

BIDDING DOCUMENTS
for
Procurement of EPC Contract
for
Construction of Multimodal IWT Terminal at Haldia,
West Bengal

VOLUME-II
TECHNICAL SPECIFICATION AND DRAWINGS

ICB No: CANW-1/IWAI/JMV/15

**Employer: Inland Waterways Authority of India, Ministry of Shipping,
Government of India**

Country: India

Issued on 03rd March, 2016

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Annexures

Annexure 1 – Geotechnical Investigation Report

1 GENERAL INFORMATION AND EMPLOYER'S REQUIREMENTS

1.1 GENERAL INFORMATION

1.1.1 Background

The Ganga – Bhagirathi - Hooghly river system from Haldia to Allahabad has been declared as National Waterway No. 1 in 1986 and since then various developmental activities on this waterway are under progress.

IWAI intends to develop an inland water terminal on National Waterway-1 at Haldia in Purba Medinipur district, West Bengal.

This call for EPC bid being addressed to potential Contractors for Engineering, Procurement of Materials & Construction of "Multimodal IWT Terminal at Haldia".

1.1.2 Site Location

IWAI is setting up a multi-cargo Inland Water Transport (IWT) terminal in an area of 61 acre at Haldia in Purba Medinipur district of West Bengal. The site is located on Hooghly River at Latitude $22^{\circ} 03' 30''$ North and Longitude $88^{\circ} 8' 40''$ East, adjacent to Haldia Dock. Google image of the proposed terminal is shown in Figure-1.



Figure 1: Google Image for Multimodal IWT Terminal Site at Haldia

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 condition met with during the execution of the work and those indicated herein.

The meteorological data of the project site is obtained from the Climatological Handbook of India, 1971 to 2000 published by Indian Meteorology Department. The nearest IMD observatory to Haldia is Uluberia, which is located at $22^{\circ} 30' N$ latitude and $87^{\circ} 57' E$ longitude and details of the same are presented below.

1.1.3.1 *Air Temperature*

The temperatures vary from 7.2 °C to 41 °C. The mean daily maximum and minimum air temperatures along with the extremes for each month are as follows:

Month	Recorded Temperature (°C)			
	Mean Daily Maximum	Mean Daily Minimum	Highest Maximum	Lowest Minimum
January	25.7	12.7	33.2	7.8
February	28.6	15.9	36.4	7.2
March	33.0	20.7	40.3	12.2
April	35.0	24.1	41.0	12.9
May	35.0	25.4	38.7	17.8
June	33.7	26.2	40.0	19.3
July	32.2	26.0	36.1	16.2
August	31.8	26.1	36.7	16.4
September	32.0	25.8	36.1	17.6
October	31.8	23.9	34.0	17.2
November	29.3	18.6	32.9	12.2
December	26.6	13.8	32.9	9.4

Source: IMD

1.1.3.2 *Wind*

The mean wind speed at the project site is found to be in the range of 2.6 km/h to 7.7 km/h. The basic wind speed at 10 m height for the project site is 55 m/s (198 km/h) as per IS 875 (Part 3).

1.1.3.3 *Relative Humidity*

The humidity is moderate to high throughout the year with the mornings being more humid than evenings. The mean relative humidity for each month of the year measured during mornings and evenings is as tabulated below:

Month	Mean Relative Humidity (%)	
	Morning (0830 hrs)	Evening (1730 hrs)
January	85	63
February	81	58
March	80	58
April	80	70

May	80	74
June	84	79
July	88	84
August	88	84
September	88	83
October	84	78
November	83	71
December	84	66

Source: IMD

1.1.3.4 **Rainfall**

The average annual rainfall in the region is about 1618.1 mm. The month-wise distribution of the average rainfall recorded for each month of the year is as follows:

Month	Monthly Total (mm)	Number of Rainy Days	Heaviest Fall in 24 Hours (mm)	Year
January	11.3	0.9	59.9	1977
February	23.7	1.5	44.6	1992
March	33.9	2.1	86.6	1981
April	52.8	3.6	54.1	1971
May	126.1	6.4	85.9	1973
June	242.6	11.7	266.8	1984
July	343.8	15.0	186.8	1990
August	332.5	15.8	255.0	1971
September	307.5	12.1	409.3	1978
October	97.5	5.5	80.0	1973
November	33.4	1.4	199.8	1986
December	13.0	0.6	91.6	1981
Total	1618.1	76.7		

Source: IMD

1.1.3.5 **Visibility**

The visibility in the project area is generally good throughout the year, except for a few days during the winter season and during periods of heavy rain. On an average, the visibility is less than 4 km for about 110 days in a year.

1.1.3.6 Seismic Zone

The terminal falls under the seismic Zone III.

1.1.3.7 Currents

Maximum ebb current of 6 knots and flood tide current of 5 knots shall be considered.

1.1.3.8 Tide Level

The following are the tidal levels at the site.

Highest High Water	+7.26 m CD
Mean High Water Spring	+5.70 m CD
Mean High Water	+5.01 m CD
Mean High Water Neap	+4.26 m CD
Local Mean Water Level	+3.23 m CD
Mean Sea Level	+2.80 m CD
Mean Low Water Neap	+2.10 m CD
Mean Low Water	+1.34 m CD
Mean Low Water Spring	+0.80 m CD
Chart Datum	0.46 m below K.O.D.S.
Lowest Low Water	-0.07 m CD

Source: Hugli River Tide Table 2015 published by Survey of India

1.1.3.9 Topographic information

The topographic survey of site was carried out during August 2015. The existing ground level varies from +4.95 m CD to +8.21 m CD and the details are presented in the **Drawing I-525/HT/1002**.

1.1.3.10 Hydrographic Information

The bathymetry survey of site was carried out during December 2015 and the details are presented in the **Drawing I-525/HT/1003**.

1.1.3.11 Geotechnical Information

The landside and riverside geotechnical investigations were carried out during December 2015. The location of boreholes are given in **Drawing I-525/HT/1004** and the geotechnical investigation report is enclosed as 'Annexure-1'. The geotechnical investigation report is only for the information of the Bidder. Required soil investigation work shall be carried out by the Contractor before design/execution of the Works.

1.2 EMPLOYER'S REQUIREMENTS

1.2.1 General

The Employer's Requirements are that the Contractor shall carryout the Engineering, Design, Procurement of materials, Construction / installation and commissioning of all the items listed below, along with associated works as outlined in the Bid for Phase-1A development with a provision to develop Phase-1B in future. For this purpose, 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 condition met with during the execution of the work and those indicated herein.

The broad items of works covered are listed below:

- Site Grading
- Berthing Structures including all associated facilities
- Approach trestles connecting the berths with back-up storage area
- Stockyard Development
- Buildings viz. Terminal Administration Building, Worker's Amenity Building, Security Office, Electrical Substation, Weigh Bridge Control Room and Compressor House for Ash Handling
- Covered Shed
- Internal Roads and Vehicle Parking Area
- Water Supply Works
- Storm Water Drainage Works
- Sewerage System
- Gate House Complex, Emergency Exit Gate and Access Gates
- Diversion of Existing Road within the Terminal
- New Culverts Outside the Terminal area
- Electrical Works
- Mobile Harbour Cranes
- Grab Type Gantry Crane
- Silos with Conveyor System
- Barge loader with loading spout
- Road Weigh Bridge
- Fire Fighting System
- Communication and IT System

1.2.2 Site Grading

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 +7.80m CD within the terminal area.

The exact quantity of fill shall be worked out based on the topographic survey of the area.

1.2.3 Berthing Structures Including All Associated Facilities

There shall be 4 berths which are continuous with a total quay length of 465m which will be developed during Phase-1A development. Out of the 4 berths, two berth (Berth no – 01 & Berth no – 02) are for handling flyash and the other two berths are Multi-cargo berths. The berths will be located at a distance of about 140 m from the existing river bank. Of the total length of 465 m of the berth, 312 m is of 30 m width and 154 m is of 50 m width as mentioned in the Drawing I-525/HT/1001. Cargo vessels shall be berthed on the front side and survey vessels shall be berthed on then rear side ends of the berth.

The top level of deck shall be +8.7 m with respect to CD.

The berth shall be connected to backup area by approach trestles.

The berth is of open piled structure with deck slab. The general arrangement of proposed berth with trestles showing typical plan and section are presented in the **Drawing I-525/HT/1005**.

While the location, alignment, length and minimum width of the berths are frozen, the sections shown in the drawings are only indicative.

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

- Fenders including all its ancillaries
- Bollards
- Mooring rings
- Safety ladders
- Handrails
 - Wooden rubbing strip for the protection of edges of berth from rubbing of mooring ropes.
 - Drain pipes shall be embedded at regular intervals. The proposed jetty shall be provided with suitable slope to drain off storm water.
 - Galvanized iron edge angles at various locations including on the sides of openings/pits.

The berth nos. 1 and 2 shall be designed and constructed to operate fixed barge loader.

The berth nos. 3 and 4 shall be designed and constructed to operate mobile harbor crane. Berth no. 4 shall have provision for handling container cargo in future.

The jetty shall have utility trench/duct to carry pipe lines, cables etc., and it shall run all along the berth. The trench covers shall be seated properly and shall be intact with the trench side walls.

