality. The adopted classification system for sample quality is according to IS and BS standards. The classification system recognizes 5 classes on the basis of feasibility of these classes is as follows:

a) Class 1: undisturbed: Strength, stiffness and consolidation.

b) Class 2: undisturbed: permeability, unit weight, boundaries of strata – fine.

c) Class 3:disturbed: sequence of layers

d) Class 4: disturbed: particle size analysis, Atterberg limit, boundaries of strata – broad.

e) Class 5: disturbed: sequence of layers.

f) The higher class includes laboratory tests of the lower class.

g) This is to assist in Geotechnical classification, identification and description of strata.

E. Factual Report

The factual report shall include an introduction outlining the objectives of the investigation, description of the procedures followed for carrying out the various field and laboratory works, equipment used, ground conditions encountered and the generalized soil profile obtained from findings of field and laboratory investigations. Engineering properties of soils shall be described in detail along with specifications, codal provisions and some engineering practice.

3.5.4.3. LABORATORY TESTS

The minimum laboratory tests to be conducted on soil and rock samples collected at each bore hole shall be as given below:

a) Particle size distribution

b) Atterberg's limits

c) Specific gravity / particle density

d) Bulk density

e) Sedimentation / hydrometer analysis

f) Chloride content, soluble sulphates, carbonate content

g) Natural moisture content

h) Tri-axial compression test – (Consolidated Un-drained)

i) Tri-axial compression test – (Unconsolidated Un-drained)

j) Direct shear test

k) Uniaxial compression test – rock sample

l) Point Load Test – rock sample

3.5.4.4. Deliverables

Following shall be minimum deliverables.

a) Daily Field report including calibration of the devices and duly signed by Field PMC Engineer and PMC Engineer.

b) Actual executed bore hole shall be plotted on the bathymetry chart with coordinates and submitted separately both in hard and soft copy in AutoCAD format.

c) Geotechnical Investigation report including interpreted data including all laboratory results.

3.5.4.5. REPORT FORMAT

The geotechnical report shall be submitted as draft for review. Final report shall be submitted incorporating the comments from PMC Engineer. The report shall contain the minimum as follows.

a) Descriptive geology of the area

b) Bore hole data (raw) and interpreted based on relevant Indian Standards

c) Description of each soil strata indicating color, consistency, grading in accordance with Indian Standards for soil classification.

d) Laboratory test results

e) Geotechnical soil profile along the jetty structure area and terminal building area

f) Soil characteristics including design strength for each bore hole strata

g) Soil strength includes SPT value, angle of internal friction, density, subgrade lateral soil modulus, modulus of elasticity of soil, undrained shear strength etc shall be provided for each soil layer either by direct testing or by interpretation from relevant literature.

h) Pile (Bored cast in-situ RC pile) axial capacity chart prepared for 1000mm, 1200mm and 1400mm piles based on IS 2911, IRC 78 and IS 14593 as deemed appropriate.

i) Pile (steel tubular piles) axial capacity chart prepared for 1220 mm and 1520 mm piles based on API codes or Euro Codes.

3.5.5 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.

Topgraphy survey of the terminal building area along the existing road shall be carried out to establish the required levels for the design of approach road and terminal building and utility area.

3.5.6 Mathematical Model Studies.

Contractor is obliged to carry out model studies. The scope of model studies is defined below :

- The Contractor should carry out numerical/mathematical model study (1D & 2D) to assess the design parameters like current speed & velocity, HFL, scour depth for designing of the Terminal facilities including riverine structure like bank protection, if any.

3.5.7 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. The 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.

3.6 Employer's Responsibilities

3.6.1 Datum Points and Levels

The Employer will give the details of a reference Benchmark in the vicinity of the Project Site and the Contractor shall establish working benchmarks linked to this and reduce to Mean Sea Level (MSL). The Contractor prior to the start of the Works shall confirm the location and details of datum points and levels. The Contractor shall convert all the levels accordingly with respect to MSL.

3.6.2 Contractor Working Area

The Employer shall provide land area of maximum 5970 sq.m within the Project Site for the Contractor's working area like site establishment, installation of batching plant, casting yard, etc. No space for the labour camp shall be provided. The Employer shall provide such land free of cost and only upto schedule completion of the Project (including approved time extension) for only Contractor's establishment, equipment and material storage. Any usage of land beyond the schedule completion of the Project shall be on chargeable basis as per prevailing rules and rates per sq.m per month in force within Employer's organization.

4 SPECIFICATIONS - CIVIL

4.1 Materials

4.1.1 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 international Codes/Standards.. 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 Bid.

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, the Contractor can choose a brand complying with the Bid 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 authorized 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. EN(Euro) or API/ASTM etc. shall be considered. The decision of the 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.

4.1.2 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 watertight 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 hydro-testing and checking the leakage of liquid retaining structures also.

4.1.3 Aggregate

4.1.3.1. 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, seashells 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. The 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.

4.1.3.2. Coarse Aggregates

Coarse aggregates are the aggregates, which are retained on 4.75 mm 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 4.1.3.1 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 grading 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.

4.1.3.3. Fine Aggregates

Fine aggregates are the aggregates which pass through 4.75 mm 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 seashores, creeks or riverbanks affected by tides, dredged sand shall not be used for filling or concrete works.

4.1.3.4. 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.

4.1.4 Sand

4.1.4.1. 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.

The usage of Brahmaputra river sand cannot be permitted to use for construction activity except for filling. Prior approval of the Employer shall be obtained by the Contractor for the same.

4.1.4.2. Grading of Sand

The particle size grading of sand shall be within the limits as specified below:

Grading of Sand

IS Sieve Designation	**Percentage**	**Method**
IS:460 (Part I)	Passing by Mass	
4.75 mm	100	IS:2386 (Part I)
2.36 mm	90 – 100	
1.18 mm	70 – 100	

IS Sieve Designation	Percentage	Method
600 micron	40 – 100	
300 micron	5 to 70	
150 micron	0 to 15	

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.

4.1.4.3. 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.

4.1.4.4. 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 seashores, creeks or riverbanks 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.

4.1.5 Cement

Cement to be used, for civil and structural works, shall be one of the following or in combination thereof, as per the relevant IS codes. For plain and reinforced concrete works minimum 43 grade and 53 grade ordinary Portland cement shall be used and the Contractor is required to quote on this basis only. The Contractor is obliged to use approved make of cement. The approved makes as approved by Assam Public Works Department will only be considered valid.

4.1.5.1. 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.

4.1.5.2. 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.

4.1.5.3. 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.

4.1.6 Steel

4.1.6.1. 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. Contractor is obliged to use approved make of steel. The approved makes as approved by Assam Public Works Department will only be considered valid.

4.1.6.2. Reinforcement Bars

All reinforcement bars to be Fe 500 S grade, low alloy steel conforming to IS 1786- latest edition. No HYSD bars of FE 415 or bars to IS 432 should be used even for secondary steel.

Reinforcement steel shall be purchased only from primary suppliers and that purchased from secondary suppliers shall not be accepted.

4.1.6.3. Structural Steel

Structural steel to be used for general structural purposes other than that for piles shall be of grade A conforming to IS:2062.

Structural steel sections shall conform to following IS specifications.

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

4.1.6.4. Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following IS specifications.

Expanded Metal Steel Sheets for General purposes	IS:412

Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (grade I) (for mild steel bars of anchor bolts, rungs, metal inserts, grating etc.)	IS:432
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
Mild Steel Tubes, tubulars and other wrought steel fillings. (for Handrail tubular sections).	IS:1239
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

4.1.6.5. 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 above.

4.1.6.6. 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.

4.1.6.7. 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.

4.1.6.8. 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.

4.1.7 Bricks

4.1.7.1. 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/mm²). 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.

4.1.7.2. 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.

4.1.7.3. 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 minimize 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.

4.1.7.4. 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.

4.1.8 Stones

4.1.8.1. General

All stones used for masonry works shall conform to the requirements of following IS Codes.

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

4.1.8.2. 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, seashells 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, considering 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.

4.1.8.3. 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.

4.1.9 Admixtures

4.1.9.1. General

All concrete admixtures shall in general comply with the following Indian standards unless otherwise stipulated in this specification.

- Specification for integral cement water proofing compounds : IS:2645
- Specification for other admixtures for concrete : IS:9103

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 recognized 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.

4.1.9.2. 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.

4.1.10 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 watertight 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 meters.

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.

4.1.11 Bitumen/Bituminous Materials

Bitumen to be used for various types of work shall meet all the requirements of relevant IS Codes as given below:

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

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.

4.1.12 PVC Pipes

PVC Pipes shall conform to the requirements of IS:4985.

4.1.13 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, following codes shall be referred.

Classification of commercial timbers and their zonal distribution	IS:399
Specification for ballies for general purposes	IS:3337
Specification for plywood for concrete shuttering work	IS:4990

4.1.14 Paint

4.1.14.1. 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.

4.1.14.2. 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 21/2 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 galvanized 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.

Painting for steel tubular piles shall be painted with marine grade corrosion protection paint in accordance with the recommendations in ISO 12944 under exposure condition C5M.

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.

4.1.15 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.

4.1.16 Rocker , Roller, Hinges bearing and neoprene bearing pads

Rocker Roller and Hinge supports shall be provided to the linkspan as per the railway bridge standards. Elastomeric bearings pads shall be provided over the pile bracket supporting the Intermediate pontoons as per the road bridge standard specifications.

4.2 Plain and Reinforced Concrete Works

4.2.1 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 jetty, approach trestle, retaining walls, underground structures, floors, buildings, 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.

4.2.2 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’.

4.2.3 Grades of Concrete

Unless otherwise noted, the grades of concrete shall generally be as per Table 1.

Table 1 – Grades of Concrete

Grade Designation	Characteristic Compressive Strength of 15 cm cube at 28 days (N/mm²)
M 15	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.

4.2.4 Type of Concrete Mix

Unless otherwise noted all lean and reinforced concrete shall be design mix types only.

4.2.4.1. Design Mix Concrete

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 1 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 considered. All mixes shall be designed, and weigh batched.

4.2.5 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. 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.

4.2.5.1. 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.

4.2.5.2. 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.

4.2.5.3. 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.

4.2.5.4. 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 plasticizer / super-plasticizer of approved make shall be taken recourse to where required for attaining proper workability as specified in Table 2 below. However, prior written approval of the Employer shall be obtained for any such use of plasticizer / super-plasticizer 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 2 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 2 - 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

4.2.5.5. 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 per standard codes. Concrete mix design shall always consider 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-2A.

Table 2A - Minimum Cement Content and Maximum Water Cement Ratio for Durability

Exposure	**Type of Cement**	**Plain Concrete**		**Reinforced Concrete**	
		Minimum Cement Content (Kg./m³)	**Maximum Water-Cement Ratio**	**Minimum Cement Content (Kg./m³)**	**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

4.2.6 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 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-3.

Table 3 - Surface Water Carried by Aggregate

Aggregate	Approximate Quantity of Surface	
	Percent by mass	Litre / m3
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.

4.2.7 Concrete Mixing

The mixing of concrete shall be strictly carried out in an Automatic Microchihp Controlled Computerized Batching Plant. 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.

4.2.7.1. 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.

4.2.7.2. Mixing Time

Mixing time shall be as indicated in the following table. 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.

Minimum Mixing time	Capacity of mixer
1½ minutes	2 m^3 or less
2½ minutes	3m^3
3 minutes	5m^3

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.

4.2.7.3. Hand Mixing

Hand mixing of concrete and mortar shall not be permitted.

4.2.7.4. 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.

4.2.8 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.

4.2.8.1. 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.

4.2.8.2. 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.

4.2.8.3. 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.

4.2.8.4. 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 stay 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.

4.2.8.5. 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.

4.2.9 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.

4.2.10 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.

4.2.11 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.

4.2.12 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.

4.2.13 Protection of Freshly Laid Concrete

Newly placed concrete shall be protected, by approved means, from rain, sun and wind.

4.2.14 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.

4.2.15 Field Tests

4.2.15.1. 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-4.

Table-4: 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	20m3	Every 20 m3 or part thereof or more frequently as decided by the Employer
		b) Silt content	Field	20m3	-DO-

		c) Particle size distribution	Field or Lab as decided by the Employer	40 m3	1)Every 40 m3 of fine aggregate/ sand required in RCC works only 2)Every 80 m3 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
		b) Particle size distribution	Field or lab as required by Employer	45 m3	For every 45 m3 or part thereof as decided by Employer
		Ten percent Fine value	Laboratory	45m3	Initial test and subsequent test as & when required by Employer.

4.2.15.2. 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.

4.2.15.3. 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 5 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 1 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 4.2.3, 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-5 - Test Requirement of Concrete

Grade of Concrete	Compressive strength on 15 cm cubes minimum at 7 days (N/mm2)	Modulus of Rupture by Beam Test, at minimum	
		72±2 hours (N/mm²)	7 days (N/mm²)
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

4.2.15.4. 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.

4.2.15.5. Frequency of Sampling

The minimum frequency of sampling of concrete for each grade shall be in accordance with the following:

Quantity of concrete in the work in m3	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 50m³ or part thereof
NOTE: At least one sample shall be taken from each shift.	

4.2.15.6. 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.

4.2.15.7. 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□15percent of the average.

4.2.15.8. 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) b) The standard deviation of concrete of a given grade shall be calculated using the following formula from the applicable IS code by considering the results of individual tests of concrete of that grade obtained as specified in 2.15.7

Δ = deviation of the individual 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 a particular grade of concrete are not available, the value of standard deviation given in Table 6 may be assumed.

Table 6 - 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, it shall be permissible to use that value.

4.2.15.9. 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.

4.2.16 Inspection and Testing of Structures

4.2.16.1. 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.

4.2.16.2. 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 4.2.16.3 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 non-conformance 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.

4.2.16.3. 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 Employer 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.

4.2.17 Finishing of Concrete

On striking the form work, all surface defects such as bulges, ridges and honeycombing etc. observed shall be brought to the notice of the Employer. If defects are noticed in the structure, such strictures are considered as not acceptable, the Employer shall be at the liberty to reject or instruct for reconstructing the structure. 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.

4.2.17.1. 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.

4.2.17.2. 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.

4.2.18 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 considered for material reconciliation purposes.

4.2.19 Form Work

4.2.19.1. 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: -6mm to +12mm of cross section of columns & beams

b) 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 50mm.
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.

c) Deviation in length (major dimension of single unit)

i)	Upto 3m	:	6mm
ii)	3m to 4.5m		9mm
iii)	4.5m to 6m	:	12mm
iv)	Additional deviation for every subsequent 6m	:	6mm

d) Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam, column or slab edge.

i)	Upto 3m	:	6mm
ii)	3m to 6m	:	9mm
iii)	6m to 12m	:	12mm
iv)	Additional for every subsequent 6m	:	6mm

e) 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.

f) 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:

up to 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.

4.2.19.2. 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. 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 4.2.17.

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 $1/100^{th}$ 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 7 are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

Table 7 - Minimum Design Pressure for Wall Formwork

Rate of pour in meter/hour	Pressure in kN/m²	
	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
1.5	46.0	37.0

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.

4.2.19.3. Inspection of Forms

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.

4.2.19.4. 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.

4.2.19.5. Chamfers and Fillets

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.

4.2.19.6. 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.

4.2.19.7. 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 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.

4.2.19.8. 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 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.

j) 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.

4.2.20 Exposed Concrete Work

4.2.20.1. Form Work

Other things remaining same as per Clause 4.2.19, 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.

4.2.20.2. 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

4.2.17.1 with the written permission of the Employer.

4.2.20.3. Reinforcement

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.

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 t he 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.

4.2.20.4. 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. Knots in the winding wire shall be placed inside & not in cover Zone. 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.

   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.

b) 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.

c) 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.

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.

4.2.20.5. 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.

4.2.20.6. 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.

4.2.20.7. 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.

4.2.20.8. 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.

4.2.20.9. 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.

4.2.20.10. Cover

Cover to reinforcement shall be as per standard codes / as directed by the Employer.

4.2.20.11. 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 pre-casting 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.

4.2.21 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 minimize 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.

4.2.22 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:

i) 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.

ii) 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.

i) 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.

ii) 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.

4.2.23 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.