The Contractor is expected to develop the above berths with a provision to develop a coal transshipment berth during Phase-1B. The coal transshipment berth shall be of the size 150m length x 28.5m width which will be located at about 85 m from Berth no. 4.

The Contractor shall adhere to and honor the Conditions of the Contract in all respects.

The Contractor while executing the Works shall observe/follow good industry practice, which however shall meet the Employer's Requirements.

1.2.4 Approach Trestles

There shall be 4 approach trestles to connect the berths to the back-up area. The proposed approach trestles have to cross a pipeline corridor of 40 m comprising of ammonia pipelines and other commodity/utility pipelines, outside the terminal boundary. A minimum vertical clearance of 0.8 m has to be maintained between the top level of the ammonia pipelines and the soffit level of the approach trestle.

The formation level of approach trestle increases from +7.80 m CD at the backup area to +11.00 m CD above the pipeline corridor and then it reduces to +8.70 m CD at berth. The gradient of the formation level of the approach trestle shall not be steeper than 1 in 30.

The approach trestles (1 to 4) shall comprise of embankment, superstructure with one through type steel truss girder of length 72m to cross over the ammonia pipeline corridor and remaining with RCC structure. The retaining structure of the embankment is of reinforced earth wall.

The typical span arrangement of the approach trestles (1 to 4) and dimensions of other structural elements are shown in **Drawings I-525/HT/1005**.

1.2.5 Conveyor System

The Contractor shall plan and develop proposed conveyor system to carry flyash from respective stockyards to the berth area so as to finally discharge the flyash into the barges using the barge loader

Conveyor gallery shall be 8.40 m wide. The typical span arrangement of the conveyor gallery and dimensions of other structural elements are shown in **Drawing I-525/HT/1005**.

1.2.6 Numerical Model Study (Optional)

If required, the Contractor shall carry out the numerical model study to check run-up and effect of the proposed structures to be erected on stability of the bank due to likely erosion, if any during and after construction is completed.

1.2.7 Stockyard Development

The Contractor shall plan and develop proposed Stockyard to a formation level of +7.80 m CD within the extents shown in **Drawing I-525/HT/1007**.

1.2.8 Buildings

The following buildings shall be constructed as part of this Contract:

S. No.	Building	Type	Total Built up Area (m ²)
1.	Terminal Administration building	Two storey building	330
2.	Worker's Amenity building	Single storey building	121
3.	Security Office	Single storey building	25
4.	Electrical Substation	Two storey building	1089
5.	Weigh Bridge Control Room	Single storey building	25
6.	RIO (Remote Input and Output) / Compressor Room	Single storey building	40

1.2.8.1 Terminal Administration Building

The Contractor shall plan, design and construct Terminal Administration building for the administration of the proposed IWT terminal, at the location identified in the layout. Typical layout and elevations are shown in **Drawing I-525/HT/1006**.

1.2.8.2 Worker's Amenity Building

The Contractor shall plan, design and construct Worker's Amenity building at the location identified in the layout. It shall have required facilities for the personnel working in the berth and yard. Typical details and dimensions are shown in **Drawing I-525/HT/1007**.

1.2.8.3 Security Office

The Contractor shall plan, design and construct security office at the location identified in the layout to handle entry and exit clearances of the Terminal. Typical layout and elevations are shown in **Drawing I-525/HT/1008**.

1.2.8.4 Electrical Substation

The Contractor shall plan, design and construct electrical substation for the electrical distribution system of the proposed IWT terminal, at the location identified in the layout. Typical details are shown in **Drawing I-525/HT/1019**.

1.2.8.5 Weigh Bridge Control Room

The Contractor shall plan, design and construct weigh bridge control room, at the location identified in the layout. Typical details are shown in **Drawing I-525/HT/1008**.

1.2.8.6 RIO / Compressor Room

The Contractor shall plan, design and construct RIO / Compressor Room, at the location identified in the layout.

1.2.9 Covered Shed

The Contractor shall plan, design and construct a suitable storage shed of the size 130 m x 30 m at the location shown in the overall layout. Typical details and dimensions of storage shed are shown in **Drawing I-525/HT/1009**.

1.2.10 Internal Roads

The Contractor shall plan, design and construct internal roads of terminal and same shall be provided as per the layout shown in tender document drawings. Any culverts /hume pipes required at the crossing of the drains / utilities shall be provided.

Details of Roads as planned have been provided herein below:

Right of Way	Length
17 m	1500 m
10 m	1800 m

Layout of internal road and typical cross-section are shown in **Drawing I-525/HT/1011**.

1.2.11 Vehicle Parking Area

The Contractor shall plan, design and construct suitable paved area for vehicle parking.

1.2.12 Water Supply

The Contractor shall do design, installation and commissioning of the complete water supply distribution system including the supply of potable / raw water to the buildings, bunkering to vessels and other terminal areas with a provision for Phase-1B development. The schematic layout of water supply system is shown in **Drawing I-525/HT/1013**.

1.2.13 Storm Water Drainage

A drainage system for carrying the storm water run-off from the terminal area is to be planned, designed and provided with a provision for Phase-1B development. Layout for Drainage is shown in **Drawing I-525/HT/1014**.

1.2.14 Sewerage System

The Contractor shall plan, design and construct complete sewerage system including laying of pipelines for collection of sewage from buildings to septic tank / sewage treatment plant.

1.2.15 Gate House Complex and Emergency Gate

A gate house complex shall be provided in the southern boundary of the terminal at the location shown in the overall layout. Typical details and dimensions of entry gate are shown in **Drawing I-525/HT/1009**.

1.2.16 Diversion of Existing Road

The Contractor shall plan, design and construct a 15 m wide Right Of Way diversion road outside the northern boundary of the terminal as shown in **Drawing I-525/HT/1011**. The length of this road is about 800 m. Any culverts /hume pipes required at the crossing of the drains / utilities shall be provided.

1.2.17 Mobile Harbour Cranes

Two numbers of mobile harbour crane having lifting capacity of 50 T at 20 m radius shall be procured and installed at berth no – 3 & 4. The said crane shall handle the cargo from design vessels at all anticipated water levels.

1.2.18 Silos with Piped Conveyor System

8 numbers storage silos each to store 1200 MT of dry fly ash with adequate margins shall be provided. Storage silos shall be of conical bottom type with the provision of air slides/fluidising pads at the bottom. Storage silos shall be provided to store precipitator fly ash with adequate air space. This silo shall be used to collect dry fly ash from the bulk carrier and further loaded to barges by conveyor system.

1.2.19 Barge loader with loading spout

Two numbers of electric operated fixed barge loader each having loading capacity of 400 TPH shall be procured and install at berth no -1 & 2. The said loader shall handle the cargo to design vessels at all anticipated water levels.

1.2.20 Fire-fighting System

The Contractor shall do installation and commissioning of the complete fire-fighting system within all the buildings and oil drum storage area.

1.2.21 Electrical Works

1.2.21.1 Employer's Requirements

The Employer's Requirements are that the Contractor shall carryout the Engineering, Design, Manufacturing/Procurement, Packing, Delivery, Storage at site, Construction/ installation, Testing, Commissioning & Handing over of all the items/systems listed, along with associated works as outlined in this tender. Brief list of Employer's requirements are as follows:

Plan, design and construct one electrical substation (ESS) for the electrical distribution system at the location identified in the tender.

Internal (Buildings) and External illumination including lighting fixtures, necessary poles and high masts, MCB boxes, accessories and hardware including civil works.

The Contractor shall provide complete Electrical works for all equipment / buildings as required.

Electrical and Control cabling from proposed ESS to individual equipment / buildings.

All Earthing and Lightning protection works.

Associated Civil Works

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

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

The Contractor shall be deemed to have examined the site and familiarized himself with all existing site conditions. He shall accept the Site in the existing condition at the time of award of the Contract.

1.2.21.2 *Detailed Electrical Scope of Work*

Power at 11kV shall be made available upto a DP (Double Pole) Structure adjacent or within the Project boundary by West Bengal State Electricity Distribution Company Limited (WBSEDCL). Beyond this DP structure, power shall be fed to the Metering cubicle of WBSEDCL through buried 11kV cable by either WBSEDCL or IWAI. DP structure shall also be provided by either WBSEDCL or IWAI. 11kV cable from metering cubicle of WBSEDCL to 11kV switchgear Incomer shall be in the scope of the EPC contractor. Power at 11kV received at the incomer of HT switchgear shall be fed at the same voltage to High Power consuming equipment(> 110kW) like Pipe Conveyors, Barge Loaders, Gantry type Grab Cranes, Transformers, Dust Extraction System and HT Capacitor Banks etc. as per requirement of **Phase 1A & Phase 1B**. The contractor shall procure the equipment for Phase 1A only & provision shall be made for Phase 1B. This tender is for Phase-1A only. Further Power distribution shall be as per the attached **Power Single Line Diagram I-525/HT/1019**.

SLD attached with this tender is indicative, final Load List and corresponding final SLD shall be prepared by the Contractor during detailed engineering and obtain approval of the Engineer-in-charge before proceeding for manufacturing / procurement.