4.2.24 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 shrinks Grout (Pre-mix type) of compressive strength not less than 40/mm² for all structures other than those covered in (a) above, as per the instructions / recommendations of the manufacturer.

4.2.25 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 4.2.8.4 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.

4.3 Pile Foundations

4.3.1 General

This section of specification includes requirement for furnishing and placing/installation of reinforced concrete bored cast in-situ piles. The piling shall be carried out during the seasons and as per the approved Construction Schedule in accordance with Appendix to Technical Part Construction Schedule – "No Contruction Period" mentioned in Vol I of RFB document. To displace the aquatic fauna prior to start of construction activities and piling, bnubble screens is to be provided as per the EMP for Guwahati Gateway Ghat. Bubble screens shall be used also for minimizing the release of sediment during the piling activity.

Bored cast in-situ Piles

4.3.1.1. 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 Permanent MS casing/Liner 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 initial & routine pile load test shall be conducted as per IS:2911 (Part 4) except where otherwise specified, described or directed by the Employer.

Piling shall be carried out in accordance with the current editions of the applicable Standards. The design of structures shall accommodate tolerances on installation of piles. Forcible corrections to pile head positions shall not be made.

The effect of sound waves on fish and fishery resources shall be mitigated by gradual ramping up of sound levels to scare fish away before sound levels reach lethal levels.

Pile testing shall be carried out to verify that pile installation complies with the Contractor's design.

4.3.1.2. 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.

4.3.1.3. 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 chiseling 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.

4.3.1.4. 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 riverine 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.

Disposal of out-of-use bentonite slurry shall be in locations approved by the Engineer using procedures that do not affect the drainage of the surrounding area.

4.3.1.5. 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.

4.3.1.6. Piling Tolerances

All concrete piles shall be installed in the positions defined on the Drawings and within a tolerance of 75mm in any direction at the head of the pile. All piles shall be installed vertical within a tolerance of one (1) degree. On completion of driving the casing shall be braced in position. The centre of the pile head of the braced pile shall be measured by a surveyor and the actual position of the casing recorded and advised to the Employer's Engineer prior to concreting of the pile. If the pile is outside the tolerances specified, the Employer's Engineer may instruct the Contractor to remove the casing and reinstall it as specified in the Drawings. Pulling or pushing concrete piles into position shall not be allowed.

4.3.1.7. 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.

4.3.1.8. MS Liners/Casing

For River piles, permanent mild steel liner shall be provided for all piles from cut off level upto the required level depending on the soil conditions and/or as approved by the Employer. The minimum length should be provided 5m below the riverbed level(design scour level).

4.3.1.9. 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. If any pile is deviated and extra material is consumed due to strengthening of cap etc. such material shall be to Contractor’s account.

4.3.1.10. 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.

4.3.1.11. 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.

4.3.1.12. 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.

4.3.1.13. Load Tests

A) General

Initial static load test shall be carried out on a pile constructed for this purpose as directed by the PMC Engineer/Engineer's Representative.

Similarly, the dynamic pile integrity and load testing shall be carried out on piles installed as part of the structure and shall be tested accordingly.

B) Initial Pile Load Test

Initial static pile load test shall be carried out on one number of piles for Vertical load and one number of piles for horizontal load as identified by the PMC Engineer/Engineer's Representative. The test pile location shall be selected such that it represents the soil conditions of the working pile but at the same time it does not interfere with the working piles. The test piles, anchor piles if any projecting above the riverbed shall be cut and removed after the completion of test. The spacing between the test pile and the anchor pile shall be at least 2.5 times the diameter.

Load tests on piles shall be carried out only after 4 weeks from the time of casting the pile. The scope of work includes all the permanent and temporary works related to construction of test pile, anchor pile, annular pile, Kent ledge, and associated equipment for measuring load and displacement, loading and unloading of weights etc. to complete the testing as per specifications and IS 2911 (Part 4).

The test load for vertical pile load test shall be 3 times the working load and 2 times the working load for horizontal load as specified in the construction drawings and specifications for piles in the vicinity or as directed by the PMC Engineer/Engineer's Representative. Calculations and method statement for the proposed Kent ledge arrangement, support / anchor piles or foundations, load and unloading sequence, calibration details of equipment, etc. shall be submitted for PMC Engineer/Engineer's Representative's approval.

The initial load test shall be carried out as per IS 2911 (part 4) and the test should satisfy the load carrying capacity as specified in the relevant bill of quantities. Prior to the load testing of piles, all calculations related to the pile load test arrangement shall be submitted for approval by the PMC Engineer/Engineer's Representative.

The test report shall be submitted to PMC Engineer/Engineer's Representative for approval.

C) Low Strain Pile Integrity Testing

As part of the verification of quality of construction, pile integrity testing shall be carried out on 100% of piles. Before commencing the piling work, the CONTRACTOR shall have on site suitable equipment and trained personnel to carry out integrity testing of piles of each diameter.

Before commencing the tests, the CONTRACTOR shall provide a detailed description and programme for the testing. The finishing of the pile head and the type of hammer or weight to be used shall be suitable for measurement in accordance with the recommendations for the testing equipment employed. The pile shall be provided with transducers which convert strain, velocity and acceleration into electric signals. Such signals shall be recorded by means of electronic equipment specifically developed for this purpose including computer facilities as required. The raw data collected at field shall be furnished in both hard and soft copy formats to the PMC Engineer/Engineer's Representative immediately after conducting the test.

The test result shall be fully interpreted by the CONTRACTOR in the CONTRACTOR's field office, unless elaboration in the Specialist firm's head office cannot be avoided. The test results shall give an indication of the integrity of the pile. In addition, the test result shall be expressed in skin friction and toe resistance.

A complete report of each pile test, including a description of the equipment used and an evaluation or judgment as to the accuracy of the results shall be submitted not later than two weeks after the completion of the test. Intermediate or tentative results shall be communicated to the PMC Engineer/Engineer's Representative or his nominee as soon as it is available.

The PMC Engineer/Engineer's Representative or his nominee will approve each pile in writing when he is satisfied with all test results. No concreting of beams on any pile shall be commenced until all piles supporting the beams to be cast have been approved. Test results shall be submitted for approval of the PMC Engineer/Engineer's Representative as soon as completion of the test. This method is covered under ASTM D5882-00 - Standard Test Method for Low Strain Integrity Testing of Piles.

D) High Strain Dynamic Load Tests

As part of the verification of pile axial load carrying capacity, dynamic testing methods shall be used on six (6) selected piles by the PMC Engineer/Engineer's Representative to derive the axial load carrying capacity. The principle of the high strain dynamic testing method to be used shall be based on the application of impacts on the prepared pile head and measurement of the response of the pile by means of equipment capable of recording and processing the pile strain versus time, acceleration versus time and velocity versus time. Unless the CONTRACTOR himself has proven experience, he shall employ a specialist firm with proven experience in this kind of work.

The pile shall be cast 2m additional height above the pile cut-off level and the tests shall be performed on top. Upon completion of the test, the top portion of pile including concrete/reinforcement as required etc. shall be cut and removed without affecting the integrity of the pile.

High strain dynamic testing consists of estimating soil resistance and its distribution from force and velocity measurements obtained near the top of a foundation impacted by a hammer or drop weight. The impact produces a compressive wave that travels down the shaft of the foundation.

A pair of strain transducers obtains the signals necessary to compute force, while measurements from a pair of accelerometers are integrated to yield velocity. These sensors are connected to an instrument (such as a pile driving analyzer), that records, processes and displays data and results.

The measured acceleration is used to compute the stress velocity by integration and is used to calculate the resistance of soil during driving (in this case, the hammer dropping at the pile head) and thus the long-term capacity can be obtained. Dynamic load testing takes a further step in analyzing the data and computing static capacity and resistance distribution. Test results shall be submitted for approval of the PMC Engineer/Engineer's Representative as soon as completion of the test. This method is covered under ASTM D4945-00 - Standard Test Method for High Strain Dynamic Testing of Piles.

E) Interpretation of tests

The interpretation of tests shall be carried by competent and experienced specialists. As a rule, and unless approved otherwise by the PMC Engineer/Engineer's Representative prior to commencement of the Works, the specialist integrity testing firm carrying out the

tests shall also interpret the results and produce the overall report.

The CONTRACTOR shall provide all available details of the ground conditions, pile dimensions and construction method to the specialist testing firm prior to commencement of the integrity testing in order to facilitate interpretation of the results.

F) Reporting

Preliminary results of the tests shall be submitted to the PMC Engineer/Engineer's Representative within 7 days of carrying out the tests. The test results and the interpretation shall be reported to the PMC Engineer/Engineer's Representative within two weeks of the completion of each cycle of testing. The report shall contain a summary of the method of interpretation including all assumptions, calibrations, corrections, algorithms and derivations used in the analyses. If the results are presented in a graphical form, the same scales shall be used consistently throughout the report. The units on the scales shall be clearly marked.

G) Anomalous results

In the event that any anomaly in the acoustic signal is found in the results indicating a possible defect in the pile, the CONTRACTOR shall report such anomalies to the PMC Engineer/Engineer's Representative immediately. The CONTRACTOR shall carry out remedial works to make pile satisfactory for its intended use or shall install a replacement pile as directed by the PMC Engineer/Engineer's Representative at no additional cost to the OWNER. Sonic logging tubes, if used, shall be grouted up after the CONTRACTOR has demonstrated that the pile is satisfactory.

H) Specialist Sub-Contractors/ Agency

The CONTRACTOR should appoint specialized agency for pile integrity test with the approval of the PMC Engineer/Engineer's Representative.

4.3.1.14. 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.

4.3.1.15. 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.

4.3.2 Steel tubular piles

4.3.2.1. General

This section of specification includes requirement for furnishing and placing/installation of reinforced concrete bored cast in-situ piles

4.3.2.2. Steel tubular piling

4.3.2.2.1. General

The technical requirements of this specification are the absolute minimum acceptable.

Where not specifically referenced herein, materials and workmanship shall comply with the latest edition and amendment of the applicable Indian Standard or approved International Standard.

Materials and workmanship shall comply with the parts and sections of IS 2911. Code of practice for the Design and Construction of pile Foundations, set out below, except where modified and/or extended by this Specification.

4.3.2.2.2. Materials for steel piles

All materials shall be supplied by the Contractor for the manufacture, fabrication and coating of steel pile sections.

The Contractor shall arrange for steel in the pile tubes to be inspected, tested and branded under the supervision of an internationally accredited authority acceptable to the Employer's Engineer or by a qualified responsible metallurgist. The Contractor shall arrange for copies of certificates to be forwarded to the Employer's Engineer, with such schedules or other documentation which permit identification of the steel so tested and branded.

Testing at the source of supply shall cover all specified requirements relating to physical properties and chemical analysis.

Welding of the steel in the shop associated with the fabrication into tube sections shall be inspected, tested and certified by an accredited authority.

Tubular steel piles shall be fabricated circular hollow sections manufactured to E275BR grade steel as per IS 2062 and IS 8500. The manufacturer and the standard to which the piles are fabricated shall be to the approval of the Employer.

Pile diameter and wall thickness shall be in accordance with the detail design and drawings of the Contractor and approved by the Employer.

Details of pile orders shall be subject to the prior approval of the Employer.

Pile shoes pile stiffening rings shall be fabricated in accordance with the Drawings from the same plate used for pile manufacture, or approved equivalent.

4.3.2.2.3. Imperfections

Imperfections of the following type shall be cause for rejection of tubular piles. This shall not be construed as limiting the Employer's Engineer's right to reject tube for imperfections other than as given below.

The tubular pile shall contain no visible dents. The length of tubular pile in which any dent occurs shall be cut out and the ends spliced together. Working the dent to restore the cross section will not be permitted.

Laminations extending into the face of the bevel of the tube and having a transverse dimension exceeding 5 mm shall be cause for rejection.

4.3.2.2.4. Fabrication and Welding

All welding shall be by an automatic welding procedure. All welds shall be qualified complete penetration butt welds in accordance with the Indian Standard.

Piles shall be formed from rolled steel shells with longitudinal seams. Alternatively, the rolled steel may be welded spirally to form segments which are butted together, and shop spliced into lengths suitable for delivery to the site.

The steel plate shall be rolled into cans not less than 3 m long. When joining cans they shall be rotated before welding to ensure that the adjacent longitudinal joints are not in line, but are displaced from each other by at least 300 mm. The bottom sections of pile shall be supplied with a welded steel driving shoe as shown on the drawings unless otherwise approved by the Engineer.

4.3.2.2.5. Tolerances

Steel tubes, sheet piles and backing plates shall generally satisfy the tolerance limits set out below. The complete tube or sheet pile sections after welding shall not deviate from straightness by more than 1:600 of its length measured from a straight line joining the head and toe. The length of a member shall not deviate from the specified length by more than 3 mm.

For machined butt joints in compression, the clearance between the surfaces shall not exceed 0.25 mm for at least 60% of the bearing surfaces. Over the remainder of the surface, the measurable gap between the surfaces shall not exceed 1 mm.

The diameter of any section of a tubular pile shall not vary by more than 3 mm from the specified diameter. The outside circumference shall not vary by more than 13 mm from the nominal circumference. The face on the ends of the tubes shall not be out of square by more than 3 mm.

All tubes and sheet pile sections shall be joined to match as near as practicable. The maximum allowable mismatch of the end to be butt welded shall not exceed 3 mm at any location on the joined surface notwithstanding the specified tolerances.

4.3.2.2.6. ISO 9002 Accreditation

Piles shall be manufactured under a strict factory quality assurance/control plan accredited with ISO 9002 certification.

4.3.2.2.7. Protective Coatings

The Contractor shall apply protective coatings to the exterior of all specified tubular piles. The coating must cover the outer surface of the piles from 3 meters below riverbed scour level to the pile cut-off level. The Contractor shall be responsible to restore or repair any damage to the coating.

4.3.2.2.8. Handling and Transport

The Contractor shall exercise the utmost care when handling and transporting the steel tube and sheet pile sections to avoid damage to any protective coating. No sections shall be transported until the protective coating has been adequately cured. Sections shall be handled using strap slings or spreader beams with end hooks. Sections shall be separated with non-abrasive material when stacked both in storage and during transport. During transport, care shall be taken to ensure that ropes or other restraining devices do not rub against any coated surface of the sections. Repair to any surface coating damaged during handling and transport shall be carried out at the Contractor's expense in accordance with the Specification and as directed by the Employer’s Engineer.

4.3.2.2.9. Storage on Site

The fabricated tube and sheet steel pile sections shall be transported to the storage area nominated on the site. The Contractor shall submit the proposed stacking arrangement to the Employer’s Engineer and obtain approval before dispatching sections to the site.

Tube and sheet pile sections being stored shall be separated when stacked and the bottom row of sections shall be stacked clear of the ground. Adequate load spreaders

shall be provided to spread loads over the ground to ensure that stacks remain true and stable. All chocks and wedges shall be secured to bearers in a manner to prevent sliding or rolling of the sections and to ensure stability of the stacks during further stacking, when the stack is completed and when sections are being removed.

4.3.2.2.10. Foundation information

The Contractor shall use the results of the existing foundation investigations (if available) to make his assessment of the nature of the sub-surface conditions at the Site.

The Contractor shall undertake new geotechnical investigations and submit detail investigation report to the Employer for approval.

The Contractor shall note the variability of strata likely to be encountered in the various sections of the Works.

The Contractor shall critically assess terminal requirements and pile installation techniques on the basis of the above information in order to achieve pile capacities consistent with the design.

The Contractor shall undertake any additional foundation investigations and testing as considered necessary to make his assessment of the nature of the sub-surface conditions at the Site to allow the piling to be carried out in accordance with the Contract.

The Contractor shall as a minimum requirement, carry out the additional geotechnical investigations and testing before any piling work is started.

4.3.2.2.11. Pile capacity

Piles shall be driven by the Contractor to the approved sets (mm per blow) as per the specification. The piles shall be driven upto the termination level as specified in approved drawing or as per the detailed design.