The particulars of power supply are as follows:

Receiving Voltage	11 KV \pm 10%
Supply Voltage	415V \pm 10%
Phase	11 KV - 3 PH 3 Wires 415V - 3 PH 4 Wires
Frequency	50 Hz \pm 3%
Combined Voltage & Frequency Variation	10%
Fault level	26.3kA for 3 second at 11KV (To be verified based on the data from WBSEDCL) 50kA for 1 second at 415V
System Earthing (415V)	Solidly Earthed
Control Circuits:	
Circuit Breaker Protection & Tripping Control System	110 V DC, 2 Wire, grounded(on any one side)
Control System:	
Server, PLC, RIO(Intelligent) I/O VDU, Keyboard, Printer	240 V \pm 10%, AC, 50 HZ \pm 3%, 1 Ph, 2 Wire; All equipment shall have internal close loop regulation & spike arrestors
UPS System, Field Hooters	240 V \pm 10%, AC, 50 HZ \pm 3%, 1 Ph, 2 Wire

The detailed scope of electrical works is given below:

S. No.	DESCRIPTION	QTY.
1.	11kV Indoor Switchgear, Drawout type, VCB of rating 630 A, as per the attached SLD.	19 Nos.
2.	11kV Bus PT, as per the attached SLD.	1 No.
3.	11kV/433V, 750KVA, indoor Dry type Utility Transformers, having off circuit tapping of \pm 10%, in steps of 2.5%, winding temperature detectors with scanner for temperature alarm and trip, door safety limit switch and accessories.	2 Nos.
4.	11kV Capacitor Panel of rating 1000kVAR as per the attached SLD at substation with 11kV main Circuit Breaker, sets of Fuse and Vacuum Contactors for each capacitor bank, automatic Power Factor Correction Relay, Capacitor banks (star connected) with series reactors, discharge resistance, residual voltage transformer & neutral	1 set

S. No.	DESCRIPTION	QTY.
	displacement protection relay.	
5.	415V Capacitor Panel of rating 355kVAR as per the attached SLD at substation with Air Circuit Breaker, sets of Fuse and Contactors for each capacitor bank, automatic Power Factor Correction Relay, Capacitor banks (delta connected) with series reactors, discharge resistance, residual voltage transformer & neutral displacement protection relay.	1 set
6.	415V panels LT switchgear as per the attached SLD.	
	a) 415V PCC at Electrical Substation(ESS)	1 No.
	b) 415V ACDB at Electrical Substation(ESS)	1 No.
	c) 415V MLDB at Electrical Substation(ESS)	1 No.
7.	Distribution Boards 415 Volts, 3 Ph, 4 wires with suitable busbars for Lighting, and Auxiliary supplies in Electrical Substation, RIO/Compressor Room, Terminal Admin. Building, Worker's Amenity Building, Security Office, Weigh Bridge Building, Sewage Treatment Plant, Covered shed & Transfer towers etc.	Lot
8.	Substation Battery, Lead Acid (Valve regulated) Sealed Maintenance Free type, 110V DC with minimum 1 Hour back up, 110V DC battery charger with dual battery and battery charging cum DC Distribution boards at Electrical Substation.	1 Set
9.	415V Silent DG Set, 250kVA at ESS with AMF Panel and exhaust pipes as per pollution norms, including foundation.	1 Set
10.	Industrial power sockets 240V 15A, 2 Nos. at each floor in Electrical Substation, RIO/Compressor Room, Terminal Admin. Building, Worker's Amenity Building, Security Office, Weigh Bridge Building, Sewage Treatment Plant, Covered shed & Transfer towers etc. & at a distance of every 30m in case of Conveyors and as required for convenience at suitable locations.	Lot
11.	Welding socket 415V TPN and earth 63A, 2 Nos. at each floor in Electrical Substation, RIO/Compressor Room, Terminal Admin. Building, Worker's Amenity Building, Security Office, Weigh Bridge Building, Sewage Treatment Plant, Covered shed & Transfer towers etc. & at a distance of every 30m in case of Conveyors and as required for convenience at suitable locations.	Lot
12.	Axial / Exhaust Fans of suitable size in Electrical Substation, RIO/Compressor Room, Terminal Administration Building, Worker's Amenity Building & as required for other buildings etc. for ventilation so as to remove heat generated by the Panels/Equipment.	Lot
13.	Internal illumination through LED fixtures and electrification including wiring & installation of fixtures, switches, sockets, fans, conduits, brackets, junction boxes, etc. in Electrical Substation,	Lot

S. No.	DESCRIPTION	QTY.
	RIO/Compressor Room, Terminal Administration Building, Worker's Amenity Building, Security Office, Weigh Bridge Building, Sewage Treatment Plant, Covered shed, Transfer towers & other buildings etc. including peripheral lighting of buildings and structures.	
14.	High Mast (30m) with HPSV & Flood Light lamps as per the "High Mast & Cable Layout", Drawing I-525/HT/1021.	7 Nos.
15.	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 & other buildings etc., to ensure minimum 10 Lux in all the buildings, conveyor galleries, all exit / entry points etc.	Lot
16.	Air conditioning of Terminal Administration Building through centralized AC system to ensure & maintain an inside temperature of 27°C maximum.	Lot
17.	Air conditioning of Control Room, RIO/Compressor Room(For Panel area), Security Office & Weigh Bridge building etc. through Split AC system to ensure maximum temperature of 27°C.	Lot
18.	Cables	Lot
	a) 11kV (E), Heavy Duty, Armoured Cable, FRLS, XLPE, stranded Aluminium Conductor and Accessories	
	b) 1.1 KV, Heavy Duty, Armoured, Power Cables, FRLS, stranded Aluminium / Copper Conductor and Accessories.	
	c) 1.1 KV, Lighting Wires, PVC Insulated, FRLS, Stranded Copper Conductor and Accessories.	
19.	FRP Cable Trays with all accessories, mounting hardware, support structures, Cable risers, cable racks etc.	Lot
	a) Cable terminations including cable termination kits, cable lugs, glands etc. for 11kV (E) grade cables	Lot
	b) Straight through Cable Joints. for 11kV (E) grade cables	Lot
	c) Cable terminations including cable lugs, glands etc. for 1.1kV grade cables for power, lighting and auxiliaries	Lot
	d) Straight through Cable Joints for 1.1kV grade cables for power, lighting and auxiliaries	Lot
20.	Earthing Protection System with Materials:	
	a) Earthing of HT, LT Equipment, Transformers, Generators, Panels, Distribution Boards, Motors, Junction Boxes and all equipment, lighting and power distribution network including conveyors,	Lot

S. No.	DESCRIPTION	QTY.
	transfer towers & all buildings etc. within the scope	
	b) Main Earthing grid in the electrical substation and overall project area	Lot
	c) Rail Earthing of Mobile machines with interconnected earth strips and adequate number of GI pipe / plate Earth Pits. Earthing grid on either side and inter connections of earth grid of both rails at intervals of approximate 25 meters.	Lot
21.	Lightning Protection for all buildings and structures within the scope as per the guidelines of the IS/IEC-62305:2010 (Superseding IS:2309:1989) comprising lightning finials, GI Strips for Horizontal and vertical conductors for Lightning protection, Earth pits with Test links for Lightning protection	Lot
22.	Excavation and backfilling of soil, sand cushion, protection bricks for buried cables wherever buried cables are taken	Lot
23.	Communication System comprising of EPABX of 200 Lines with Telephone Instruments as per the requirement	Lot
24.	Electrical Sub-station Safety Equipment	Lot
	a) CO2 type Fire extinguisher of 1 gallon capacity, each mounted on wheeled portable trolley	
	b) Sand buckets (4 nos) filled with sand alongwith required stand	
	c) Caution Board (11 KV & 415 V) and shock treatment chart	
	d) 900mm wide 12mm thick rubber mat (Electrical grade) in front of panels	
	e) First Aid box	
	f) 11kV Safety gloves	
	g) Discharge earthing rod for 11kV rating	
25.	Special maintenance tools & tackles like	Lot
	a) Earthing trucks of each type in electrical substation	
	b) CB Racking handles of each type in electrical substation	
	c) Spring Charging handle of each type in electrical substation	
	d) Any other item as per recommendation of manufacturer of equipment	

S. No.	DESCRIPTION	QTY.
26.	Any other item not included above but required for completion	

Note: The above quantities are indicative only.

1.2.21.3 *Civil*

S. No.	ITEM DESCRIPTION	Qty.
1.	At Electrical Substation Building Complete construction of Electrical Substation building including design, preparation of construction drawings and interior power and lighting as per the “ Substation Equipment Layout ”, I-525/HT/1020.	Lot
2.	RIO/Compressor Room including design, preparation of construction drawings and interior power and lighting for housing of Electrical equipment like Remote Input-Output(RIO) Panel, UPS & Compressor & Lighting Distribution board etc.	Lot
2.	Cable trenches etc.	Lot
3.	Supports and foundations of lighting poles, DP structure, high masts, transformers, DG set etc.	Lot
4.	Cut outs on walls for taking cables, drilling & fixing of fasteners for fixing of fixtures/cables/conduits etc.	Lot

1.2.21.4 *Miscellaneous/General Works/Services*

1.	Mobilisation of all resources including Construction Machinery / Tools & Tackles / Welding Sets / Cranes / DG Set etc. for expeditious construction / fabrication / erection / installation of the required System to ensure timely implementation of the Works.
2.	Contractor shall arrange & post sufficient number of skilled and experienced personnel at Site to ensure trouble free Installation, Erection, Construction, Operation and Handing over to the Employer.
3.	The Contractor's Scope of Work shall include development of land / construction of his site fabrication yard at area allocated to him by the Employer.
4.	Fabrication and Erection of all temporary structures, arrangement for temporary power and water supply etc. adequate site lighting arrangement, transport logistics at site etc.
5.	Supply of all consumables / materials / lubricants, hydraulic fluids, oil, etc. including fuel oil for DG set.
6.	Clean up at site of all debris and temporary structures on a daily basis and final clean up at the time of handing over of the plant.

7.	All electrical safety requirements during site fabrication, erection, testing and commissioning, including adequate earthing of erection machinery and equipment.
8.	Proper and safe storage / security of all equipment and materials at site in the areas designated by the Employer in line with the Customs Employer / Regulations, where applicable.
9.	Supply of Lubricants, Oil, etc. for Initial fill, flushing, cleaning, refill, topping up & maintenance of Material handling system till the Works is put into satisfactory and continuous commercial use and has been "Taken Over" by the Employer.
10.	Attending meetings at the office of the Employer/ Employer's Representative or site or at any other station that may be fixed by the Employer for planning, co-ordination, clarifications, review, discussions etc.
11.	Co-ordination with other contractors, if any, and supplying necessary engineering data / information to the Employer to ensure satisfactory installation of equipment / execution of works.
12.	Supply of necessary calibrated instruments for carrying out performance tests of Equipment.
13.	Complete lot of base plates, foundation bolts, inserts, embedment, clamps, nuts, washers etc. as required for the system.
14.	All necessary painting and corrosion protection. The painting and corrosion protection for the equipment and structures is included in Contractor's scope. The painting and corrosion protection shall be as per the specification furnished elsewhere. The painting scheme and the finish colour for all the equipment shall be as specified by the Employer after award of contract. Necessary finish paints including touch-up paints, if not applied at shop, should be supplied by the Contractor, in sealed containers for site application.

1.2.22 Control and Automation Works

1.	Server at Control Room with Control (SCADA software) and required Management software and interfaces, complete with all necessary accessories and High Speed Printer as per attached Control Architecture. Software for operating Terminals shall have interfacing capability with all equipment and SAP.	1 No.
2.	Programmable Logic Controller (PLC) (with hot stand-by processor and various communication modules) at Control room, Processing Control & Associated Communication Modules. Data processing software and required interfaces, hot standby, complete with all accessories. The communication module should support the communication between RIO (Intelligent), Other operating Terminal PLCs/ Controllers and all third parties interfaces.	1+1 (Hot Standby system)

3.	Managed Ethernet Switch (Redundant)	1+1 (Dual Redundant)
4.	Mimic, Large Screen Video Display LED, Size 64" at Control room.	1 No.
5.	Operating Station Terminal with necessary software	1 No.
6.	Programming Station Terminal with necessary software	1 No.
7.	Remote Input Output units (Intelligent) (RIO) with mini processor, suitable for field mounting with IP 65 degree of enclosure protection inside transfer towers or at outdoors (IP-55 or IP-54 degree of protection inside the rooms) complete with in-built UPS (1 hour back-up- status shall be indicated in CCR-VDU), signal converter and transmitter and all accessories having the following parameters. RIO Units shall also include the Belt Watch System to monitor the Safety Switches installed in the field.	1 No.
8.	Digital Input Module, 32 unit module	Lot
	Digital Input Module, 16 unit module	
	Digital Output Module, 32 unit module	
	Digital Output Module, 16 unit module	
	Resistance Temperature Detector (RTD)	
	Analogue Input Module, 32 unit module	
	Analogue Input Module, 16 unit module	
	Analogue Output Module, 32 unit module	
	Analogue Output Module, 16 unit module	
9.	21" LED coloured Monitors, PC Keyboards and software as per functional requirements.	3 Nos.
10.	CCTV System including the following:	
	a. Network Video Recorder (NVR) at Control Room with required software and complete with all accessories.	1
	b. PC Computer terminal having 21" LED Monitors, PC Keyboards and mouse with NVR software as per CCTV functional requirements. It shall support the communication between all operating terminal PC and IP-based cameras	1

	located at various areas.	
	c. PTZ Infrared cameras (IP-based) 36 X Optical Zoom.	6 Nos.
	d. Media Converters (Ethernet to Optical Converter)	Lot
	e. Auxiliary Hardware, like connectors, converters, light-interface units, networks adapters/Switches etc. for the complete system under scope of this contract.	Lot
	f. Power Cables (to feed power to the Contractor's supplied items)	Lot
11.	Plant Control Data Bus Cable, fibre optic (8 core-single mode-armoured), must be capable of high-speed data transmission inside/outside the plant in a recognized universal configuration along with all accessories.	Lot
12.	Copper Data Cable (RS-485-ModBus RTU), Shielded, individual & overall screened 4 core twisted pair.(CAT5e)	Lot
13.	Auxiliary Hardware, like connectors, line amplifier (if necessary, for long conveyor system to get the status of all safety switches to nearest RIO's and respective MCC's, line diverters, networks, alternators, multipliers, etc. for the complete system under scope of this contract.	Lot
14.	Interconnecting hardwired multicore cables, shielded 2.5 mm ² copper (or larger to suit the requirement), FRLS insulated, between vendor items (LCP/JB/LV switchgear) to the nearest FI. (Hand-Off-Auto control stations/Local Panel for bought out items (by others)	Lot
15.	Local-Off-Auto Station - IP-65 (Lockable at 'OFF' Position)	Lot
16.	Field warning hooters (IP-65)	
	a. ½ K.M range	Lot
17.	Control Junction Boxes (Terminal Blocks)(IP-67)	Lot
18.	Single to Multi-channel Junction Box(IP-67) for Fibre Optic Cable	Lot
19.	CDB's (Control Power Distribution Board) shall be furnished, manufactured and installed in Sub-station, Control room and Transfer Towers & at suitable locations as per requirement for feeding power supply to Contractor supplied items.	Lot
20.	Required accessories, connectors, auxiliary contactors, timers, counters, opto-couplers, Ethernet switches, Light interface	Lot

	units, transducers etc.	
21.	UPS at Control room for Control System, on line complete with all accessories and batteries as per Specification (1 hour back-up). Status shall be indicated in CCR-VDU.	2 Nos.
22.	3D Level Scanners above each Silo with all accessories. Necessary software for the scanners shall be installed in Control Room Terminals	8 Nos.
23.	Chairs matching with decor, revolving with rollers and storage cabinet	Lot
24.	Any other item not included above but required for completion	

Note: The above quantities are indicative only.

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 December 2015. 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.

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

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

Wherever details for part of works are not defined adequately in Indian Standards, relevant acceptable International Standards shall be adopted. Codes and standards covering the major part of the works are 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:

Jetty	- 50 years
Fenders, Bollards and ladders	- 8 years
Buildings and shed	- 40 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 Design Vessel Sizes

The design vessel size and characteristics to be considered for design of jetty are as follows:

Design Vessel Size	LOA	Beam	Loaded Draft
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(DWT)	(m)	(m)	(m)
3,000	95	15	2.5

2.1.4 Berthing Structures and Approach Trestles

2.1.4.1 Loads

2.1.4.1.1 Dead Load

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

Plain Concrete : 2.40 T/m³

R.C.C. : 2.50 T/m³

Steel : 7.85 T/m³

Compacted Earth Fill : 1.80 T/m³

Water : 1.00 T/m³

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

2.1.4.1.2 Live Load

The live load to be considered on the deck of jetty includes the following loads

Uniform distributed Live load of 3.5 T/m² for all berths and approach trestles

Uniform distributed Live load of 5 T/m² for Berth No. 4

IRC class A/AA /70 R vehicle for all berths and approach trestles

Loads due to mobile crane with a 40 T lifting capacity on hook at 20 m radius for berths only

2.1.4.1.3 Berthing Load

Berthing Energy

The design vessels are assumed to approach the berths under difficult berthing conditions at an angular approach of 10°. Based on this criterion the approach velocity perpendicular to the berth has been calculated to arrive at the design berthing energy for various design vessels.

Berthing loads are considered as per IS: 4651 Part III-1989. The Berthing energy calculated for 3,000 DWT vessel using IS: 4651 as per details below:

Dead Weight Tonnage (DWT)	3,000
Displacement Tonnage (DT)	3,990
Overall Length, LOA (m)	95

Beam Width, B (m)	15
Loaded Draft, d (m)	2.5
Berthing Velocity (m/s)	0.45

The design berthing energy works out to 59 Tm considering required safety factors.

2.1.5 Fendering System

Considering the level variation of the order of 5.7 m between high water level and low water level at the site and also the variation in the sizes of vessels to be handled at the jetty, the fendering system is designed such that sufficient contact area between the hull of the vessel and the fender face is ensured at all water levels. It is required to provide a suitable fender system, not only to absorb the design berthing energy of the vessel but also to keep the vessel's hull pressure below the limit of 20 T/m².

Based on these criteria, arch fenders of AN 800, grade E3.0 of Trellborg make or equivalent are proposed at each fender pile.

2.1.6 Mooring Load

Mooring force of 30 T, as per Table-4, IS: 4651- Part III, shall be applied at any of the bollard location.