Size of the steel tubular piles proposed in riverine structures are given below:

Sr. No.	**Structure**	**Dimension of Pile**
1.	Dolphins for Berthing Pontoons	Φ1.520m, thk.25 mm
2.	Dolphins for Intermediate Pontoons	Φ1.520m, thk.31.8mm
3.	Bankseat	Φ1.220m, thk.31.8 mm

At least four weeks before any pile driving is planned to start, the Contractor shall submit to the Employer, for approval, calculations and charts showing the proposed sets for each pile type to achieve the required ultimate resistance, based on approved pile-driving formula, such as the Hiley formula. The calculations and charts shall be prepared by the Contractor for the particular pile-driving hammers proposed and shall cover the full range of pile lengths to be driven and expected temporary compressions.

4.3.2.2.12. Plant and Methods

At least four weeks before any piling is due to start, the Contractor shall submit to the Employer for approval full details of the pile driving plant and hammers proposed, together with detailed method statements for the supply/fabrication/casting, handling, splicing, driving and testing of piles. The details shall include the proposed sequence of

working.

The Contractor shall select his pile driving equipment and hammers to ensure that the piles can be driven to obtain the required ultimate resistances covered above. Unless otherwise approved by the Employer, the minimum rated energy/blow for the pile hammers shall 130 kJ/blow.

4.3.2.2.13. Pile Testing

The Contractor shall submit the method of pile test loading at least twenty- eight (28) days prior to the test equipment being required on Site, for approval by the Employer's Engineer. This information shall include, but is not limited to:

- Full details and proposed layout of any load transfer beams, reference beams, kentledge and/or reaction piles.
- Any proposed jacking arrangement and deflection gauge layout.
- Full design calculations confirming the structural adequacy of any load transfer beams and reaction piles, including where Permanent Works piles are used as reaction piles. Any such calculations shall demonstrate the tension pull out capacity of the reaction piles and their ability to resist the forces imposed during the load test.

No pile load test shall proceed until the proposed test method and the onsite set up has been accepted by the Employer's Engineer.

The results of any pile load testing shall be forwarded to the Employer's Engineer within 48 hours of the completion of the test.

The pile load testing shall be carried out in incremental load stages as directed by the Employer's Engineer to measure pile head displacement with load and time during the loading and unloading cycles in accordance with codes. The maximum load shall be maintained for up to 24 hours on each cycle with incremental loads being maintained for up to 2 hours.

The load increments and unloading decrements shall be 20% of the maximum test load. The load gauge / jack to be used shall be accompanied by a recent calibration certificate from a registered accredited testing laboratory. Equipment for testing of the pile shall be capable of testing piles of all diameters and up to the maximum loads for each type of pile.

a) Dynamic Load Tests: Independent Consultant

The Contractor shall arrange for an approved independent consultant to undertake all dynamic pile testing (both high and low strain) and to analyses the output from the dynamic pile testing, using the Pile Driving Analyser/CAPWAP system. The independent consultant shall not be a subsidiary company of the Contractor nor have any common ownership or parent company structure with the Contractor. The independent consultant shall confirm in writing that the onsite testing Employer's Representative is suitably trained, certified and capable to accurately conduct the onsite measurements.

4.3.2.2.14. Splicing of steel piles

a) General

Open Steel piles shall be spliced on Site yard by the Contractor to lengths, to the approval of the Employer, before pile pitching, no in-situ splicing of steel tubular

piles are allowed during driving.

Piles shall be supplied true to shape and size, without distortion, and with all necessary provisions for handling and Site yard splicing. Sections damaged by hammer marks of otherwise marked, or defaced, shall be rejected.

Splicing of adjacent lengths of tube shall be affected by complete penetration butt welds made with single or double V penetration of the plate to be joined in accordance specifications for welding and inspection. Internal steel backing plates can be used, or alternatively, the welds shall be back gouged internally, and a sealing weld applied.

Sections to be joined shall be chosen so that diameters in both sections match as near as practicable by rotating one section until the best fit is achieved. Longitudinal seams in piles shall be staggered as per the specifications.

Ends shall be accurately cut square to the axis and shaped for splicing if required.

The tolerance on straightness of a completed spliced pile length shall not exceed 15mm for lengths over 15m.

The minimum distance between splices shall be 900mm. There shall be no more than two splices in any 3m interval of pile. No splice shall be located closer than 1m from a joint with another structural number, unless otherwise approved by the Employer.

During splicing, the Employer shall have free access to the works at all reasonable times for the purpose of carrying out inspections and for carrying out of such inspections. Pile lengths shall be laid out for splicing, as necessary, so that all parts are accessible for inspection.

Inspections by the Employer shall not prevent the ultimate rejection of any work or materials in which defects have been found.

b) Welding

All welding shall be as specified in the specifications for welding and inspection. Prior to commencing any welding, welding procedures including pre-heating and the methods and extent of inspection to be used shall be submitted to the Employer for review and approval. Records of all qualification tests and inspection reports shall be maintained by the Contractor. The Contractor shall submit in detail the procedure for welding of joints in formation of piles including welders qualification, machinery to be mobilized, types of welding rods ec. Details of tests for check of weld quality of joints formed.

4.3.2.2.15. Installation

a) Vibrations

The Contractor shall take all practicable precautions to keep vibrations caused by piling work under the Contract to a level that will not cause cracking, settlement or distortion of adjacent elements or structures and the existing structures.

The Contractor shall ensure that no vibrations from his piling work cause damage to newly cast concrete sections in the Works. To this end, the Contractor shall carry out investigations to determine the minimum distance from land piling and from river piling where concrete placing/curing can take place. Without being affected by vibrations.

b) Plant and Equipment

The Contractor shall obtain the Employer's approval of proposed plant, equipment and operators. The Contractor will be required to produce evidence of their ability to satisfactorily perform the work. All plant and equipment shall be kept in good condition and shall be capable, without modification, of performing the work required in this Contract.

Pile driving plant type and capacity shall be capable of maintaining a sufficient rate of pile driving progress to meet the performance requirements specified, and without driving assistance from jetting or similar methods. No jetting or pre-boring will be accepted, unless specifically approved by the Employer, in exceptional circumstances.

c) Marking

Each pile shall be clearly marked with its overall length and in 500mm intervals, to facilitate the making of piling records, which shall be taken over the full driving length of the pile.

d) Handling and Pitching

Piles shall be handled and stacked so that they are not damaged, bent or twisted. Piles shall be stacked clear of the ground and such that no rainwater will accumulate and stagnate inside the steel tubular piles/splice sections.

Defects or damage may be repaired and straightened, only with the consent of the Employer. Where directed by the Employer, damaged sections shall be replaced.

Pile frames shall have firmly supported guides extending down to the lowest point to be reached by the hammer.

Handling transportation and pitching of piles shall be carried out in such a manner as to ensure that the piles are not damaged in any way.

The Contractor shall where practicable, peg the position of each pile and establish a grid of recovery pegs to enable the setting out to be checked at any time.

e) Driving

Piles shall be set out to the alignment and centres as shown on the Drawings and with the piles axes in correct rake and orientation.

Each pile shall be driven continuously, until the approved set and/or depth has been reached, except that the suspension of driving may be permitted when it is apparent that the rate of penetration, prior to the cessation of driving, will be substantially re-established on its resumption or, if suspension of driving is unavoidable. A follower (long dolly) shall not be used unless approved in which case the set shall be revised to take into account the reduction in effectiveness of the hammer blow.

Unexpected changes in driving characteristics shall be reported to the Employer.

At the start of work or at a new section or area of the work and for every one in 10 piles, sets shall be taken at 0.5 metre intervals over the full driven depth to establish the behaviour of piles.

The final set of each pile shall be recorded as the number of millimeters penetration per blow averaged over the last five blows. When a final set is being measured the following requirements shall be met:

i. The exposed part of the pile shall be in good condition, without damage or distortion.

ii. The dolly and packing if any shall be in sound condition.

iii. The hammer blow shall be in line with the piles axis and the impact surfaces shall be flat and square to the pile and hammer axis.

iv. The hammer shall be in good condition and be operating correctly.

v. The temporary compression of the pile shall be recorded.

Set shall be monitored during driving by recording the number of blows required to achieve a 25mm penetration. Detailed records of sets shall be taken by the Contractor over the last 0.5m of penetration before the final set and when sets reduce significantly. Final sets shall be witnessed by the Employer.

Piles shall be driven in a sequence to minimize detrimental effects of heave and lateral displacement. Measurements to determine the movement of the ground or of any pile during the driving process shall be made and recorded.

Proposed details for correcting the movement to adjacent piles together with proposed methods to prevent recurrence in subsequent work shall be submitted to the Employer for review and approval.

Temporary bracing details shall be submitted to the Employer for review and approval prior to installation.

f) Hammers

Piles shall be driven with a drop, an air, a diesel a hydraulic hammer and Vibratory Hammer conforming to these specifications. Pile driving hammers shall be of the size needed to develop the energy required to drive the piles at a blow count that does not exceed 10 blows per 25 mm at the required ultimate pile capacity.

In case the required penetration is not obtained by the use of a hammer complying with the minimum requirements above, the Contractor may be required to provide a hammer of greater energy or, when permitted, resort to supplemental methods such as jetting or predrilling.

g) In-situ Splices

No in-situ splicing of steel tubular piles during driving allowed. Splicing shall only be carried out to the required lengths in the factory or in the splicing yard at site.

h) Installation Tolerances

The permissible positional deviation for a pile at cut-off level, on completion of pile driving and with the pile unsupported shall be as follows:

Tolerances in installation of piles

Pile Type	Plan Position	Inclination
Vertical River Pile	±150mm	1½ %
Raking River Pile	±150mm	4%

i) Obstructions

The Contractor shall provide equipment ready and available on site for dealing with obstructions, such as isolated boulders, which may be encountered during pile driving. Obstructions shall be dealt with by the Contractor based on his proposals to the approval of the Employer.

j) Excavation

After driving of the tubular steel piles if designed to be anchored in rock and open-ended piles, the insides of the piles shall be excavated by an approved method. Excavation shall be continued beyond the toe of the pile in the same direction as the pile to the top of rock with a minimum of 80% core recovery. The diameter of the excavated hole beneath the pile toe shall be a minimum of 75mm. The method of excavation shall be such as to avoid damage to the internal stiffening ring at the base of the pile.

Excavated material shall be disposed of by the Contractor to the approval of the Employer.

k) Rock Coring

Before the start of excavation or after completion of excavation the Contractor shall carry out rock coring using a method and equipment approved by the Employer along the centerline of each open-ended tubular steel pile, to determine the level which corresponds to the top of sound dense rock with a minimum core recovery of 80%.

As an alternative to rock coring along the centerline of each raking pile the Contractor may drill a borehole and rock core vertically at a location approved by the Employer where sound dense rock with a minimum core recovery of 80% is likely to be reached along the centerline of the raking pile. The method of borehole drilling and rock coring and the equipment shall require the prior approval of the Employer.

Coring shall continue for at least 5m into rock with a minimum of 80% core recovery. The coring shall be carried out under the supervision of an experienced geotechnical engineer.

l) Rock Socketing

Rock sockets for open-ended tubular steel piles shall be formed in sound dense rock having a minimum core recovery of 80% to the minimum diameter and length requirements specified in the tender. The level of the top of each rock socket shall be based on the results of the rock coring and shall be submitted to the Employer for approval with the coring records before any socketing starts.

The method of socketing roughening and cleaning shall be to the approval of the Employer and shall be submitted for review before commencement. Rock sockets

shall be clean and shall have rough surfaces. The methods of checking size geometry and cleanliness shall be to the approval of the Employer.

After socketing the inside of the pile excavated hole above the rock socket and rock socket shall be cleaned by airlift to remove all loose material and flushed out with clean fresh water before installing the reinforcement cage.

The material removed from the rock socket and all flushing-out water shall be disposed of to the approval of the Employer.

m) Concrete Infill

Concrete infill if required as per the design to open-ended tubular steel piles shall be carried out within 48 hours of completion of rock socketing and final cleaning/flushing out. If the time is extended by the Contractor to greater than 48 hours, the Employer may require the Contractor to check on the cleanliness of the hole and quality of the fresh water inside and re-flush out the hole and refill with fresh water in necessary.

The reinforcement cage shall be maintained in the required location with the required cover and projection as shown on the Drawings.

The top of the steel pile shall be cut off to the required level before the reinforcement is placed.

The concrete infill shall be placed by the Contractor for the full pile length in one operation using a tremie method as covered in Pile Reinforced Concrete.

n) Pile Heads

Pile heads shall be cut off by the Contractor and prepared for incorporation in the adjacent structure. Using methods approved by the Employer to a tolerance of ±5mm from the levels shown on the Drawings. The methods shall be such as to ensure that the remaining pile lengths are not damaged in any way.

Cut-off lengths and other removed material shall be stored for future use where applicable or disposed of to the approval of the Employer.

o) Piling Records

Pile driving records shall be submitted to the Employer within 24 hours of completion of the driving of each pile. Records shall include the following:

i. Date of driving pile.

ii. Location dimensions of the pile and pile type.

iii. Pile number, original driven length, quantity of water infill and timing in relation to driving (where applicable) and final driven length.

iv. Cut-off level, toe level, off-cut length.

v. Characteristics of driving equipment, energy/blow at final set.

vi. Set record over last 0.5m penetration based on number of blows to achieve a 25mm penetration.

vii. Full set record in blows per 0.5m penetration for every one in 10 piles and piles at the start of each row, section or area.

viii. Final set in mm/blow based on average for the last five blows and average final temporary compression and assessed ultimate resistance.

ix. Type and condition of the packing on the pile head, and of the dolly or follower if used.

x. Any deviation from specified location and inclination.

xi. Any other relevant information.

The toe level of all piles shall be marked up on a pile layout plan within 24 hours of driving of each pile. The level reached shall be compared with adjacent piles and any change in level of more than one metre between adjacent piles shall be reported to the Employer immediately with a copy of the relevant section of the plan and piling records.

A penetration record of blows per metre (or less) for the full length of the pile shall be taken for the first pile and other selected piles on the site.

Coring and socketing records shall be submitted in addition where socketing is required within 48 hours of completion of concrete infill. Records shall include the following:

i. Date(s) of excavation, coring, rock socketing and placing concrete infill

ii. Excavation coring and rock socketing equipment.

iii. Level of bottom of rock socket and core log details.

p) Damaged Piles

Piles damaged in any way during handling, driving or by subsequent construction operations or incorrectly located shall be withdrawn and replaced with sound piles to the approval of the Employer.

q) Temporary Bracing

Immediately after driving riverine piles shall be temporarily braced as necessary to the approval of the Employer to resist direct loads and vortex induced oscillations due to current and/or wave action and to resist construction loads. Bracing shall not be removed until the approval of the Employer has been received.

r) Bearing Plates

Bearing plates for steel piles shall be fabricated and welded to the piles in accordance with the Drawings before the installation of the precast concrete pile caps. All welding shall be carried out in the dry. In some locations this will require the use of a temporary watertight chamber fixed to the pile to protect the top of the pile from the ride and wave action or equivalent system approved by the Employer.

s) Pile Cap Supports

For all riverine piles for construction of in-situ concrete deck, temporary support from the piles prior to the deck concrete infilled with adequate strength for the supports to be carried out and submitted for Employer Engineer approval. It is envisaged that the Contractor will install temporary brackets clamped and or welded to the piles, which will support the load from the pile caps and act as formwork for the pile cap soffit for the concrete infill. Details of the proposed method of supports shall be provided to the Employer for comments at least 21 days prior to fabrication. The pile sleeves, where required, shall be installed over the piles before fixing of the pile cap

support brackets. The brackets will need to be removed before the pile sleeves can be fixed in their final location. Any local damage to the piles caused by fixing of the brackets such as welding shall be made good by the Contractor by grinding back or similar to the approval of the Employer.

4.4 Pontoon

4.4.1 General Requirement

a. The Pontoon shall be suitable for transit / passenger services and for operations in inland waters and shall be built as per Inland Vessels Act 1917 and subsequent amendments/ Indian Register of Shipping (IRS) rules / IWAI / AIWTRA regulations for dumb barge / pontoon applicable to inland waters.

b. The Pontoons are to be stationed at jetty locations along the river where these would be moored at respective sites via dolphin piles. The Contractor shall construct pontoons and install the required structural or outfitting elements, which are required for mooring the pontoons.

c. Standard shipbuilding practices shall be adapted in the construction. Any material / fitting / equipment or procedure not described or left out of these specifications but considered as normal and necessary for intended services of these Pontoons shall be supplied and fitted by the Contractor without any extra charge.

d. The Contractor shall be responsible for all the extra work, which arises out of the recommendations, and remarks made by the Classification Society as well as IWT surveyors.

e. The terms and conditions mentioned in these specifications shall be, in general, final for all contractual obligations. However, items shown on the General Arrangement Drawing (GAD) but not stated or stipulated in these specifications shall also be considered. In the event of any inconsistency in the GAD, the specifications shall prevail.