2.1.7 Current Load

The current loads on the structure shall be applied on the submerged parts of the structure as per IS: 4651 - Part III. The current velocity considered are as given below:

Operation condition	:	1 m/s
Extreme condition	:	3 m/s

2.1.8 Wind Load

The wind load on structure is considered as per IS: 875-Part 3. The basic wind speed (V_b) for operational and extreme condition shall be 24 m/s and 55 m/s respectively.

2.1.9 Temperature Load

Daily maximum and minimum temperature difference is $\pm 25^\circ\text{C}$

Coefficient of thermal expansion for RCC structure is taken as $11.7 \times 10^{-6}/^\circ\text{C}$.

In temperature analysis, long term elastic modulus of the concrete is taken as half the instantaneous elastic modulus of the concrete.

2.1.10 Earthquake Load

Earthquake load shall be considered in design as applicable for the site as per IS 1893-2002.

The design horizontal seismic coefficient α_h is calculated based on the following parameters:

$$\alpha_h = Z I (S_a/g) / (2R), \text{ where}$$

$$Z = \text{Zone factor} = 0.16$$

$$I = \text{Importance factor} = 1.5$$

$$R = \text{Response reduction factor} = 5$$

S_a/g = Average response acceleration coefficient, which depends on Time Period of the Structure. The Time Period, T of the structure will be evaluated by STAAD Analysis considering Dead Load and 50% Live Load.

2.1.11 Slamming Forces

The wave slamming forces shall be considered in accordance with Coastal Engineering Manual.

2.1.12 Scour Depth

With reference to CWPRS model study report near to the proposed Haldia IWT terminal, the parameters for scour depth are as follows:

Velocity of stream	:	1.75 m/s
Mean discharge	:	24.50 m/s
Water level at highest discharge	:	+ 4.0 m CD
Scour level	:	(-) 25.53 m CD say (-) 25 m CD.

2.1.13 Load Combinations

The above loads with appropriate load combinations, as per IS 4651 (Part 4): 2014 have been applied on the different components of the jetty.

Sl. No.	Description	Limit State of Serviceability		Limit State of Collapse			
		Short term	Long Term	Normal	Extreme / Survival	Temporary	Reversal
1.	Dead Load	1.0	1.0	1.5	1.2	1.2	0.9
2.	Live Load						
a	Impact or dynamic load	1.1	0.5	1.5	1.2	1.2	0.9
b	Static	1.0	0.5	1.5	1.2	1.2	0.9
3.	Berthing Force	1.0		1.5	1.0		1.5
4.	Mooring Force	1.0		1.5			1.5
5.	Seismic Force	1.0			1.2		1.5

6.	Wind Force						
a	Operational	1.0		1.0			
b	Extreme				1.2		1.5
8.	Current	1.0		1.2	1.0	1.0	1.0
9.	Temperature Force		1.0				

2.1.14 Minimum Cover

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

- a) Pile : 75 mm
- b) Top, bottom & side of footing (if any): 75 mm
- c) Beams : 50 mm
- d) Slab : 50 mm

2.1.15 Serviceability Criteria

Deflection Limit

The Deflection at the deck level is generally considered as $H/350$ in operating condition and $H/250$ in extreme condition. H is the distance from the average point of fixity to the top elevation of deck.

Crack Width

The crack width is calculated for service load combinations in accordance with IS: 4651(part 4)-2014.

Exposure Zone	Maximum Crack Width (mm)	
	Sustained Load	Transient Load
Atmospheric zone – above splash zone	0.2	0.3
Splash zone – zone between CD and design wave height above MHWS	0.1	0.2
Continuous sea immersion zone	0.2	0.3
Below seabed level	0.3	0.3

2.1.16 Material Specification

The specifications are as given in this volume.

Structural Concrete	M-40
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Wearing coat (average 75mm thick)	M-40
Reinforcement	Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500 conforming to IS1786
Cement	<p>Ordinary Portland Cement of minimum grade 53 as per IS:8112</p> <p>If Chloride & Sulphate content as per the soil investigation report will found on the higher side. i.e.</p> <p>Chlorides</p> <p>Prestressed Concrete or grouting Mortar:- 500mg/l</p> <p>Concrete with reinforcement or embedded metal parts:- 1000 mg/l</p> <p>Concrete without reinforcement or embedded metal parts:- 4500 mg/l</p> <p>Sulphur</p> <p>The Sulphur content of the water must not be more than 2000 mg/l</p> <p>Measures</p> <p>Use of Sulphate resistance cement</p> <p>Low water/cement ratio</p> <p>Curing suited to the structure</p>
Structural Steel	As per IS:2062 (Grade-A) with minimum thickness of 10 mm
Protective coating to structural steel	Minimum DFT of 240 micron after sand blasting to SA 2.5 grade.

2.1.17 Embankment of Approach Trestle

Embankment of approach trestle shall be designed for the movement of vehicular traffic IRC class AA, class 70R, etc. in addition to the movement of maintenance cranes, when necessary. The design shall be carried out as per applicable Indian Standards. The gradient of the embankment shall not be steeper than 1 in 30. The retaining structure of the embankment is of reinforced earth wall.

2.1.18 Type of Bearings

The types of bearings for the approach trestles are as follows:

- Neoprene / Elastomeric
- POT-PTFE

- Roller-Rocker

2.1.19 Stockyard Development

The top 2 m of the Stockyard shall be heavily compacted in layers of 225 mm. Stockyard shall be developed to 8 m high stockpiling of stone aggregate and 3 high stacking of oil drums for future provision. The stockyard should also have provision to stack containers in future. Ground improvement, if necessary shall be carried out to achieve required bearing capacity accordingly.

Density of stone aggregate : 1.6 T/cum

2.1.20 Building Works and Storage shed

2.1.20.1 General

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 1000 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 analyzed 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.

2.1.20.2 Foundations

Type of foundation system shall be decided based on loading arrangement, load intensity and soil strata. Design of foundation at various levels shall be dependent up on the soil profile, which in turn shall be as per recommendation of soil investigation report. All foundations shall be designed in accordance with relevant parts of IS: 2974 and IS: 456.

2.1.20.3 Loads

Dead Load

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

Live Load

Live load shall be considered as given below and shall also satisfy the requirements of IS: 875.

Flat Roof	150 kg/m ² + Dust load of 50 kg/m ² hanging load for pipe shall be considered as 100 Kg/m ² and 50 Kg/m ² for electrical, ventilation & air conditioning (wherever applicable)
Non-accessible roof	75 kg/m ² + Dust load of 50 kg/m ²
Inclined roof	Roof slope upto 10 Deg: 75 Kg/m ² +50 Kg/m ² Roof slope above 10 Deg: $[(75-(\theta-10) \times 2)] + 50$ Subjected to a minimum of (40+50) =90 Kg/ m ² For sloping roofs with slope greater than 10°, members supporting the roof purlins, such as trusses, beams, girders etc may be designed for two-thirds of live load stated above
MCC Floor	300 kg/m ² +1.2T/m of Panel

Seismic Load

- Zone factor : Corresponding to seismic zone-III
- Importance factor : 1.50
- Response reduction factor : 5

Equipment Load

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

Impact Factor

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

2.1.20.4 Load Combinations

The load combinations shall be in accordance with IS: 456, IS: 800 and any other combinations as instructed by the Employer during detail engineering.

2.1.20.5 **Minimum Cover**

Clear cover to main reinforcement shall be as mentioned hereunder but shall not be less than the diameter of such reinforcement.

Pile	75 mm
Top, bottom & side of footing (if any):	50 mm
Pedestal / column - Below ground - Above ground	50 mm 40 mm
Beams	25 mm
Slab	20 mm
Face of walls & grade beam	50 mm (in contact with soil)
Face of walls not exposed to soil	25 mm(min.) or dia of main bar
At each end of reinforcing bar	20 mm or twice the dia of bar whichever is greater
Columns of max. dimension 200mm or under and with longitudinal reinforcement diameter not exceeding 12mm	25 mm

2.1.20.6 **Serviceability Checks**

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

2.1.20.7 **Material Specification**

The specifications are as given in this volume.

Structural Concrete	M-30
Reinforcement	Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500 as per IS 1786.
Cement	Ordinary Portland Cement of minimum grade 53 as per IS:8112
Structural Steel	As per IS:2062 (Grade-A) with minimum thickness of 10 mm
Protective coating to	Minimum DFT of 240 micron after sand blasting to SA 2.5

structural steel	grade.
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If Chloride & Sulphate content as per the soil investigation report is found on the higher side.
i.e.

- Chlorides
 - Prestressed Concrete or grouting Mortar:-500mg/l
 - Concrete with reinforcement or embedded metal parts:-1000 mg/l
 - Concrete without reinforcement or embedded metal parts:-4500 mg/l
- Sulphur
 - The Sulphur content of the water must not be more than 2000 mg/l
- Measures
 - Use of Sulphate resistance cement
 - Low water/cement ratio
 - Curing suited to the structure

2.1.20.8 **Grade Slab**

All ground floors shall be of R.C.C. (M-20) with minimum thickness of 150 mm over 75mm thick P.C.C. (M-10) base. The sub base shall be 230 thick Stone/bolder soling over compacted earth. The floor finish shall be 40mm thick including 13mm thick metallic hardener topping as per specification. Floor top shall be laid to slope minimum 1:100 towards floor drain for floor washing.

2.1.20.9 **Drain**

Drain shall be of RCC with natural slope towards collecting area.

2.1.20.10 **Stair Case**

Minimum clear width (General / Fire escape)	:	0.8m
Tread width	:	not less than 250mm
Riser	:	not greater than 180mm

Continuous Hand rail shall be provided.

2.1.21 **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 1.5% for All Roads

Maximum super elevation	:	5%
Sight Distance	:	Intermediate sight distance
Turning Radius at junction	:	Min. 25 m
Design Speed	:	80 km/hr
Pavement Design:		
Traffic	:	20 MSA
Specifications	:	
Flexible Pavement Embankment T/cum	:	Min. density shall be 1.6
Sub grade	:	Min. CBR 8% and density 1.75 T/cum
Granular Sub Base	:	Minimum 200 mm
Granular Base	:	Minimum 250 mm
Bituminous Surfacing		
- Binder course	:	Dense Bituminous Macadam
- Wearing course	:	Bituminous Concrete
Rigid Pavement		
Pavement Quality Concrete	:	Minimum M-40 grade
Dry lean concrete	:	Minimum M-10 grade
Sub-grade	:	Minimum CBR 8%
Panel size	:	Minimum 4.50 m
Maximum axle load		
- Single Axle	:	10.2 T
- Tandem Axle	:	18.0 T

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

2.1.22 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 of the entire terminal area.

No allowance for sillage shall be kept.

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.

2.1.23 Sewerage System

The pipelines of suitable size shall be laid for collection of the sewage from the buildings to a septic tank followed by soak pit / sewage treatment plant. The design and laying of the pipelines shall be carried out as per the provision of relevant IS codes.

2.1.24 Water Supply System

The minimum capacity of the underground sumps should be 200 m³ and the minimum capacity of the overhead tank shall be 60 m³. The broad design parameters for water supply system are given below:

Wastage and leakage in system: 15% of the total theoretical demand

Hydraulic design of the pipeline shall be using Hazen-Williams formula

All pipelines shall be laid 1.2 m below ground.

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 45°C 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:

- i) MOM with contractor in reverse chronological order.
- ii) Technical specifications
- iii) Tender drawings
- iv) Schedule of Quantities
- v) Bureau of Indian Standards
- vi) International Standards
- vii) In all case of doubt or omissions or discrepancies noticed in any item of work any drawing, the decision of the Engineer-in-Charge shall be final and binding on the contractor.

2.2.3 Other Technical Requirements

The contractor shall arrange all the instruments, materials and labour involved in setting out the works to the satisfaction of the Engineer-in-Charge.

2.2.4 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 (Part 1) : 2012	Led Modules for General Lighting Part 1 Safety Requirements
IS:16103 (Part 2) : 2012	Led Modules for General Lighting Part 2 Performance Requirements
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) : 2012	Luminaires Performance Part 1 General Requirements
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:

- a) Indian Electricity Act
- b) Fire insurance regulations
- c) Regulations laid down by Chief Electrical Inspector of West Bengal
- d) Regulations laid down by the Factory Inspector
- e) Regulations for the electrical equipment of Tariff Advisory committee
- f) Any other regulations laid down by the Employer
- g) Regulation of Pollution Control Board of West Bengal

2.2.4.1 **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.

2.2.5 **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.

2.2.5.1 ***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.

2.2.5.2 ***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.

2.2.5.3 *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;

- 1. It shall have high electrical conductivity, which should remain constant and unaffected by changes in temperature & moisture.
- 2. It shall permanently remain embedded and should neither dissolve in and swept away by water.
- 3. It shall have an ability to absorb large amount of water and retain the same over a long periods of time.
- 4. It shall decreases earth pit resistance with passage of time.
- 5. Solubility: Shall be partly miscible; so that it does not dissolve fully like common salt and thus increasing the Earth Pit Life.
- 6. The pH value shall be near neutral so that it does not pollute soil or water and also does not corrode earth electrode.
- 7. 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.

8. Chemical Compound shall be thermally conductive, in order to maintain a constant Earth resistance in temperature range of -50 to +60 degree Celsius.
9. The Compound shall have relatively High conductivity so that it can create very low resistance even in rocky areas.
10. It shall have low earth resistance, carries high peak current repeatedly.
11. It shall have a Long and reliable life.
12. 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.

2.2.5.4 **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.

2.2.5.5 **Earthing of Equipment**

- All lighting panels, junction boxes, receptacles, fixtures, conduit etc. shall be grounded in compliance with the provision of I.E. rule.
- 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.
- Lighting panels shall be directly connected to ground system grid by two nos. 25 x 6 mm GI strip at two different locations.
- 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.

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

2.2.5.6 **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.

2.2.6 **Lighting System**

2.2.6.1 **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
Stockpile and Jetty Area	30	2x400W HPSV twin lamp & 1x1000W Flood Light, weather proof, Heavy duty High Mast light in

		die cast Aluminium alloy housing
Electrical Substation, Transformer, DG Room, Worker's Amenity Building, Sewage Treatment Plant, RIO/Compressor Room, Waste Collection Center, Weigh Bridge Building & Security Office	200	General Purpose Industrial compact batten suitable for 2x20 W LED Tube Light fitted with Aluminium heat sink
Terminal Admin. 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
Storage shed	100	Open type vertical Medium Bay LED luminaire with high power COB 50W LED as light source
Belt Conveyors walkways, Transfer Towers	50	Vertical/Horizontal surface mounting pressure die-cast aluminium well glass luminaires with high power 40W LED as light source

2.2.6.2 **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.

2.2.6.3 **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.

2.2.6.4 **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.

2.2.7 **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:

- a Switchgear shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.
- b All panels, boards, etc. shall be suitably labeled with labels of design approved by the Engineer.
- c 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.
- d 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°C as an ambient temperature.
- e 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"
- f 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.
- g All controls shall be suitable for 240V AC / 110V DC.
- h 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.

2.2.8 Cables

2.2.8.1 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
- c) 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%
- d) Other factors to be considered:-
 - Short circuit capacity to be considered while selecting HT cables
 - Factor for Ambient temp. 45°C
 - 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.

2.2.8.2 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.

2.2.9 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 NEMA FG 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 ± 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.

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 2 months 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.

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

3.2 TEMPORARY WORKS

The Contractor shall design, install and maintain all temporary facilities required for the construction of facilities under this contract Package, which he requires on or at the site throughout the execution of the work, and remove the same on completion of the works. He shall provide all such buoys, 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, for approval, within 30 days of award of 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.

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.

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.

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 instrument, tools & tackles required for Material testing laboratory /QA facility at project site to be submitted by the bidder for Employer approval.

3.3 ENVIRONMENTAL PROTECTION

The Contractor shall comply with all the conditions stipulated by the relevant statutory and regulatory organisation of Govt. of West Bengal / Govt. of India.

3.3.1 Fires

Fires and burning of rubbish on the Site are not permitted except when authorized by Employer.

Where fires or burning is permitted, the Contractor shall prevent the structures which are to be preserved from staining and smoke damage. The Contractor shall restore, clean and make good stained or damaged work to new condition.

3.3.2 Disposal of Waste and Cleanliness

The Contractor shall not bury rubbish and solid waste materials on the Site and he shall not dispose of waste or volatile materials, such as mineral spirits, oil or paint thinner into the waterways, storm water drainage or sanitary sewers.

The Contractor shall keep all pavements and areas leading to and from the site, clean and free of mud, dirt, and debris at all times for movement of vehicles and pedestrians.

3.3.3 Drainage

The Contractor shall provide temporary drainage and pumping facilities as necessary to keep the adjoining areas of work site free from water logging and flooding.

3.3.4 Pollution Control

The Contractor shall cover or wet down dry materials and rubbish to prevent blowing dust and debris, and provide dust control for temporary roads and yards.

The Contractor shall take all measures necessary to ensure that no pollution of the waterways or any land areas occurs as a result of his activities. He shall undertake at his own expense all measures necessary to clean up or otherwise rectify any pollution arising from his activities under this Contract to the satisfaction of the Employer.

3.3.5 Environment

The Contractor shall deploy most suitable construction equipment to minimise the suspension of fine sediments at the work site.

3.4 SUBMISSION OF DOCUMENTS DURING PROJECT EXECUTION

3.4.1 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

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.

3.4.2 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).

3.4.3 Maintenance Plan

3.4.3.1 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.

3.4.3.2 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.

3.4.4 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.

3.4.5 Design & Drawing Submissions

3.4.5.1 *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 Employer.

The Contractor shall submit for the approval of 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 design calculations pertaining to all structures.

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.

3.4.5.2 *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 / initialed 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.

3.4.5.3 ***Submission of Drawings***

All drawings submitted for the EMPLOYER'S approval shall comply with the following:

1. 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.
2. All drawings shall be submitted in digital format on compact disc, as well as three paper prints.
3. Drafting Standards employed in the preparation of all drawings shall be sufficient to produce legible 297mm x 420mm (A3) reduced drawings.
4. Drawings from various sub-contracting services, specialist suppliers etc. shall also be presented in a similar manner (identical title blocks/format etc.) to provide a matched set of drawings.
5. All drawings shall clearly show the status and revision of the drawings. Revised drawings shall clearly indicate the nature and details of the revision work and also revision cloud & revision mark shall be marked wherever revised.
6. All drawings shall clearly identify the drafts-person responsible together with the identity of the drawings checker.