Principal Particulars: The main particulars of Pontoons are as given hereunder:

Details	Requirement
Type of Pontoon	Box Type Steel all welded
Length	60 m
Width	15 m
Moulded Depth	2 m
Draft	1.5 m

4.4.2 Classification, regulation and certificates

a. The Pontoon shall be designed and built in accordance with the requirements of the rules and regulations of:

b. IRS (Indian Register of Shipping) or any other Classification Society who is a member of the International Association of Classification Society (IACS).

c. The Inland Vessel Act 1917 (latest amendment thereof).

d. Detail design and calculations are to be prepared and the same needs to be approved by DIWTA / Assam Inland Water Transport Regulatory Authority's Engineer, who shall be deployed by NHIDCL at site.

4.4.3 Trim and Stability

Construction, Supply, Transportation, Installation, Testing and Commissioning of Steel Pontoons for providing floating facilities at GGG on EPC mode.

a. The Pontoon shall comply with IMO's stability requirements and shall not have any trim by fore in any of the operating loading conditions.

b. Permanent ballasting will not be allowed. An inclining experiment is to be conducted by the Contractor in the presence of the IWT surveyors and the Employer's Engineer. A detailed trim and stability booklet duly approved by State IWT Directorate / AIWTRA shall be submitted to the Employer's Engineer.

c. The mooring system must sustain pontoons in the maximum expected wind and current speed.

4.4.4 Hull Structure

General

The Pontoon is to be shaped with rounded corners and swims ends. The hull is to be divided into several watertight subdivisions.

Scantlings

The steel to be used is to be of IS 2062 Grade B and classification society shall carry out necessary testing of the samples of steel as required by class. The welding is to be of excellent quality and using high quality electrodes. The hull scantlings are to be not less than given below:

Plating		**Profiles**	
(a) Bottom Plating	8 mm	i. Bottom Longitudinal	1A 75 x 75 x 8
(b) Side Plating	6 mm	ii. Side shell stiffeners	1A 65 x 65 x 6
(c) End Bulkheads	6 mm	iii. Deck Longitudinal	1A 65 x 65 x 6
(d) Internal Bulkhead	6 mm	iv.Bulkhead Stiffeners	1A 65 x 65 x 6 / 1A 100 x 100 x 10
(e) Deck Plating		6 mm chequered plates	
(f) Tank Boundaries		6 mm	

4.5 Site Grading

4.5.1 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 +37.0 m MSL within the terminal, upto the boundary wall of the terminal, stockyard, parking and road area & locations where buildings have to be constructed. While carrying out site grading, it is ensured that no existing natural drainage shall be blocked without providing required cross- drainage structures or alternative drainage arrangement.

The formation level of +37.0 m shall be achieved by carrying out cutting and filling of the existing ground levels inside the terminal area. The Contractor shall satisfy himself as to the nature of the material to be excavated by examination of the Site and geo-technical investigation report available for the Project Site. The Contractor shall carry out any further investigations necessary to enable him to assess and foresee the nature of the material and to decide on the most suitable type of equipment and method of excavation / cutting.

4.5.2 Material

4.5.2.1. 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	:	200mm
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

4.5.2.2. 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.

4.5.2.3. 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.

4.5.2.4. 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)

4.5.2.5. 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: 1990, will be considered provided the Contractor undertakes comparative tests.

4.5.3 Compaction

4.5.3.1. General

During the reclamation process the Contractor shall place approved material within the reclamation 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.

4.5.3.2. 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 on an average of one in every 40,000m² or 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 : 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 2,500m² 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 5,000m² 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 300mm of fill in reclamation area as follows:

Test	**Test Frequency** **(Not less than one test per)**
Dry density	600 m²
Moisture content/maximum dry density relationship	2000 m²
Particle size distribution	2000 m²
Atterberg limits	2000 m²
Linear shrinkage	2000 m²
CBR	2000 m²
Sulphate content	2000 m²
Chloride content	2000 m²

4.5.4 Disposal of Surplus Excavated Material

Subject to provision of this specification all materials arising from site grading activity 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.

4.5.5 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.

4.6 Roads and Pavement Works

4.6.1 General

This section covers the specification for the construction of road and pavement works.

These specifications includes 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 the cargo handling equipment to operate at their optimum rates and to allow for storm water to the drainage system.

4.6.2 Water Bound Macadam Layers for Roads & Flexible Pavements

4.6.2.1. General

This specification covers the material and construction details for earthwork in filling for embankment, filling with sand/murrum, WBM sub-base, WBM base course and shoulders for roads and flexible pavements.

4.6.2.2. Reference Codes and Standards

B.I.S Specifications.

IS: 2720- Methods of Test of Soil

Indian Road Congress Standards.

IRC: 19 - Standard Specification and Code of Practice for Water Bound Macadam

4.6.2.3. Earth Work in Filling

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.

i) Mechanical analysis or gain size analysis as per IS: 2720 Part IV.

ii) Liquid limit as per IS: 2720 Part V.

iii) Plastic limit as per IS: 2720 Part V.

iv) 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.

Filling for Embankment 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 ramp filling. All clods, lumps etc. shall be broken before compaction.

In general, the soil shall be spread uniformly over the entire width of ramps.

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, slope, cross-sections and dimensions of ramp as approved by the Employer.

Extra material shall be removed and disposed-off as directed by Employer. Tolerance Ramps for roads shall be carried to within a tolerance of 3 cm. from final lines but shall

be to the required grades and slopes.

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 M² area 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.

4.6.2.4. 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.

4.6.2.5. 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.

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. Spreading Coarse Aggregates The sub grade or sub-base to receive WBM coarse shall be prepared to the required grade and camber.

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 aid 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.

4.6.3 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 3 metre 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.

4.6.4 Screenings

4.6.4.1. 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 per cent

4.6.4.2. Grading Requirements of 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.

4.6.4.3. Application of Screenings

After the coarse aggregate has been rolled as described in Clause 4.5.3, 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 as 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.

4.6.4.4. 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.

4.6.4.5. 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.

4.6.4.6. 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.

4.6.4.7. 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.

4.6.4.8. Construction of Berms

After the WBM course is laid and compacted, the existing surface at side berms 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.

4.6.5 Flexible Pavements

4.6.5.1. General

This specification establishes material and construction requirements for the flexible pavement with Bitumen Premix Carpet.

4.6.5.2. Bitumen Premix Carpet

Material

i) 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.

ii) 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.

iii) 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.

4.6.5.3. Quantities of Materials

Material	**For Premix Carpet per 100 m²**	**For seal Coat per 100 m²**
For Premix Carpet 20mm thick		
Coarse Aggregate 12mm	2.75 m³	and downsize
Bitumen 80/100	150 kg.	68.3 kg.
Coarse sand as sealing aggregate		0.6m3
For Premix Carpet 25mm thick		
Coarse Aggregate 12mm and downsize	3.5m³	
Bitumen 80/100	185 kg.	68.3 kg
Coarse sand as sealing compound	0.6 m³	
For Premix Carpet 50 mm thick		
Coarse Aggregate 25mm and downsize. (For 35 mm thick carpet layer)	5.5m³	
Coarse Aggregate 12 mm and downsize (for 15 mm thick carpet layer)	2.0 m³	
Bitumen 80/100		
For 35mm thick Carpet (I layer)	269 kg.	68.3 kg
For 15mm thick Carpet (II layer)	110 kg.	
Coarse sand and sealing aggregates	0.6m3	
For Premix Carpet 75 mm thick		
Coarse Aggregate 25mm and downsize (for 50mm thick layer)	8.5m³	
Corse Aggregate 12mm and down thick II layer)	3.5m³	
Bitumen 80/100		
a) For 50 thick I layer	375kg.	68.3kg.
b) For 25 thick II layer	185kg.	
Coarse sand as sealing aggregate	0.6 m³	

4.6.5.4. Laying

i) 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.

ii) Tack Coat

The bitumen shall be heated in asphalt boilers to 177°-188℃ and shall be spread uniformly at the rate of 1 kg / m² 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.

4.6.5.5. 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. 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.

Rolling

When the premix has been laid for a length of 15-20 meters, rolling shall be commenced with tandem rollers (8 to l0 tones) Rolling should commence from edges and proceed towards the center 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.

4.6.5.6. Seal Coat

i) For low rainfall areas - under 150cm/yr.

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 4.5.5.2.

ii) For high rainfall areas - over 150cm/yr.

The material requirement for seal coat in high rainfall areas is as under:

Binder 80/100 = 98 kg/100m² of road surface

Coarse aggregates = 6.3mm passing IS. 10mm Square mesh retained on
IS sieve 2.36mm = - 0 9m³/100m² of road surface.

A liquid seal coat, preferably with chippings as above (though coarse sand can also be used) should be applied after laying the carpet. The binder, heated to permissible temperature, should be applied to the cleaned surface, blinded with chippings and rolled.

Traffic may be allowed on the road preferably 24 hours after providing the seal coat.

4.6.6 Lean Concrete Base

4.6.6.1. 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.

4.6.6.2. 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.

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.

4.6.6.3. 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 m² of base laid. From each sample the Contractor shall prepare two 150 mm 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/mm² or more than 16 N/mm. 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.

4.6.6.4. Rectification of Surfaces

Any area of lean concrete base which is outside the tolerance of + 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.

4.6.7 Concrete Block Paving

4.6.7.1. Materials

Concrete paving blocks shall comply with relevant IS codes and requirements given hereunder:

i) 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/m3

ii) 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.

iii) Water

Water shall be clean, free from deleterious matter and comply with IS: 3025.

iv) 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.

v) 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.

vi) 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.

vii) 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

viii) 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/mm2 and the crushing strength of any individual block shall not be less than 40 N/mm2.

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.

4.6.7.2. Construction of Concrete Block Paving

Concrete block paving shall be laid to comply with IS: 6509 and the requirements as given hereunder:

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 I

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 I 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.

Sub-base

Materials for the sub-base shall comply with the requirements for granular sub-base given in Clause 4.5.2.4 of the Specification. The sub-base layer shall be laid on the prepared formation and compacted in accordance with Clause 4.5.2.4. The thickness of the sub-base shall be as per approved design.

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 4.5.6.2 of this specification.

Edge Restraints

Edge restraints shall be formed before compacting adjacent blocks. 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.

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-1 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.

i) Permissible tolerance on centre line of pavement construction relative to horizontal alignment: +10 mm.

ii) Permissible tolerance on surface levels:

Table-1: 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.

4.6.7.3. Kerbs and Gutters

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.

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, Section 2, Plain and Reinforced Concrete.

Reinforcement, where used, shall comply with the Specification Section 2, Plain and

Reinforced Concrete. Equipment

Equipment shall be of the number and type outlined in the Contractor's Programme of Work as approved by the Employer. 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 32 mm 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.

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.

4.6.7.4. Construction Requirements

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 ramps, it shall be to the full width of the top of the ramps.

Material placed in the top 300 mm of ramps, 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 4.4.3 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.

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 Section 2.

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.

Reinforcement

Reinforcement, if required shall be held in the position by clips, bar chairs, or other approved devices.

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 12 m 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 3 mm in 3 m. Standard precast concrete quadrant units shall be used where appropriate.

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.

Curing

Kerbs shall be cured in accordance with the provisions for Section 3.2, Plain and reinforced concrete Clause 4.2.14.

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.

4.6.8 Removal of Surplus Earth

Surplus earth and soil from excavation shall be removed from construction area to the area demarcated by the Employer.

4.6.9 Brick Pitching

4.6.9.1. Excavation

Trench shall be excavated/dressed true to line, section and grade as per approved drawings prior to starting the pitching work.

4.6.9.2. 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.

4.6.9.3. 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.

4.6.10 Traffic Markings

4.6.10.1. 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.

4.6.10.2. 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 plasticized and drying shall be by solvent evaporation alone. It shall have the properties given in Table II given below.

Epoxy resin adhesive shall comply with AASHTO M237

Table II: Paint for Kerbs

Property	**Allowable Limits**
Relative density	1.48 minimum
Viscosity at 21ºC	65 to 70 KU
Drying Time	Approx. 10 –15 min
Coverage	3 m² per litre maximum
Brightness	80 minimum
Flexibility	Passes around 12 mm diameter mandrel
Chlorinated rubber content	9.0%

4.6.10.3. 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.

4.6.10.4. Construction Requirements

General

Traffic shall be kept off markings until the installation has fully cured. 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/m2.

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.

4.7 Storm Water Drainage

4.7.1 General

The intent is to drain the storm water of entire terminal area without any undue pooling and finally water to be let in the river.

4.7.2 Scope

The schematic layout of drainage system is shown in drawings.

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.

c) Storm drain outlets into river including flap gates and related features.

d) Sewage Collection & Transfer system

4.7.3 Materials

4.7.3.1. 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.

4.7.3.2. 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.

4.7.4 Execution

4.7.4.1. 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.

4.7.4.2. 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.

4.7.4.3. Repair and Retesting

Sections of pipe not meeting the pressure test requirements shall have individual joints tested and sealed.

4.7.4.4. 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.

4.7.4.5. Tolerances

Pipe Inverts: Plus 10 mm, minus 10 mm

Catch Basin Grates: Plus 0.00 mm, minus 10 mm

4.7.5 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.

4.7.6 Construction of Catch Basins and Trench Drains

4.7.6.1. 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.

4.7.6.2. Concrete Work

Cast-In-Place Concrete

Prior to placing formwork compact existing in-situ 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.

Precast Units

Prior to placing precast units compact existing in-situ soil and provide a layer of compacted bedding material.

4.7.6.3. 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 trowelled smooth. Prevent mortar from drying out and cure by applying a curing compound. Extensions shall be watertight.

4.7.6.4. 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.

4.7.6.5. Cleaning

Upon completion, clean each structure of all silt, debris, and foreign matter.

4.7.6.6. 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.

4.7.7 Installation of Flap Gate

Install flap gates at locations as per manufacturer's recommendations.

4.7.8 Rainwater Harvesting System

Rainwater harvesting system shall be provided for all the building in the terminal.

4.8 Earthwork

4.8.1 General

This section of the specifications includes requirements for accomplishing all earthworks including filling, anti-termite treatment, riprap and yard grading for this Contract.

4.8.2 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.

4.8.3 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.

4.8.4 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.

4.8.5 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.

4.8.6 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.

4.8.7 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.

4.8.8 Filling & Backfilling Generally

During compaction the backfill as specified in Clauses 4.7.8.1 & 4.7.8.2 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.

4.8.8.1. 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).

4.8.8.2. 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 4.7.8.3 below.

4.8.8.3. 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.

4.8.8.4. Hardstand for Coal & Stone Chips Stockyard and Under Building Floor

Hardstand shall unless otherwise directed consist of gravels/brick ballast/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.

4.8.8.5. 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.

4.8.8.6. 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.

4.8.8.7. 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.

4.8.9 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.

4.8.10 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.

4.8.11 Existing Levels

Before work commences at the site the Contractor shall agree to the existing ground levels with the Employer.

4.8.12 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 Employer before work commences.

4.8.13 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 4.7.8.0 & 4.7.8.1. 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.

4.8.14 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.

4.8.15 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.

4.8.16 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.

4.8.17 Anti-Termite Treatment

The treatment shall be carried out by an approved specialist sub-contractor. The chemicals used shall conform to IS: 8944.

4.8.17.1. 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.

4.8.17.2. 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.

Above clauses 4.7.17.1 and 4.7.17.2 shall be carried out simultaneously to establish the chemical barrier.

4.8.17.3. 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.

Treatment of Critical Areas

Soils under piers, utility pipe openings, floor drains and 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 4.7.17.2 is disturbed/broken, additional treatment to such areas will be necessary.

4.8.17.4. 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. The form of guarantee to be provided is given at the end of this section in Appendix I.

4.8.17.5. 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

4.9 Brick Masonry Works

4.9.1 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.

4.9.2 Materials

Refer specifications under ‘Materials’.