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

3.4.5.4 **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.

3.4.5.5 **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:

Programming procedures;

System specifications;

Electrical power requirements;

Expansion of internal fault diagnostics;

Troubleshooting procedures;

Powering up procedures;

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:

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

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

- 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:

List of recommended spare parts.

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

3.4.5.6 **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.

3.4.5.7 ***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.

3.4.5.8 ***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.

3.5 **QUALITY CONTROL AND ASSURANCE**

3.5.1 **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.

3.5.2 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.

3.5.3 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.

3.5.4 Submission and Certification of Construction Documents

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

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

3.5.5 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.

3.5.6 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.

3.6 FIELD SURVEYS AND INVESTIGATIONS

3.6.1 General

The Contractor shall carry out 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.

3.6.2 Setting Out

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

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

3.6.3 Topographic Surveys

The Contractor may 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.

3.6.4 Geotechnical Investigations

The Contractor may carry out additional geotechnical investigations in the Works area.

3.6.5 Post Construction Survey

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

3.7 EMPLOYER'S RESPONSIBILITIES

3.7.1 Datum Points and Levels

The Employer will give the details of a reference Bench Mark 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 works shall confirm the location

and details of datum points and levels. The Contractor shall convert all the levels accordingly with respect to MSL.

3.7.2 Contractor Working Area

The Employer shall provide land area limited to 2 acres within the Project Site for the Contractor's working area. No space for the labour camp shall be provided.

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. The material shall be tested before bringing it to the site.

This specification establishes and defines the requirements of various materials to be used in Civil and Structural works.

Whenever any reference to IS Codes is made, the same shall be taken as the latest revision (with all amendments issued thereto) as on the date of submission of the Tender.

Apart from the IS Codes mentioned in particular in various clauses of this specification, all other relevant codes related to specific job under consideration regarding quality, tests, testing and/or inspection procedures shall be applicable. Reference to some of the codes in various clauses of this specification does not limit or restrict the scope of applicability of other referred or relevant codes.

In case of any variation/contradiction between the provision of IS Codes and this specification, the provision given in this specification shall be followed, unless the Employer agrees/consents to follow IS codes or other proposal of the Contractor as provided in the Contract.

All materials shall be of standard quality and shall be procured from renowned sources/manufacturers approved by the Employer. It shall be the responsibility of the Contractor, to get all materials/manufacturers approved by the Employer prior to procurement and placement of order.

Wherever brand is not mentioned, Contractor can choose a brand complying with the tender specifications however mentioning the brand considered in the Bid submission for the approval of the Employer if required.

Whenever called for by the Employer, all tests of the materials as specified by the relevant IS Codes shall be carried out by the Contractor in an approved laboratory and test reports duly authenticated by the laboratory, shall be submitted to the Employer for his approval. If so desired by the Employer, tests shall be conducted in the presence of the Employer or his authorised nominee.

Quality and acceptability of materials not covered under this specification shall be governed by the relevant IS Codes. In case IS code is not available for the particular material, other codes e.g. B.S. or DIN or API/ASTM etc. shall be considered. The decision of Employer in this regard shall be final and binding on the Contractor.

Whenever asked for, the Contractor shall submit representative samples of materials to the Employer for his inspection and approval. Approval of any samples does not necessarily

exempt the Contractor from submitting necessary test reports for the approved material, as per the specification/relevant IS Codes.

The Contractor shall submit manufacturer's test reports on quality and suitability of any material procured from them and their recommendation on storage, application, workmanship etc. for the intended use. Submission of manufacturer's test reports does not restrict the Employer from asking fresh test results from an approved laboratory of the actual material supplied from an approved manufacturer/source at any stage of execution of work.

All costs relating to or arising out of the tests and submission of test reports and or samples to the Employer for his approval till the date of issuance of Performance Certificate shall be borne by the Contractor.

Materials for approval shall be separately stored and marked, as directed by the Employer and shall not be used in the Works till these are approved. All rejected materials shall be immediately removed from the site by the Contractor at his own cost.

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 water tight reservoirs made with bricks/stone or reinforced concrete. Brick/stone masonry reservoirs shall have RCC base slab and shall be plastered inside, with 1 part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be of sufficient capacity to meet the water requirements, at any stage of construction.

Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for preparation of cement mortar, concrete as well as for curing of plain/reinforced concrete and masonry works. Sea water shall not be used for 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 alkalis, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, sea shells etc.

Source and type of aggregates shall be got approved by the Employer prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, the Employer subject to the Contract may accept the proposal to change. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Employer. Aggregates, which may chemically act with alkalis 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 sea shores, creeks or river banks 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.

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	
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 or 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 sea shores, creeks or river banks affected by tides shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below grading zone-III as per IS-383 shall be allowed for filling.

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.

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.

4.1.6.2 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works shall be round bars of Grade I quality complying to IS:432 "Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement" or High Yield Strength Deformed round bars of grade Fe500 conforming to IS:1786-2008".

As in this case for coastal regions, epoxy coated TMT bars confirming to IS:13620-1993 shall be considered.

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 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 & nuts 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 Hand rail 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

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.

4.1.6.5 **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.

4.1.6.6 **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.

4.1.6.7 **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 minimise breakages and defacement of bricks. The supply of bricks shall be so arranged that as far as possible, at least two days' requirements of bricks are available at site at any time. Bricks, of different class, shall be stacked separately.

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
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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, sea shells etc. Unless otherwise approved, stones from one single quarry shall be used for any one work. The strength of stones should be adequate to carry the imposed load and shall meet all the requirements of IS:1905, taking into account the appropriate crushing strength of stone and type of the mortar used. The percentage of water absorption, when tested in accordance with IS:1124, shall not exceed 5 percent.

Stones normally used, shall be small enough to be lifted and placed by hand. The length of the stone shall not exceed 3 times the height. Width of stone on base shall not be less than 150 mm and in no case exceed $3/4^{\text{th}}$ 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 recognised and approved laboratories or any other document directed by the Employer for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Employer for his selection. In case, both the names are rejected, the Contractor shall submit a fresh list of two manufacturers for approval by the Employer.

The Employer may direct the Contractor to submit test results as required by IS:2645 or IS:9103 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.

In case of non-availability of any IS code for testing and acceptability criteria, relevant British, American or German Code shall be applicable in the order of preference.

Prior approval of the Employer shall be obtained while using water reducing admixtures in the concrete (PCC/RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless prior approval taken from the Employer. Once approved, utmost care shall be taken at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/mortar so produced.

The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates together with any other materials to be actually used in the works as per the direction of Employer. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved 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 water tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. This shall be able to withstand a water head of at least 12 metres.

Performance requirements of PVC water bars shall meet the requirements of IS:12200. These shall be of approved make and of ribbed/serrated/plane type with a bulb at the centre. The thickness shall not be less than 5 mm and width less than 150 mm. The joining of the water bars shall be carried out by vulcanising strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

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
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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 ply wood 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 galvanised surfaces are to be painted, they shall be cleaned and washed with a solution of Copper Sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Engineer.

All steelwork unless specified otherwise, shall be painted as per the following schedule:

- a) Two coats of epoxy base zinc rich primer (92% zinc on dry film) shall be applied. The dry film thickness of two coats shall be 60 microns minimum.
- b) After the application of primer, all surfaces shall receive two coats of coal tar epoxy or any other high build epoxy compatible with the primer. The finish paint shall be applied to establish an endurable protection of the prime coat. It shall be resistant to atmospheric heat, reflect heat and rays and withstand mechanical stresses without crumbling. The total dry film thickness for these 2 coats shall be 200 microns minimum. The colours for the finishing coats shall be as approved by the Engineer.
- c) Total dry film thickness for the system shall be 260 microns minimum.
- d) For steel work intended to be painted only at Site, a primary coat of Red Oxide Zinc Chromate shall be given at the shop before dispatch.

4.1.15 Polysulphide Sealants

All Polysulphide Sealants shall conform to IS:12118 and be of approved make. Test conditions and requirements shall be as given in the above referred IS code.

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/mm ²)
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 nominal mix and design mix types respectively.

4.2.4.1 Nominal Mix Concrete

This concrete shall be made (without preliminary tests) by adopting nominal concrete mix with proportions of materials as specified in **Table-1A**.

Table 1A - Proportions for Nominal Mix Concrete

Nominal mix of concrete (by mass)	Quantity of water per 50 Kg of cement (max) / Litres
1:5:10	60
1:4:8	45
1:3:6	34

Note:

1. The proportions of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregates becomes larger. Graded coarse aggregates shall be used.
2. The cement content of the mix shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio, as specified, is not exceeded.

4.2.4.2 **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 taken into account.

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 plasticiser / super-plasticiser 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 plasticiser / super-plasticiser before submitting the proposed design-mix for approval. Where adequate workability is difficult to obtain at maximum permissible water-cement ratio, increased cement content shall also be alternatively considered while designing the mix proportions.