4.9.2.1. 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.

4.9.2.2. 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.

4.9.2.3. 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.

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.

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.

4.9.3 Construction Procedure

4.9.3.1. 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.

4.9.3.2. 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, leaving no pan 1 me lower than the other. If this cannot be adhered to, 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 under sub section 8.3.2.1 and 8.3.2.2. 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 under sub section 8.3.2.1 and 8.3.2.2 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.

4.9.4 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.

4.9.5 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.

4.9.6 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 concrete of 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.

i) Sufficient sills or underpinnings, in addition to base plates, shall be provided, particularly, where scaffoldings are erected on soft grounds.

ii) Adjustable bases to compensate for uneven ground shall be used.

iii) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

iv) Horizontal braces shall be provided to prevent the scaffolding from rocking.

v) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

vi) The scaffolding/staging shall be checked at every stage for plumb line.

vii) 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.

viii) All nuts and bolts shall be the clamps/couplings are firmly tightened to avoid slippage.

ix) 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.

4.9.7 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.

4.9.8 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.

4.9.9 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.

4.9.10 Galvanized Mild Steel Butterfly Wall Ties

For all vertical joints between brick work and concrete galvanized 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 brick wall, the skins shall be tied together with galvanized 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 vertically at ends jambs and quoins.

4.10 Structural Steel Work

4.10.1 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 specification. 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.

4.10.2 Structural Steel

4.10.2.1. Steel Grades

All steel materials supplied by the CONTRACTOR unless otherwise specifically provided for in this Contract shall be new and conform to the requirements of the Specifications and Contract Documents and be approved by the PMC Engineer/Owner prior to use in the Work. All materials necessary for the proper completion of the Work, except those listed as being supplied by the PMC Engineer/Owner, shall be supplied by the CONTRACTOR. Steel shall conform to the following specifications:

Unless otherwise stated all steel shall conform to one of the following grades.

- High Strength Structural Shapes and Plates : IS 2062 Grade E350
- Mild Steel Structural Shapes and Plates : IS 2062 Grade E250 Quality C

- High Strength Structural Steel Pipes : API 5L X52 or equivalent
- Mild steel Structural Steel Pipes : API 5L Grade B or equivalent
- Handrails for Outdoor : API 5L Grade B or equivalent
- Handrails for Indoor : Stainless steel SUS 316L
- All bolts, washers and nuts conforming to IS 1363 Grade 8.8

4.10.3 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.

4.10.4 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".

4.10.5 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”.

4.10.6 Galvanizing

Galvanizing where specified shall be of the best quality conforming to IS: 2629 “Recommended Practice for Hot Dip Galvanizing of iron and Steel”.

4.10.7 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.

4.10.8 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.

4.10.9 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.

4.10.10 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.

4.10.11 Manufacturer's Certification

The PMC Engineer/Engineer's Representative may permit the use, prior to sampling and testing, of certain materials or assemblies when accompanied by manufacturer's certificates of compliance stating that such materials or assemblies fully comply with the requirements of the contract. The certificate shall be signed by the manufacturer. Each lot of such materials or assemblies delivered to the Work shall be accompanied by a certificate of compliance in which the lot is clearly identified.

Materials or assemblies used on the basis of certificates of compliance shall be sampled and tested at any time and if found not to be in conformity with contract requirements shall be subject to rejection whether in place or not.

All steel for the steel work and fasteners shall be supplied with test certificates. The CONTRACTOR shall submit these certificates to the PMC Engineer/Engineer's Representative prior to the supply of the materials. Materials obtained from stocks may be checked by the PMC Engineer/Engineer's Representative for exterior defects either in the workshop or at the site.

Test requirements for the materials to be ordered are specified in IS 2062 and shall include V notch impact tests at 0°C from each quantity of 20 tonnes or part thereof. The results of these tests shall be included in the test certificates.

4.11 Steel/Aluminium Doors, Windows and Ventilators

4.11.1 General

This section of the specification includes the requirements necessary to provide in place all steel/Aluminium doors, windows and ventilators.

4.11.1.1. Indian Standards

IS 6248	Specification for metal rolling shutters and rolling grill
IS 1081	Code of practice for fixing and glazing of metal (steel and Aluminium) doors, windows and ventilators.
IS 4351	Specifications for steel door frames.
IS 1948	Specifications for Aluminium doors, windows and ventilators.
IS 1361	Specifications for steel windows for Industrial buildings.
IS 1038	Specifications for steel doors/windows and ventilators.
IS 1200 (Part XIV)	Method of measurement of glazing.
IS 3614	Specifications for fire check doors.
IS 7452	Specification for hot rolled steel sections for doors, windows and ventilators.
IS 2835	Flat transparent sheet glass.
IS 5437	Wired and Figured glass.
IS 25583	Safety glass.

4.11.2 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).

4.11.3 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 airtight 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. Glasses 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.

4.11.4 Steel Windows & Ventilator

Steel windows, ventilators shall in general conform to IS 1081, IS 1038,IS 7452.

4.11.4.1. Materials

Rolled Steel Sections

Rolled steel sections for the fabrication of steel windows, ventilators shall conform to IS 7452.

Glass Panes

Glass panes for glazing purpose shall be 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 open as 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 dipped galvanizing confining 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.

4.11.5 Rolling Shutters

4.11.5.1. 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.

4.11.5.2. Galvanizing

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 galvanized 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/m² both sides and the coating shall be free from flaking or peeling conforming to IS: 1477-1977 (Part I& II).

4.11.5.3. 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 galvanized 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.

4.11.5.4. 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.

4.11.5.5. 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.

4.11.5.6. 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 workmen's-like manner so that the operation of the shutter is easy and smooth.

4.11.5.7. Grilled Curtain

Wherever specified rolling shutter shall be provided with grilled curtain partly or fully, as required.

4.11.5.8. 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.

4.11.6 Aluminium Glazed Doors/Windows/Ventilators

4.11.6.1. General

Aluminium glazed doors/windows/ventilators shall be of specified sectional size, dimension and profile as per Contractor's drawing.

4.11.6.2. Materials

All Aluminium sections shall be extruded sections of INDAL aluminum 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.

i) 5.5 mm thick wired glass conforming to IS 5437.

ii) 6.3 mm thick laminated safety glass conforming to IS2553.

iii) 5.5 mm thick transparent sheet glass conforming to IS 2835 (wt. 72 kg/sqm)

4.11.6.3. 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. shall be as per drgs.

Side hung window shutters shall either be fixed to the frame with pivots, or aluminum 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 aluminum 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 anodized 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 aluminum 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, aluminum 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 aluminum 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 aluminum (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 aluminum catch plate riveted/welded to the outside of the outer shutter frame bar. Aluminium or cadmium plated brass chord pulley wheel in an aluminum 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 coupling member is fitted over an external opening shutter.

Glazing shall be fixed to the extruded sections by means of extruded aluminum beading. Glass panes shall be provided with rubber lining before fixing.

The aluminum frames shall be fixed to the masonry by means of aluminum lugs fixed to the frame (by counter sunk galvanized 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 aluminum shall be galvanized.

The windows/ventilators/doors shall be checked to ensure smooth operation, perfect level and plumb.

4.12 Steel Sheet Roofing and Siding

4.12.1 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 following Indian Standards:

IS 277:	Galvanized steel sheet (plain& corrugated)
IS 730:	Hook bolts for corrugated sheet rooting.
IS 459:	Specification for unreinforced corrugated and semi corrugated asbestos cement sheets
IS 1230:	Cast iron rainwater pipes & fittings.
IS 1728:	Specification for sheet metal rainwater pipes upto 100 mm nominal size gutters, fittings and accessories

4.12.2 Materials

4.12.2.1. Corrugated GI Sheet Roofing / Cladding

Corrugated GI sheet

G.I. sheets shall be of specified thickness and of class-3 galvanized 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 galvanized 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 galvanized 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 galvanized 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.

4.12.3 Workmanship

4.12.3.1. 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 at least 225 mm. Ridges & hips shall be fixed to the purlins with polymer coated hook bolts, thrust washer and polymer cap. At least 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 end-lap of ridges and hips shall be joined together by at least galvanized 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 weatherproof 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 at least 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.

4.12.3.2. 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 galvanized 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 topcoat of min. 16 microns of specified colour.

Properties

The precoated galvanized 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℃
- 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

4.13 WOODWORK

4.13.1 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.

Prefabricated & 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.

4.13.1.1. Indian Standards

IS:2202-Part I	Specification for wooden flush door shutters (solid core type) plywood face panels
IS:2202-Part II	Specification for wooden flush door shutters (Solid core type) practice board and hard board face panels.
IS:1003 Part - I	Specification for Timber panelled and glazed shutters -Door shutters
IS:3087	Specification for wood particle boards (medium density) for general purposes
IS:3097	Specification for Veneered particles board

IS:848	Specification for synthetic Resin Adhesives for plywood (phenolic and Amino plastic)
IS:205	Specification for non-ferrous metal butt hinges
IS:2338	Code of Practice for finishing of wood and wood based materials (Part-1& Part-11)
IS:1341	Specification for steel butt hinges
IS:4021	Specification for timber door, window and ventilator frames
IS:303	Specification for plywood for general purpose

4.13.2 Material

4.13.2.1. Timber

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 Woodwork

Workmanship for wood and joinery shall be as per 1S:1200 and IS:4021.

Painting / Polishing of Woodwork

Painting/polishing of woodwork shall be in accordance with specifications under ‘Painting’.

4.13.3 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 framework shall be perfect with square edges and shall be pinned with hard wood/bamboo pins of 10 to 15 mm dia.

Woodwork 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 woodwork 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.

4.13.3.1. Shutters

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 4.12.2.1 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.

4.13.3.2. Medium Density Fibre Board Panel Shutter

MDF board panelled shutter shall in general conform to IS: 1003.

Materials

i) MDR-board

Medium density fiberboard 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 categorized 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 4.12.2.1 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 topcoat and undercoat of shade to match the topcoat as recommended by the manufacturer and specified under 'Painting'.

iv) Hinges Specification of hinges shall be same as specified in Clause 4.12.3.1 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.

4.13.3.3. Glazed Wooden Door Shutter

Materials

i) Wood

Teakwood for various members like stiles, rails, etc. shall be as specified-in Clause 4.12.2.1 of this section.

ii) Glazing

Glass sheets for glazing shall be

a) 4 mm thick plain glass (wt. 7.2 kg/m²) 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 4.12.3.1 (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.

4.13.3.4. Fly mesh Shutter for Door and Window

Specifications for Fly mesh 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) Fly mesh 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.

4.13.3.5. 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 recognized 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)

4.13.3.6. 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 galvanized. The shutter shall be supported by hinges as specified in Clause 4.12.3.1(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.

4.13.3.7. 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

d) 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.

4.14 ROOFING TREATMENT

4.14.1 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.

4.14.2 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/cm² 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.

4.14.3 Workmanship

4.14.3.1. 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.

4.14.3.2. 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:

4.14.3.3. 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/m² 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℃)

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 rainwater pipes by at least 100mm.

4.14.3.4. 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 M² 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/rainwater 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).

4.14.4 Guarantee

The applicator shall execute a form of Roofing Treatment Guarantee.

4.15 PLASTERING AND POINTING

4.15.1 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.

4.15.2 Materials

4.15.2.1. Cement

Cement shall conform to specifications under 'Material' unless otherwise specified.

4.15.2.2. 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 does 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 riverbeds 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.

4.15.2.3. Water

Water for plastering and pointing shall conform to specifications under 'Material'.

4.15.2.4. Cement Mortar

Preparation of cement mortar shall conform to specifications under 'Brick Masonry' unless otherwise mentioned.

4.15.3 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 4.14.2.4 above.

4.15.4 Workmanship

4.15.4.1. 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.

4.15.4.2. 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 4.14.4.1 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.

4.15.4.3. Scaffolding/Staging

Scaffolding/staging for plastering/pointing shall be as per specification under Brick Masonry, Clause no. 4.8.6 of Specification.

4.15.4.4. 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.

4.15.5 Plain Cement Plaster

4.15.5.1. Preparation of Mortars

The mortars of specified mix shall be used as per the specifications of "Cement Mortar' described in Clause 4.14.2.4 above.

4.15.5.2. 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 4.14.5.2. 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.

4.15.5.3. 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.

4.15.6 Sand Face Plaster

4.15.6.1. Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in Clause 4.14.2.4.

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 4.14.5.2 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 4.14.5.3.

4.15.7 Exposed Aggregate Finish Plaster

4.15.7.1. Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in Clause 4.14.2.4. 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.

4.15.7.2. 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 4.14.5.2.

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.

4.15.7.3. Curing

Curing shall be as described above in Clause No. 4.14.5.3.

4.15.8 Pointing

Pointing shall be of the type specified such as flush, cut or weather struck, raised and cut etc.

4.15.8.1. 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 4.14.2.4.

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 leveled. 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 4.14.5.3

4.16 Floor Finishing

4.16.1 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 specialized workmen experienced in the respective trade of work.

Reference shall be made to the following Indian Standards:

IS: 4971 Recommendations for selection of Industrial floor finishes

IS: 2114 Code of practice for laying in-situ terrazzo floor finish. IS: 1237 Specification for Cement concrete flooring tiles

IS: 777 Specification for glazed earthenware wall tiles

IS: 2571 Code of practice for laying in situ cement concrete flooring

IS: 4631 Code of practice for laying of epoxy resin floor toppings. IS: 3462 Code of practice for unbaked flexible PVC flooring

IS: 5318 Code of practice for laying of flexible PVC sheet and tile flooring

IS : 3461 Spec for PVC asbestos floor tiles

IS: 1443 Code of practice for laying in situ granolithic concrete floor topping IS: 5491 Code of practice for laying in situ granolithic concrete floor topping IS: 4441 Code of practice for use of silicate type Chemical resistant mortars IS : 4443 Code of practice for use of resin type chemical resistant mortar

IS : 1196 Code of practice for laying Bitumen Mastic flooring

4.16.2 Cement Concrete Flooring General

4.16.2.1. General

Cement concrete flooring shall in general conform to IS 2571. Cement concrete flooring shall consist of a subbase (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 be as per specifications.

The bed for flooring shall be prepared either level or sloped as instructed by Employer.

4.16.2.2. 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 to 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.

4.16.3 Cement Concrete Granolithic Flooring

4.16.3.1. 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.

4.16.3.2. Workmanship

Workmanship shall in general conform to IS : 5491.

Sub-base

Refer Clause 4.15.2.2 above. *Base Course (under-layer)* Refer Clause 4.15.2.2 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 4.15.2.2 above.

Curing

Refer Clause 4.15.2.2 above.

4.16.4 Heavy Duty Flooring

4.16.4.1. General

Heavy duty Flooring in workshop shall consist of a sub-base, a base course and a finishing layer of floor finish.

4.16.4.2. Workmanship

Sub-base

Refer Clause 4.15.2.2 above.

Base Course

Base course shall consist of one layer of cement concrete of specified mix and thickness laid on sub-base in panels in accordance with Clause 4.15.2.2 above.

Floor Finish

Finishing layer shall 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 hardener and four parts of cement by weight shall be mixed dry. This dry mixture shall be mixed with stone grit of 6mm and downsize 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.

4.16.5 Precast Hydraulically Pressed Cement Tiles Flooring

4.16.5.1. Materials

Cement Concrete Tiles

Cement concrete tiles shall conform to IS 1237 and shall be of approved shade, with 10 mm downsize stone aggregates and using a 1:6 or as directed mixture of white and ordinary cement and shall be of specified thickness and approved 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 4.15.2.1 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 s hall 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 titles 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

covered 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.

4.16.6 Cement Plaster Skirting

4.16.6.1. Material

Cement plaster skirting shall be laid with cement mortar as per Clause 4.8.2.1 specification under Brick Masonry Work and shall be of specified proportion and thickness.

4.16.6.2. 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 4.14.4.1, 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.

4.16.7 Cast-In-Situ Terrazzo Flooring

4.16.7.1. 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 specified 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.

4.16.7.2. 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 underlayer. 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 thoroughly 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 spreader 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 with machines and shall start after 7 days of laying. First grinding 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 Clause 4.15.7.2. 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 with carborundum stone of 120 to 150 grit size. The surface shall then be prepared again after first grinding.

The fourth grinding 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 slightly moistened oxalic acid powder @ 33 gm 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.

4.16.8 Cast-In-Situ Terrazzo Skirting and Dados

4.16.8.1. Material

Refer Clause 4.15.7.1 above.

4.16.8.2. Workmanship

Cast-in-situ Terrazzo in skirting and dado shall be of specified thickness and of same shades 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 4.15.7.2 above. Other details shall be same as for flooring excepting grinding which shall be manual.

4.16.9 Precast Hydraulically Pressed Terrazzo Tile Flooring

4.16.9.1. 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 4.15.7.1 above.

Cement Mortar

Refer Clause 4.15.5.1 above.

4.16.9.2. Workmanship

Refer Clause 4.15.8.2 above.

Curing

Refer Clause 4.15.7.2 above.

Grinding and Polishing

Refer Clause 4.15.7.2 above.

4.16.10 Terrazzo Tiles in Risers of Steps, Skirting and Dado

4.16.10.1. Material

Terrazzo Tiles

Same as in Clause 4.15.9.1 above. The average thickness of tiles shall however be 20mm.

Pigments

Same as in Clause 4.15.7.1 above.

Cement Mortar

Same as in Clause 4.15.5.1 above.

4.16.10.2. 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 sand 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 4.15.7.2 above.

4.16.11 Glazed Tiles Work

4.16.11.1. 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 4.15.7.1 above.

Cement Mortar

Same as in Clause 4.15.5.1 above.

4.16.11.2. 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 4.15.7.2 above.

4.16.12 Glazed Tiles in Risers of Steps, Skirting and Dado

4.16.12.1. Materials

Same as in Clause 4.15.11.1 above.

4.16.12.2. Workmanship

Same as in Clause 4.15.11.2 above.

Curing

Same as in Clause 4.15.7.2 above.

4.16.13 Kota Stone Flooring

4.16.13.1. 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.

4.16.13.2. 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 chiseling. Polishing etc. shall be done in accordance with Clause 4.15.7.2 mentioned above except that cement slurry shall not be applied on the surface before each polishing.

4.16.14 Kota Stone in Risers of Steps, Skirting and Dado

4.16.14.1. Materials

Same as in Clause 4.15.13.1 above.

4.16.14.2. Workmanship

Same as in Clause 4.15.13.2 above.

Curing, Polishing and Finishing

Refer Clause 4.15.7.2 above.

4.16.15 Marble Stone Flooring

4.16.15.1. 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 be machine cut to the requisite dimensions.

Pigments

Same as in Clause 4.15.7.1 above.

Cement Mortar

Same as in Clause 4.15.5.1 above.

4.16.15.2. Workmanship

Same as in Clause 4.15.13.2 above.

Curing

Same as in Clause 4.15.13.2 above.

Polishing and Finishing

Same as in Clause 4.15.7.2 above.

4.16.16 Marble Stone in Risers of Steps and Skirting

4.16.16.1. Materials

Same as in Clause 4.15.15.1 above.

4.16.16.2. Workmanship

Same as in Clause 4.15.13.2 above.

Curing, Polishing and Finishing

Same as in Clause 4.15.7.2 above.

4.16.17 P.V.C. Flooring

4.16.17.1. 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.

4.16.17.2. Workmanship

Preparation of Base

The preparation of sub-base and base course shall be same as in Clause 4.15.2.2.

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 liters of warm water or detergent as per approved manufacturer's specifications.

4.16.18 Acid Resistant Tiles in Floors

4.16.18.1. Material

The tiles shall be vitrified ceramic tiles and shall be homogeneous. They shall have the following properties:

S.No	Characteristics	Value Required	Norms
1	Water Absorptions	+ 0.5%	ASTM C 373
2	Scratch Resistance	> 6	ASTM C 373
3	Chemical Resistance	Unaffected	ASTM C 650
4	Abrasion Resistance	> 100	ASTM C 501 (Hardness)

5	Breaking Strength	1400 kg/sq.cm	ASTM C 648
6	Density	> 2.0 Gm/CC	

4.16.18.2. Workmanship

The base course shall be in accordance with Clause 4.15.2.2 and background surface shall be prepared as per Clause 4.15.13.2 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.

4.16.19 Epoxy Floor Coating

4.16.19.1. 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.

4.16.19.2. 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.

4.16.19.3. 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

4.17 Painting

4.17.1 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.

Indian Standards

IS 712 Specification for building limes.

IS 55 Specification for Ultramarine blue for paints. IS 63 Specification for whiting for paint and putty. IS 427 Distemper (dry), colour as required.

IS 428 Distemper (Oil Bound), colour as required.

IS 5410 Cement paint, colour as required. IS 384 Brushes, paints and varnishes, flat

IS 486 Brushes, sash, tool, for paints and varnishes.

IS 110 Ready mixed paint, brushing, grey filler enamels for use over primers. IS 426 Paste filter for colour coats.

IS 345 Wood filler, transparent liquid.

IS 3585 Ready mixed paint, aluminum brushing priming water resistant for woodwork

4.17.2 White Washing

White washing in general shall confirm to IS 6278.

4.17.2.1. 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 whitewash is to be applied.

Surfaces already white/colour washed shall be broomed down to remove all dust, dirt, loose scales of whitewash 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 sqm. 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 Whitewash

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 utter marine 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

Whitewash 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 whitewashed shall be protected from being splashed upon. Such surfaces shall be cleaned of whitewash splashed if any.

4.17.3 Colour Washing

4.17.3.1. Workmanship

Scaffolding

Scaffolding shall be as per Clause 4.16.2.1 above.

Preparation of Surface

Refer Clause 4.16.2.1 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 whitewash solution shall be prepared in accordance with above Clause 4.16.2.1. Mineral colours of approved shade and quality not affected by lime shall be added to the whitewash 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 whitewash solution.

Application of Colour Wash

Application of colour wash shall be in accordance with above Clause 4.16.2.1.

Protective Measure

Same as in Clause 4.16.2.1 above.

4.17.4 Dry Distempering

4.17.4.1. Workmanship

Scaffolding

Same as m Clause 4.16.2.1 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 4.16.2.1.

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 at least 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 4.16.2.1 above.

4.17.5 Oil Bound Distempering

4.17.5.1. Workmanship

Scaffolding

Same as in Clause 4.16.2.1 above.

Preparation of Surface

Preparation of surface shall in general be in accordance with above Clause 4.16.4.1 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 4.16.2.1 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 at least 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 4.16.2.1 above.

4.17.6 Waterproof Cement Paint

4.17.6.1. Workmanship

Scaffolding

Same as in Clause 4.16.2.1 above.

Preparation of Surface

Preparation of surface shall be in accordance with Clause 4.16.2.1. 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 manufacturer's 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 at least two days following the final coat.

Protective Measure

Same as In Clause in 4.16.2.1 above.

4.17.7 Acrylic Emulsion Painting

4.17.7.1. Workmanship

Scaffolding

Same as in Clause 4.16.2.1 above.

Preparation of Surface

Same as in above Clause 4.16.5.1 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

i. 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.

ii. No oil base putties shall be used in filling cracks/holes.

iii. Washing of painted surface shall not be done within 3-4 weeks of application.

Protective Measures

Same as in Clause 4.16.2.1 above.

4.17.8 Acrylic Copolymer Aggregate Finish

4.17.8.1. Material

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.

4.17.9 Painting to Woodwork

4.17.9.1. Preparation of Surface

Preparation of surface shall conform to IS 2338 (Part-1) in general. All woodwork 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 woodwork.

Particle board's 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 at least 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-l)

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 hessain 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 linseed oil, but, usually consist of insoluble, semi-transparent pigments ground in linseed 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 sandpaper 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.

4.17.10 Painting To Steel and Other Metal Surface

4.17.10.1. General

Items to be Painted

All structural steel work and metals including handrails, brackets and steel inserts shall be painted except if otherwise specified.

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.

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 galvanized 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.

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)

d) Total System Thickness = 250 m DFT without Strip Coat

e) 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.

f) 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.

4.17.10.2. 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, sandpaper 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.

4.17.10.3. 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.

4.18 Sanitary and Plumbing Works (Buildings)

4.18.1 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.

4.18.2 By-Laws and Regulations

The installation shall be in conformity with the By-laws, Regulations and Standards of the local authorities concerned, 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 By-laws and Regulations, then the By-laws and regulations shall govern the requirement of this installation.

4.18.3 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.

4.18.4 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 Employer.

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.

4.18.5 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.

4.18.6 Water Supply

4.18.6.1. G.I. Pipes & Fittings

G.I. Pipes

All pipes for water supply inside the building shall be genuine galvanized 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 galvanized 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:

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 protect 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 pipe coat primer and pipe coat 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.

Pipe coat 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 pipe coat primer shall essentially be in a layer for quicker drying.

The surface shall be dry at the time of applying pipe coat 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 pipe coat 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.

Pipe coat primer shall be applied with brushes after cleaning the pipe thoroughly. Pipe coat 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.

4.18.6.2. 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.

4.18.6.3. 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.

4.18.6.4. Laying and Jointing G.I. Pipes (Internal Work)

Cutting, threading ad jointing – Ref. Clause 4.17.6.1.

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.

4.18.7 Soil, Waste, Vent and Rainwater Pipes and Fittings

4.18.7.1. 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 rainwater 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 and 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 galvanized 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.

4.18.7.2. 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.

4.18.7.3. 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.

4.18.7.4. Jointing

a) All joints for CI soil waste and vent pipes conforming to IS:1729/IS:3989 shall be made with malleable 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.

b) 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.

4.18.7.5. 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.

4.18.8 Sanitary Fixtures and Fittings

4.18.8.1. 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.

4.18.8.2. 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.

4.18.8.3. 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.

4.18.8.4. Sanitary ware

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.

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- siphonage 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.

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.

Wash Basin

Wash basin shall be flat back of 550 mm x 400 mm size with one tap or two tap holes 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 aluminum 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.

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 aluminum beading all around. It shall be fixed to the wall on wooden blocks with CP brass screws and CP washers.

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.

Towel Rail

Towel rail shall be of aluminum/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.

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. *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.

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.

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.

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.

HCI 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.

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.

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.

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.

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.

4.19 Water Supply and Distribution System

4.19.1 General

This specification covers the installation and commissioning of the complete water supply distribution system within the terminal area including the supply of potable water to ferry and buildings and the supply of raw water for landscaping and greenery.

4.19.2 Material

4.19.2.1. Pipe

Piping for supply and distribution lines shall be HDPE pipes conforming to IS: 4984.

4.19.2.2. 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.

4.19.3 Execution

4.19.3.1. Installation

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.

Adjacent Facilities

Water Lines

Water lines shall not be laid in the same trench with sewer lines, gas lines, fuel lines, or electric wiring.

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.

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 + 5 mm.

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 re-laid. 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.

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.

4.19.3.2. 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 kilometer, 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.

4.19.3.3. 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

4.20 Sewerage Collection & Transfer System

4.20.1 General

The intent is to install a sewerage system in the yard area to cater to the collection and transfer of sewage generated from Buildings.

4.20.2 Scope

The scope covers collection of all sewerage from all terminal buildings/sheds to the collection pit/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, labor, 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.

4.20.3 Material

4.20.3.1. 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.

4.20.3.2. 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.

4.20.3.3. Septic Tank

A septic tank is a combined sedimentation and digestion tank where the sewage is held for one to two days. This shall be provided at suitable location. 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.

Design

Septic tank shall be watertight, 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. The sizes of the septic tank shall be based on IS: 2470 (Part I).

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.

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

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.

4.20.4 Execution

4.20.4.1. 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.

4.20.4.2. 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.

4.20.4.3. Repair and Retesting

Sections of pipe not meeting the pressure test requirements shall have individual joints tested and sealed.

4.21 Berthing Appurtenances

4.21.1 General

This specification includes requirements for furnishing, constructing and placing all berth appurtenances complete in all respects including but not limited to the following:

Fenders Bollards Ladders Mooring Rings Rubbing strip Edge angles Handrails Expansion joints Drain-pipes

4.21.2 Fenders

For the berthing pontoons, suitable type of fenders of Trelleborg make or any other equivalent fenders shall be used.

The supplier of the fenders should be actively involved in erection of fenders.

4.21.2.1. Materials

Rubber

The material used for the fender shall be natural or synthetic rubber of high quality having sufficient resilience, anti-aging, weather-resistant and wear-resistant properties to meet all normal service conditions. The material shall be homogeneous without any defects, impurities, pores, cracks etc. and generally have the following properties:

PROPERTY	TEST STD & CONDITION		CRITERION	EQUIVALENT INTERNATIONAL STD		
				ASTM	BS ISO	DIN
TENSILE STRENGTH	JIS K6251 NO. 3 DUMBBELL	BEFORE AGING AFTER AGEING 70 DEG X 96 HRS	16 MPA MIN. MORE THAN 80% TO ORIGINAL	D412	BS ISO 37 BS 903 A3*1	DIN 53504
ELONGATION		BEFORE AGING AFTER AGEING 70 DEG X 96 HRS	360% MIN. MORE THAN 80% TO ORIGINAL			

PROPERTY	TEST STD & CONDITION		CRITERION	EQUIVALENT INTERNATIONAL STD		
				ASTM	BS ISO	DIN
HARDNESS	JIS K6253 DUROMETER A	BEFORE AGING AFTER AGEING 70 DEG X 96 HRS	82 MAX.LESS THAN +8 TO ORIGINAL	D2240	BS ISO 48 BS 903 A26*1	DIN 53505
AGEING	JIS K6257	70 DEG X 96 HRS		D573	BS ISO 188 BS 903 A19*1	DIN 53508
COMPRESSION TEST	JIS K6262	70 X 24 HRS	30% MAX	D395	BS ISO 815-1BS 903 A6*1	DIN53517
TEAR RESISTANCE	JIS K6252	CRESCENT TYPE	70N/MM MIN	D624	BS ISO34-1BS 903 A3*1	DIN53507
ABRASIVE WEAR	JIS K6264	AKRON METHOD	1.5CC MAX	D5963-04	BS ISO 4649 BS 903 A9	DIN 53516
BOND STRENGTH	JIS K6256-2	90 DEGREE	7N/MM MIN.	D429	BS 903 A21.1	
SEA WATER RESISTANCE	JIS K6258	3% NACL SOLUTION 23 DEG X 24 HRS	VOLUME CHANGE +10%/-5% MAX. HARDNESS CHANG	D471	BS ISO 1817 BS 903 A16*1	
OZONE RESISTANCE	JIS K6259	50PPHM 20% ELON. 40 DEG X 72 HRS	NO CRACK	D1149	BS ISO 1431-1 BS 903 A43*1	DIN 53509
DENSITY	JIS K6268		1.1 g/cc to 1.30 g/cc	D1817	BS ISO 2781 BS 903 A1*1	

Accessories

The materials for fender accessories shall generally conform to the following requirements

i) Protector (Frontal) Panels Frame shall be made of rolled steel to ASTM A441 or equivalent

ii) Bolts, nuts, and washers used for fixing the Protector Panel Frame to the Fender Body shall be of stainless steel to AISI 304 or equivalent

iii) Shackles and turnbuckles where required shall be galvanized carbon steel to ASTM A 575 Gr. 1025 or equivalent

iv) The chain and its components shall be sized to withstand the maximum loads with a minimum factor of safety of three on breaking strength, but with a stock size of not less than 30 mm. Suspension chains shall have provisions for field adjustment. All chains and pad eyes for attaching chains shall be hot dip galvanized carbon steel to ASTM A 575 Gr. 1025 or equivalent subject to approval of the Employer

v) U-anchor where required shall be of stainless steel to AISI 304 or equivalent

vi) The material for resin anchor sleeve shall be made of synthetic resin and proved satisfactory to the following requirements

Physical Properties:

Tensile Strength (23oC) - Min 300 kg.sq. cm ASTM 638

Water absorption (weight change) - Max 3%
Chemical resistance to 10% NaCI - Max 1%
(weight change)

Elongation (23oC) - 20% ASTM 638

vii) The anchor bolt shall be made of stainless steel to AISI 304

viii) Frontal pads shall be provided with low function UHMP protective pads Dispatch of Fenders. Fenders shall not be dispatched from manufacturer's works to the Site without the written Employer of the Employer.

4.21.2.2. Performance Verifications

All testing shall define fender performance under linearly decreasing or sinusoidal-decreasing deflection velocities to simulate actual, vessel-berthing conditions.

Rated Performance Data (RPD), manufacturer's published performance curves and/or tables, shall be based on:

a) Initial berthing velocity of 0.25 m/s and decreasing to no more than 0.005 m/s at test end

b) Testing of fully broken-in fenders.

c) Testing of fenders stabilized at 23C ± 5C

d) Testing of fenders at zero degree angle of approach e) Berthing frequency of not less than one hour

Catalogues shall also include nominal performance tolerances as well as data and methodology to adjust performance curves and/or tables for application parameters

different from RPD conditions. Adjustment factors shall be provided for initial velocities, temperatures and contact angles.

Adjustment factors for velocity and temperature shall be provided for every catalogue rubber compound or other energy-absorbing material offered by each manufacturer.

4.21.2.3. Fender Testing

Performance testing to establish design data may use either of two methods as mentioned in PIANC Guidelines for the Design of Fenders Systems–2002.

The traditional and widely used Constant Velocity (CV) Method and

Decreasing Velocity (DV) Method

4.21.2.4. Test Apparatus

The test apparatus shall be equipped with a calibrated load measuring device such as load cell(s) or pressure transducer and linear transducer(s) for measuring displacement capable of providing continuous monitoring of fender performance.

The test apparatus shall be capable of recording and storing load-cell and transducer data at intervals of 0.01H-0.05 H, where H is a fender's nominal height, and storing manually-entered inputs. Also information related to serial nos., date, time at start, test ambient temperature etc. shall be furnished.

For fender tests, all equipment used to measure and record force and deflection shall be calibrated, and certified accurate to within ± 1(one) percent in accordance with ISO or equivalent JIS or ASTM requirements. Calibration shall be performed within one year of the use of the equipment, or less, if the normal calibration interval is shorter than one year. Calibration of Test Apparatus shall be checked annually by a qualified third-party organization, using instrumentation, which is traceable to a certified, national standard.

4.21.2.5. Test Protocol

The performance test shall deflect specimens according to either of the two methods, Method CV or Method DV. Clear and unambiguous calculations must be provided for any adjustments made to the test results.

4.21.2.6. Supporting Protocols

Supporting Protocols shall cover temperature stabilization, Velocity Factor (VF) and Temperature Factor (TF) as mentioned in PIANC Guidelines for the Design of Fenders Systems – 2002.

4.21.2.7. Verification/Quality Assurance Testing

Energy/Reaction Compliance Testing

Samples for verification testing shall be actual fender elements fabricated for the project following the PIANC Guidelines for the Design of Fenders System – 2002.

A minimum of ten percent of the fender order shall be tested for compliance with energy/ reaction requirements.

Break in Deflection

Break-in deflection of actual elements should be at least manufacturer rated deflection. At least one cycle should be performed.

Other Testing

Effect of contact angle and durability tests should be carried out as per PIANC Guidelines for the Design of Fenders Systems – 2002 recommendations.

4.21.2.8. Dimensions

Fenders shall meet manufacturer's specified dimensional tolerance.

4.21.2.9. Steel frame, Frontal Frame, Hardware, Chains and Related Accessories

All steel hardware for securing of fenders shall be stainless steel grade AISI 304 or equivalent.

All hardware shall be of sufficient capacity to safely resist all normally anticipated loading conditions. Chain anchor assemblies shall be designed to resist the maximum loads with a minimum factor safety on breaking strength and concrete pillion of four.

4.21.3 Bollards

4.21.3.1. General

Cast Steel bollards to be installed on the berthing pontoons as required for the spectrum of vessels to be berthed and they should not be protruding out. The bollards have to withstand sudden jerking effect from ropes connected to vessels and to resist rubbing effect of ropes on its sides. For the proposed Jetty minimum 10 T capacity bollards shall be provided.

The Contractor shall provide bollards of suitable type at all locations of jetty.

Painting and numbering of the bollards shall be done.

4.21.3.2. Standards and Codes

The following latest editions of standards and codes or approved equivalent international codes shall be followed for the manufacturing and testing of cast steel bollards.

IS 1030 - Specifications for carbon steel casting for general engineering purposes

IS 1387 - General requirements for supply of metallurgical materials

IS 3664 - Code of practice for ultrasonic Pulse Echo Testing by contact & Immersion methods

IS 1599 - Method for bend test for steel products other than sheet, strip, wire & tube

IS 1608 - Method of tensile testing of steel products

4.21.3.3. Classification

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.) Chemical composition:

The limit for Sulphur and phosphorous in the steel when analyzed shall be as follows:

Sulphur : 0.05% max.

Phosphorous : 0.5% max.

4.21.3.4. Specifications for Casting

4.21.3.5. 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, and uniformity, correct grain size to develop shock resistance properties and to avoid any blow-holes.

4.21.3.6. 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.

4.21.3.7. 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 to the Employer, the method of heat treatment and all relevant records.

4.21.3.8. 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.

4.21.3.9. 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.

4.21.3.10. 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.

4.21.3.11. Testing

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.

Type of Test

i) 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

ii) 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.

iii) 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.

iv) 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.

v) 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.

vi) 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.

vii) 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.

4.21.3.12. Bolts, Nuts and Washers

All anchor bolts, nuts and washers shall be of stainless-steel conforming to AISI 304 or equivalent.

4.21.3.13. Fixing Details

The Contractor shall submit the detailed fixing arrangements of the bollard to the deck with full details of bolt etc. to the Employer for his approval.

The Contractor shall submit the following documents and certificates at suitable time for the approval of Employer

Drawing showing the complete details of cast steel bollard.

Drawing showing the fixing arrangements of bollard in the deck of the berth. All relevant test certificates.

4.21.4 Ladders

Ladders shall be provided on the berth face either in grooves without protruding outside the berth face or providing fender bars on either side of the ladder if it is protruding outside the berth face. Design & location of these shall be planned in such a way that shall not interfere with the ship's mooring operations.

The ladders and connecting hardware shall be made of zinc metallized steel, steel grade St 37-2, DIN 17100 or equivalent and approved by the Employer, hot dip in factory to achieve a commercial coating of not less than 600 g of zinc per square meter.

4.21.5 Rubbing Strip

Wooden / Galvanized iron rubbing strip complete in all respects shall be provided as instructed by the Employer at relevant locations of the berthing pontoon suitably. Painting of the same shall be done.

4.21.6 Edge Angles

Galvanized iron edge angles shall be provided at the edges of the berthing pontoon and painting of the same shall be done.

4.21.7 Drain Holes

The Contractor shall provide drain holes on the deck of dolphins for berthing pontoons and dolphins for intermediate pontoons to drain surface water. Drain holes shall be by pipes of sufficient diameter through the deck.

4.21.8 Life Saving Equipment

Lifesaving equipment shall be provided as per the international standard at regular intervals along the waterside area. Life-saving equipment shall be a "Perri-buoy" life buoy or equivalent approved with lines and shall comply with Safety in Docks - Docks Regulations 1988 and Guidance by UK Health & Safety Commission in all respects.

4.21.9 Expansion Joints

Expansion Joints at suitable interval shall be provided to the satisfaction of the Employer.

4.21.10 Information Technology Systems

4.21.10.1. IT Architecture

For Project Facilities the IT architecture will have the following components: Business systems for Terminal.

TAS- Terminal Administrative System/ERP System.

Ticketing System –SMS ticket service, online ticket facility by mobile app with the help of QR code scanner.

System Software – Operating Systems,
Database. IT Infrastructure & Facility
Management.

Business Intelligence/ Data
Warehousing. Networking –Wired &
Wireless.

Hardware Systems (Servers, Storage, Desktops/Laptops) ISP Connectivity

Backup & Recovery systems

BCP/DR.

5 SPECIFICATIONS – ELECTRICAL, CONTROLS AND AUTOMATION

5.1 Electrical Equipment

5.1.1 HT Switchgear

5.1.1.1. 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 26.3kA for 3 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.

5.1.1.2. 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, busbars, 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.

5.1.1.3. Bus and Bus Taps

Main buses and connections shall be of high conductivity aluminum, sized for specified current ratings with maximum temperature limited to 90℃. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm². The busbars shall be designed for a short circuit rating of 26.3kA for 3 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.

5.1.1.4. 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 26.3kA. 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 Signalling 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.

5.1.1.5. 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 pickup 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.

5.1.1.6. 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.

5.1.1.7. 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

5.1.1.8. 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.

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.

5.1.1.9. 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.

5.1.1.10. 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.

5.1.1.11. 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.

5.1.1.12. 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.

5.1.1.13. 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.

5.1.1.14. 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 background. 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.

5.1.1.15. 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 sockets. 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.

5.1.1.16. 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.

5.1.1.17. Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.2 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 +3% to -5% 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℃ ov er 45℃ ambient
Parallel operation of transformer	: Yes, only momentary
Short circuit withstand duration	: 2 seconds
11kV System fault level	: 26.3kA for 3 sec

415V System fault level : 50kA for 1 sec

5.1.2.1. 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.

5.1.2.2. 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.

5.1.2.3. 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^{o}C or better.

5.1.2.4. 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.

5.1.2.5. 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, weatherproof, 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.

5.1.2.6. 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.

5.1.2.7. 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.

5.1.2.8. 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-energized operation only' shall be fitted.

5.1.2.9. 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.

5.1.2.10. 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.

5.1.2.11. 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

5.1.2.12. 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.

5.1.2.13. Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.3 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 45ºC. 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/mm² and for Copper busbars as 1.25 Amps/mm².

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 online 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.

5.1.4 Design and Construction

5.1.4.1. 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.

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 3KA. The capacity of the transformer shall be decided such that there is at least 20% margin over the total lighting load.

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. 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.

5.1.4.2. 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.

5.1.4.3. 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.

5.1.4.4. 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.

5.1.4.5. Contactors

Motor starter contactors shall be air brake, 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.

5.1.4.6. 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.

5.1.4.7. 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.

5.1.4.8. Push Buttons

Pushbuttons 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 500V AC. All pushbuttons shall have two normally open and two normally closed contact, unless specified otherwise. The contact faces shall be of silver alloy. All pushbuttons shall be provided with integral escutcheon plates marked with its function. All emergency pushbuttons 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.

5.1.4.9. Indicating Lamps

Indicating lamps shall be of the panel mounting, LED type .The lamps shall have escutcheon plates marked with its function, wherever necessary. 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

5.1.4.10. 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

5.1.4.11. 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.

5.1.4.12. Power Cable Termination

Cable termination compartment and arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminum 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.

5.1.4.13. 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.

5.1.4.14. 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 aluminum 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 aluminum 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℃. All horizontal and vertical busbar joints shall be covered by insulating shrouds.

5.1.4.15. 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.

5.1.4.16. 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 Pushbuttons 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

5.1.4.17. 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.

5.1.4.18. Spares List

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.5 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.

5.1.5.1. 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 correction scale	2 Nos per Battery
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 above items	2 Nos per Battery

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.

5.1.5.2. 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 another 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 overload
- 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.

5.1.5.3. 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.

5.1.5.4. Spares List

Suitable number of commissioning and successful running for 2 years spares list shall

be submitted for approval.

5.1.6 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 drops 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 : 26.3 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, aluminum 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 aluminum wire. For multicore armoured cables, armouring shall be of galvanized steel strip/wire as per applicable IS.

Outer sheath shall be of PVC black in colour having followed 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 into the PVC compound of the outer sheath.

5.1.6.1. Construction

HT cables

Cables shall be XLPE insulated, screened, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed , stranded aluminum 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.

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 aluminum conductor conforming to IS: 7098 Part-I.

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.

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.

5.1.6.2. 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.

5.1.6.3. 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.

5.1.6.4. 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.

5.1.6.5. 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

5.1.6.6. Spares List

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.6.7. Lighting System

This specification covers the requirements of Illumination system. The lighting system includes

- 100% Normal AC lighting
- Internal Lighting Load 100% on DG set & 20% external (High Mast Load) on main power failure
- Emergency lighting through battery backed 5 Watt LED lantern with dimming and SOS feature in selected areas of the terminal during terminal emergency conditions.

Normal AC Lighting shall be energized 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.

Battery operated emergency lighting unit consist of aesthetically designed rechargeable 5 Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type & 5V DC Li-ion charger with 1 hour battery backup in Electrical Substation, RIO/Compressor Room, Terminal Admin Building, Worker's Amenity Building, areas near local panels, staircases and other strategic areas during AC supply failure to ensure

minimum 10 Lux in all required buildings, conveyor galleries, all exit / entry points etc.,. Emergency lighting shall normally be “off,” and upon loss of normal AC supply, emergency lights shall be turned “on” in auto mode.

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. 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

All receptacles shall be of high quality Polyamide P-6 body (shock proof, rust free, corrosion free, acid and chemical resistant, fire retardant, having high impact, made of halogen and silica free recyclable material) & terminals with Solid high-quality turned contacts made of copper alloy (Brass). All steel components (screws, springs etc) shall be Zinc plated & blue-chromed or nickel plated. For each contact double screws shall be available to give better cable strain relief. It shall be heavy duty type, IP67 suitable for fixing on wall/column and complete with individual switch.

In general, the receptacles to be installed shall be of the following type:

Power Socket - 15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having 19 mm conduit entry and a metallic screwed cover tied to it with a metallic chain and suitable for indoor & outdoor installation in Control room building & Local Control rooms etc.

Welding Socket - 63A, 415V, 3 Ph, 4 Wire, 5 pin interlocked plug and switch with earthing contact to be used in transfer towers and along the Conveyor length. Other requirements shall be same as type RA. Welding sockets shall not be connected to lighting distribution board and shall get supply from feeders in the MCC/ACDB/PDB. For long conveyor feeders shall be provided from MCC/ACDB/PDB at head end (for 50% load) and from tail end (for 50% load) at interval of 100M.

Suitable number of 63 ampere, 3 phases, 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.

15A, 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 Fixture	:	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.

Receptacles

- Power Socket - 15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having 19 mm conduit entry and a metallic screwed cover tied to it with a metallic chain and suitable for indoor & outdoor installation in Control room building & Local Control rooms etc.

- Welding Socket - 63A, 415V, 3 Ph, 4 Wire, 5 pin interlocked plug and switch with earthing contact to be used in transfer towers and along the Conveyor length. Other requirements shall be same as type RA. Welding sockets shall not be connected to lighting distribution board and shall get supply from feeders in the MCC/ACDB/PDB. For long conveyor feeders shall be provided from MCC/ACDB/PDB at head end (for 50% load) and from tail end (for 50% load) at interval of 100M.

5.1.7 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 & fireproof 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 topmost 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

5.1.7.1. 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.

5.1.7.2. 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.

5.1.7.3. 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 meters. Risers shall additionally be painted/stenciled with identification numbers at every floor. Tray covers shall be provided for overhead cable trays on topmost 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.

5.1.7.4. 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.

5.1.7.5. Spares List

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.8 415V Silent Diesel Generator Set

The output from the unit shall be 250KVA (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 : 45ºC
- Relative humidity : Above 90%
- Altitude : Sea-level

5.1.8.1. 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 24V 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 (20ºF to 110ºF) 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.

5.1.8.2. 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.

5.1.8.3. 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.

5.1.8.4. 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 hours 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.

5.1.8.5. 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.

5.1.8.6. 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.

5.1.8.7. 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.

5.1.8.8. Alternator

Alternator shall be air cooled, brushless, 3 phases, 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

5.1.8.9. 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

C) 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

D) 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

5.1.9 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.

5.1.10 415V Capacitor Bank with Automatic Power Factor (PF) Correction Control Panels

415V Automatic Power Factor Control Panels shall comprise of Air circuit breaker, sets of Fuse & Contactors for each capacitor bank, PF Meter, Automatic PF Correction Relay, Capacitor Banks (Heavy Duty, Delta 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.

5.1.11 Solar Panel System

5.1.11.1. Purpose

Purpose of this specification is to describe the minimum technical requirement for design, engineering, purchase of all bought out items, manufacturing, testing at manufacturer's works, properly packed for transportation, supply at site, installation, testing, commissioning, putting into successful commercial and trouble free operation of the solar power generation system which will be used for Terminal Building.

5.1.11.2. Design basis

The solar system will be used for generating the electrical power from a designated area on roof top of linkspan and capable to generates 20 Kw power. This power shall be used for terminal building till the time this power is available. When the solar power is not available i.e. during the nighttime and rainy day, the aforesaid consumers will use grid available power supply. Standby diesel generator set is also available for this area. This will supply power when both the normal grid supply and solar supply is not available. That means Building has three (3) types of power supply sources. Necessary integration and synchronization of the solar power generation system with normal grid supply and diesel generator supply shall be done by the solar power supply system contractor. Solar power will be generated at 415 V, 3 phase, 50 Hz, AC. To generate that voltage, necessary design of the solar inverter shall be done by the solar contractor. During non-availability of solar power, the inverter shall be disconnected from the system and as soon it will start generating power and after crossing a threshold limit, the inverter shall be automatically synchronized with the main power

supply system. Complete design calculation including estimation of the available power at various cases, shadow analysis and array layout preparation based on the analysis shall be done by the contractor.

5.1.11.3. Specific requirements

a) PV Solar Module

- Solar PV modules shall consist of required number of crystalline PV cells.
- PV modules shall be made and tested according to IS 14286, IEC 61215 and IEC 61730.
- These PV modules shall be used in riverine environment throughout their lifetime and these shall meet the requirement of 61701.
- The total solar PV array capacity should not be less than allocated capacity (kWp) and should comprise of solar crystalline modules of 250 Wp and above wattage.
- Surge protective device at the PV module shall be provided. Low voltage drop bypass diodes shall be provided.
- The module frame shall be made of corrosion resistant materials, preferably having anodized aluminium.
- The rated output power of any supplied module shall have tolerance within +/-3%.
- The peak-power point voltage and the peak-power point current of any supplied module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings, as the case may be.
- The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weatherproof lid with captive screws and cable gland entry points or may be of sealed type and IP-65 rated.

a. PV solar module

b. Module mounting structure

c. Inverter

d. DC and AC cables

e. Data acquisition and Plant monitoring

f. Earthing and Lightning protection

g. Distribution board, Junction boxes and all other accessories

5.1.12 List of Approved Makes

S. No.	Equipment / Component	Preferred Makes
1.	HT Switchgear	Adlec (Schneider) / SPC Electrotech (L&T) / RISHA (L&T) / NITYA

S. No.	Equipment / Component	Preferred Makes
		(Siemens)/Schneider/Siemens/L&T
2.	LT Switchgear	Adlec (Schneider) / RISHA (L&T, ABB) / SPC Electrotech (L&T) / Vidhyut Control (L&T) / NITYA (Siemens)/Schneider/Siemens/L&T
3.	Distribution Boards	SPC Electrotech (L&T) / NITYA (Siemens) / RISHA (L&T, ABB) / Adlec (Schneider)
4.	Distribution Transformer	Areva / Emco / Crompton / BHEL / Voltamp / Bharat Bijlee / PETE Hammond
5.	HT cables	Havells / Ravin / Gemscab / Gloster / Paramount
6.	LT Power cables	Havells /Ravin / Gemscab / Gloster / Grandlay / Paramount
7.	Control Cables, Wires & Flexible cables	Havells / Gemscab / Ravin / Gloster / Grandlay / Paramount
8.	Copper Wires PVC FRLS	Skytone / Echo Cables / National / Finolex / Polycab
9.	Cable Glands/Lugs	Jainsons / Dowells / Gripwell / SMF
10.	Cable Trays (FRP)	Ercon / Indiana / Sumip Composites / Sintex
11.	Capacitor Panel with Banks and other related accessories	L&T / Epcos / Schneider / ABB / Asian / Madhav / Havells
12.	Battery	Exide / Amco / Amara Raja / Chloride / HBL
13.	Battery Charger with DCDB	Chhabi Electricals / Caldyne / Mastek / DB Electronics / HBL
14.	Diesel Generator Set	Powerica / Jakson / Sudhir/ Greaves
15.	Alternator	Crompton Greaves / Kirloskar / Stanford
16.	Lighting fixture with street light poles	Bajaj / Philips / GE Lighting / Havells / Pharox / Surya
17.	High Mast	Bajaj / CGL / Philips / Surya
18.	Plate-Switches & Sockets, Boxes	MK / Crabtree (Havells) / Anchor
19.	GI Conduit with accessories	BEC / AKG / SENCO / Jindal
20.	VCB	Siemens / L&T / ABB / Schneider
21.	ACB	Siemens / L&T / ABB / Schneider
22.	MCCB	Siemens / L&T / ABB / Schneider
23.	MCB / ELCB / RCB / MPCB	Siemens / L & T / MDS / Schneider / Havells

S. No.	Equipment / Component	Preferred Makes
24.	Fuse/Link	Siemens / L&T / Alstom / Schneider / C&S / Areva
25.	Switch Fuse Units	Siemens / L&T
26.	Contactors	Siemens / L&T / ABB / Schneider
27.	Indicating Lamps / Push buttons	Siemens / Schneider / Teknic / Kaycee / L&T / Essen / Vaishnav / BCH / C&S
28.	Push button stations	Siemens / Schneider / Teknic / Rishabh / L&T / BCH / Control Group
29.	Meters (digital) MFM	Schneider (Conzerv) / L&T / Secure
30.	Voltmeter / Ammeter / PF Meter / Frequency Meter/ KWH Meter	AEI / IMP / MECO / INDCOIL / Enercon / L&T / Rishab / Siemens / Industrial Meters
31.	Selector Switch	L&T / Siemens / Schneider / Kaycee / Salzer / C&S / Vaishnav
32.	Auxiliary Contactors/ Relays	L&T / Siemens / BCH
33.	Overload Relays (Hand Reset Type)	L&T / Siemens / BCH / Telemachanique
34.	Protective/Auxiliary Relays	Areva / Schneider / Siemens / EasunReyroll / ABB / Telemechanique / L&T
35.	Time Delay Relays	BCH / Siemens / L&T / English Electric
36.	Power Contactor with 2NO+2NC	L&T / Siemens / Telemechanique
37.	Timer	Siemens / L&T / BCH / Schneider
38.	Terminal Blocks	Elmex / Connect Well
39.	Current Transformer/ Potential Transformer	AE / Kappa / L&T / Siemens / Pragati
40.	Switches & Sockets	Havells / Legrand /Anchor/Roma
41.	Power & Welding Sockets	Hensel/Mennekes/Walther
42.	PVC Conduit and accessories	BEC / Polypack / Precision /AKG
43.	Cable Termination Kits & Straight Through Joints	Raychem / M-Seal (3M)
44.	Motors	BHEL / Kirloskar / Crompton / Siemens / Havells
45.	Chemical Earthing	Ampere Protection / JK Earthing / JMV/OBO/Uniearth

S. No.	Equipment / Component	Preferred Makes
46.	Exhaust Fan	Bajaj/Orpat/Havells
47.	Axial Flow / Exhaust Fans	Almonard / Dynamic Engineerings
48.	Air Conditioners	O'General / Samsung / Blue Star / LG / Hitachi
49.	EPABX	Panasonic / Coral

5.1.13 Cables and Wires

5.1.13.1. Control Cables

This specification covers the requirements for Voltage Grade 1100 V armoured, multi core XLPE (cross linked polyethylene) insulated and PVC sheathed, FRLS cables for control purposes.

All cables shall be designed and manufactured such that no damage occurs during transportation, installation and operation of the cables under stipulated conditions.

The cables shall be suitable for laying in trays, pipes, ducts, closed trenches and directly buried underground. All cables shall be armoured type.

Cables shall be provided with additional overall Shielding with Aluminium Mylar tape with 100% coverage and 25% overlap on laid up cores for shielding against static/ electromagnetic interference.

System Particulars

Voltage : 1100 V grade

Ambient Temperature : 50℃.

5.1.13.2. Conductors

The conductor shall be of plain annealed high conductivity copper stranded wires which before stranding shall be generally circular in section, smooth, uniform in quality and free from scale spills, splits and other defects. The conductors shall confirm to relevant IS. The stranded conductor shall be clean and uniform in size and shape and its surface shall free from sharp edges.

5.1.13.3. Insulation

The insulation shall be chemically cross linked polyethylene XLPE conforming to the physical, electrical and ageing properties as required by relevant IS. Only natural unfilled compounds shall be used for insulation of cables. The insulation shall be free from micro voids and shall be heat resistant.

5.1.13.4. Inner Sheath

For all cables having two or more cores, the individual cores shall be laid up and then be surrounded by common covering applied either by extrusion or wrapping or filling material containing a thermoplastic material. A proofed or plastic tape may be applied over the common covering when a wrapped common covering is employed. It must be ensured that the circularity of the cable is maintained.

5.1.13.5. Armouring

Armouring shall be arranged over the inner sheath for the cable consisting of two or more cores. The armour of cables shall be either of galvanized steel wires or

galvanized steel strips.

5.1.13.6. Outer Sheath

A tough outer sheathing of PVC insulating material in standard colours shall be provided over the armouring to offer a high degree of mechanical protection against abrasion. Additional compound shall be applied under and over each layer. In order to prevent adhesion, a coating of lime wash or other suitable material shall be applied to the outside of the cable. Outer sheath shall be FRLS.

5.1.13.7. Colour Scheme for Identification of Cores

Cores shall be identified by colour scheme of PVC/ XLPE insulation. The following colour scheme shall be adopted:

Up to five cores- Red, Yellow, Blue, Black and Grey.

For cables having more than five (5) cores, two adjacent cores (counting and directional) in each layer may be coloured blue and yellow respectively and the remaining cores may belight grey.

5.1.13.8. Manufacturer's Identification

The manufacturer shall be identified throughout the length of the cable by manufacturer's name or trademark, voltage grade and year of manufacture of the cable indented or embossed on the cable. The indentation or embossing shall be done only on the outer sheath.

5.1.13.9. Serial Data Cable (RS485)

These shall be shielded twisted pair copper cable with minimum of four cores. These cables shall be insulated and PVC sheathed FRLS cables for serial data communication purposes.

All cables shall be designed and manufactured such that no damage occurs during transportation, installation and operation of the cables under stipulated conditions.

5.1.13.10. Junction Boxes

All the JBs (Junction Box) shall be metal enclosed, suitable for mounting on wall (or) sheet structure in material dust laden atmosphere. The enclosure shall be made of high quality Polycarbonate (shock proof, rust free, corrosion free, acid and chemical resistant, fire retardant, having high impact[IK 08],totally insulated [class II] made of halogen and silica free recyclable material), UV resistant, having high grade gasket made of Polyurethane, should withstand glow wire test at 9600c in accordance with IEC 60 695-2-11, should be flame retardant, self-extinguishing the Junction box should have test certificate in accordance with IEC 60 670-22 The JBs shall be dust and vermin proof and shall have IP-66/67 degree of protection as per relevant code. The JBs shall be suitable for both top &bottom cable entry and shall be provided with removable undrilled gland plates or knockouts. Clip-on type/screw terminal shall be mounted on the base chalked in the JBs. The base channel shall have space for accommodating another 20% extra terminal. Two numbers of earthing points suitable for 12 SWG GI wire shall be provided on the body of the JBs.

There shall also be a single to multichannel JB for fibre optic which shall be stand-alone field mounted with canopy & IP-67 degree of protection as per relevant code.

5.1.13.11. Packing and Marking

The cable shall be wound on a wooden drum and packed as per the requirement of relevant IS. The ends of the cable shall be sealed by means of non-hygroscopic sealing material.

The cable shall carry the following information either stencilled on the drum or contained in a label attached to it:

- Reference to Indian Standard
- Manufacturer's name or trade-mark
- Type of cable and voltage grade
- Number of cores
- Nominal cross-sectional area of conductor
- Cable code
- Length of cable on the drum
- Number of lengths on the drum (if more than one)
- Direction of rotation of drum (by means of an arrow)
- Gross mass
- Year of manufacture.
- Dispatch

The cables shall be dispatched in suitable drums with weatherproof packing.

5.1.14 CCTV Surveillance System

5.1.14.1. General

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 LED monitors located at different locations as shown in **Drawing.**

525/HT/1021 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 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 fiber 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.

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.

5.1.14.2. Equipment Specifications for CCTV Surveillance System

NVR Server

The NVR shall have enterprise class reliability with a RAID 6 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 up to 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 LED colour monitor, mouse controller, CD/DVD drives and network cards.

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, 65 inch XVGA LED colour monitors, mouse controllers, CD/DVD drives, network cards.

Processor	Intel i5 processor,
Clock Speed	3.6 GHz
Random Access Memory	4GB- DDR2-ECC-SDRAM Clock Frequency = 1667MHz
Hard Drive 1 Optical Drive	320 GB SATA CD/DVD read write
Communication Ports	Parallel Port-1,Serial Ports (Universal)-3, USB Ports-8
Power Source	240 V AC,50/60 Hz
Network card	Additional Gigabit/10/100 MBPS Ethernet PCI-E Network Card (in total 2 network connections)
Permissible Humidity	20%-80%

Design Ambient temperature	50ºC
Operating System	Windows 7/ 8/ 10
Power Source	240 V Ac,50/60 Hz
Display Type	Compensated TN ,Full colour TFT LED Luminance :1150cd/m2
Resolution	At least 1280*1024 (NI)
Size	65 inch Diagonal
Operating Condition	Temperature : 0ºC-40ºC Humidity : 20% - 80%
Contrast Ratio	30000:1
Viewing Angle	140ºH, 140ºV
Safety Standards	UL6500/C-UL

Optical Fibre Cables

Multimode/Single mode (depend upon the distances), armoured optic cable 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.

Ethernet Cable (Cat 5e)

Category-5e 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.

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 36x (Optical Zoom) PTZ Camera and an Image Sensor with CCD sensor, approx. with wireless capability with advanced digital Signal Processing Capability, High Horizontal Resolution, Day and night Type, 360 degree continuous Pan Rotation with complete power supply and accessories.

Image Device	Better format CCD sensor
Optical Zoom	36 X or better
Number of pixels	1280X960 or above
Scanning system	PAL
Pan Travel	360º continuous
Tilt travel	0 - 90º continuous
Iris Control	Auto
Focus	Auto

White Balance	Auto
Electronic shutter	Auto
S/N ratio	>= 40 dB
Frame Rate	PAL – up to 30 frames per second in all resolution
Operating Temperature	- 10 º to 60 º C.
Operating Range	Up to 190 meters
Mounting Frame	Aluminum (or any which suits whether conditions)

Mounts

All the cameras shall have appropriate mounts based on the camera design and the functional requirement of the same.

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.

Video Management Software

Processor	Intel Xeon i5 processor
Clock Speed	3.86 GHz
Cache Memory Size	12 MB Cache L3 1333 MHz front side bus
Random Access Memory	8 GB DDR4 Clock Frequency: 1333 MHz
Hard Drive 1	10 TB (7,200rpm) SAS
Hard Drive 2	6 TB GB SOS
Communication Ports	Parallel Port-1, Serial Ports (Universal)- 3. USB Ports-8
Power Source	240 V AC,50/60 Hz
Network card	Additional Gigabit Ethernet PCI-E Network Card (in total 2 network connections)
Permissible Humidity	20%-80%
Design Ambient Temperature	$50^{O}C$
Operating System	Windows

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.

6 SPECIFICATIONS - FIRE FIGHTING SYSTEM

The equipment and materials covered by this specification are subject to the referenced attachments. The Contractor shall be responsible for and governed by all the requirements of this Specification and Standard Conditions of the Contract.

All designs, specifications and other technical data shall be based on the metric systems of measurement.

6.1 Scope of firefighting Works

The Scope of Work is for the installation of Fire Fighting Systems in buildings. The firefighting system shall consist of dry powder stored pressure by nitrogen gas with inbuilt pressure gauge to indicate pressure.

S. No.	Area	Class of Fire	Classification of Occupancy	System Proposed
1	Buildings	A, B & C	Ordinary Hazard	Dry power stored pressure confirming to IS:13849. Pressurised by nitrogen gas with inbuild pressure gauge to indicate pressure.

However, if in the opinion of the Bidder, the above requirement needs to be enhanced for better performance or any other imperative criteria, the same shall be quoted separately as an alternative.

7 DRAWINGS

7.1 Please refer enclosure 6 – Tender Drawings