The suggested ranges of values of workability of concrete measured in accordance with IS: 1199 are indicated in Table 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 take into account the type of cement, minimum cement content

irrespective of the type of cement and maximum water-cement ratio conforming to the exposure conditions as given in Table-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./m ³)	Maximum Water-Cement Ratio	Minimum Cement Content (Kg./m ³)	Maximum Water-Cement Ratio
Normal	OPC* PPC* PSC*	Nominal mix	0.6	300	0.55
Moderate	OPC* PPC* PSC'	250	0.6	350	0.50
Severe	SSC* PSC* SRC'	310	0.45	400	0.45

Note:

1. Severe exposure shall include structures exposed to sea or saline water (e.g. tidal rivers, brackish water, estuaries etc.), alternate wetting and drying, freezing whilst wet and subject to heavy condensation or corrosive environment. This shall also include structures exposed to Sulphate and/or chloride attack due to presence of these chemicals in Soil and ground water. Total SO₃ content of 0.2% and above in Soil and 300 ppm in ground water shall be considered to constitute severe exposure. Similarly, chloride (as Cl) 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 / m ³
Very wet sand	7.5	120
Moderately wet sand	5.0	80
Moist sand	2.5	40
Moist Gravel or Crushed Rock	1.25-2.5	20-40

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

4.2.7 Concrete Mixing

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

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.

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

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

4.2.7.3 Hand Mixing

Hand mixing of concrete shall not be permitted. However, for non-critical structures located at far away isolated places, this may be permitted by the Employer as a special case. Ten percent (10%) extra cement shall have to be added to the normal mix when mixed by hand. It shall be carried out on a water tight platform and care shall be taken to ensure that mixing

is continued until the mass is uniform in colour and consistency. No extra payment shall be made to the Contractor for mixing by hand or for using extra cement due to hand mixing. However, extra cement consumed shall be considered for reconciliation purposes where such concreting is allowed by the Employer.

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, stays and braces (serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations) shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These shall not be buried in the concrete. Concrete shall be thoroughly compacted with vibrators and fully worked around the reinforcement, embedded fixtures and into corners of formwork before setting commences and shall not be subsequently disturbed. Methods of placing shall be such as to preclude segregation. The formation of stone-pockets or mortar bondage in corners and against face forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding as directed by the Employer. Care shall be taken to avoid displacement of reinforcement and embedded inserts or movement of formwork.

Unless otherwise approved, concrete shall be placed in single operation to the full thickness of foundation rafts, slabs, beams and similar members. Concrete shall be placed continuously until completion of the part of the work between approved construction joints or as directed by the Employer.

The method of placing and compaction employed in any particular section of the work shall be to the entire satisfaction of the Employer.

During hot weather (atmospheric temperature above 40 degree Celsius) or cold weather (atmospheric temperature below 5 degree Celsius), the concreting shall be done as per the procedure set out in IS:7861. Concrete that has set standing and becomes stiffened shall not be used in the work.

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 hand 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	20m ³	Every 20 m ³ or part thereof or more frequently as decided by the Employer
		b) Silt content	Field	20m ³	-DO-
		c) Particle size distribution	Field or Lab as decided by the Employer	40 m ³	1) Every 40 m ³ of fine aggregate/ sand required in RCC works only 2) Every 80 m ³ of fine aggregate/sand required for other items
2	Store aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test where required by the Employer or as specified	As required by Engineer	For all quantities
		b) Particle size distribution	Field or lab as required by Employer	45 m ³	For every 45 m ³ or part thereof as decided by Employer
		Ten percent Fine value	Laboratory	45m ³	Initial test and subsequent test as & when required by

					Employer.
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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/mm ²)	Modulus of Rupture by Beam Test, at minimum	
		72±2 hours (N/mm ²)	7 days (N/mm ²)
M15	10.0	1.5	2.1
M20	13.5	1.7	2.4
M25	17.0	1.9	2.7
M30	20.0	2.1	3.0
M35	23.5	2.3	3.2
M40	27.0	2.5	3.4

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 m ³	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 & above	4 plus one additional sample for each additional 50m ³ or part thereof
NOTE: At least one sample shall be taken from each shift.	

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 ± 15 percent 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) The standard deviation of concrete of a given grade shall be calculated using the following formula from the results of individual tests of concrete of that grade obtained as

specified in 2.15.7

$$\text{Estimated standard deviation}(s) = \sqrt{\frac{\sum \Delta^2}{n - 1}}$$

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 honey-combing etc. observed shall be brought to the notice of the Employer. The Employer may at his discretion allow rectification by necessary chipping and packing or grouting with concrete or cement mortar. However, if honey-combing or sagging are of such extent as being undesirable, the Employer may reject the work totally and his decision shall be binding. No extra payment shall be made for rectifying these defects, demolishing and reconstructing the structure. However, quantity of cement actually used for this purpose may be considered for reconciliation of materials. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as from the formwork except that honey-combed surface shall be made good as specified above.

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 taken into account 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 50 mm.
 - iii) Thickness : ± 0.05 times the specified thickness.

Note: Tolerances apply to Cast-in-situ concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

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

i)	Upto 3m	:	$\pm 6\text{mm}$
ii)	3m to 4.5m	:	$\pm 9\text{mm}$
iii)	4.5m to 6m	:	$\pm 12\text{mm}$

Additional deviation for every subsequent 6m: $\pm 6\text{mm}$

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 $1/100^{\text{th}}$ 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/m^2	
	at 10° (in Celsius)	at 24° (in Celsius)
0.6	36.0	29.0
0.9	40.0	32.0
1.2	44.0	35.0
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.

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 the Employer. The bars shall be allowed to cool gradually without quenching.

Bars shall be bent in a slow and regular movement to avoid fractures. Bars which develop cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time is radius of the bend less than 4 times bar diameter for plain mild steel or 6 times bar diameter for high strength deformed bars. Care shall also be taken when bending back bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

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 : $\pm 10\text{mm}$
- b) For effective depth more than 200mm : $\pm 15\text{mm}$

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 be plugged at the start of the work so as to minimise the entry of water into the tube and it shall be entirely sealed at all times and kept full of concrete upto the bottom of hopper. Concreting operations once commenced are to be completed in full without break otherwise the structure shall be considered as rejected.

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, stair cases and ladders.
or
- b) Free flow non shrink 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.

4.3.2 Bored cast in-situ Piles

4.3.2.1 *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 M35 conforming to IS:10262. The cement content for piling work shall be minimum 400 kg/m³ 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.

4.3.2.2 *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.

4.3.2.3 *Boring*

Boring shall generally be carried out by recommended procedure as set out in IS:2911 by either rotary or percussion equipment, grabbing equipment or by reverse or direct mud circulation method. If the soil is found to be unstable, the boring tools should be such that suction effects are minimized. Walls of boreholes shall be stabilized by using removable bottom casings with or without drilling fluid depending upon the soil conditions. In soils liable to flow, the bottom casing should be kept ahead of the boring in all cases to prevent the entry of soil into the bore, so preventing the formation of cavities and settlements in the adjoining ground. Continuous pumping shall not be used for excavating inside the boreholes. While below sub-soil water level, precaution shall be taken so that no boiling of the bottom of the hole occurs due to the difference in hydrostatic head. The size of cutting tool shall not be less than the diameter of pile by more than 75 mm.

Where stabilization of the sides of the boreholes is effected by the use of drilling fluids, the fluid level shall be maintained at a level not less than 1.5 m above the level of the sub-soil water or high water level as the case may be and the hole shall then always be kept almost full with it till the concreting is completed.

The specific gravity and composition of the fluid shall be such as to suit the requirements of the ground conditions and to maintain the fine materials from the boring in suspension.

Boring of any pile must be completed in one continuous operation without interruption. In case such interruptions are unavoidable, steps shall be taken to prevent the collapse of sides of the boreholes.

The Contractor shall be responsible in the event of bore collapse due to any reason, at the discretion of the Employer, re-boring or additional bores shall be carried out at no extra cost. If additional pile is driven and extra material is consumed due to strengthening of cap etc. such material shall be to Contractor's account.

Boring in rock shall be carried out either by chiselling or by any other approved method. The bottom of the borehole shall be cleaned off by air lifting all the spills and sediments so that the bases of piles shall be free from loose materials. Rock shall be classified in six grades I through VI in accordance with the classification made in BS 5930. Employer's interpretation in this context shall be final and binding.

The Contractor shall be responsible for the prompt removal from the Site of all spoil due to the boring upto a distance of 4 km and at places specified by the Employer. The cost of such disposal shall be deemed to have been included in the price.

Foundation elevation of each pile will be individually approved by the Employer on the basis of the Employer satisfying himself, from observations, designs in supporting of the founding levels and all data including SPT tests at his disposal, of the soundness of the end bearing stratum. However, the piles shall be socketed minimum 1 (one) diameter into hard rock. For determining the founding strata, standard penetration tests shall be carried out in the borehole by "Nordmeyer Standard Penetrometer" for 2 piles in every 50 m, as decided by the Employer. Before commencing a penetrometer test, the bottom of the borehole shall be cleaned.

4.3.2.4 Drilling Fluid

Bentonite used in the works shall be of the best quality. Bentonite shall be mixed thoroughly with clean fresh water to make a suspension, which will maintain the stability of the pile excavation for the period, necessary to place concrete and complete construction. The fluid used shall be such as to form a suspension, which remains stable under the saline conditions likely to be encountered at the Site and suitable in all respects for the construction of marine piles.

Control test shall be carried out on the bentonite suspension using suitable apparatus. The frequency of testing the drilling fluid and the method and procedure of sampling shall be as directed by the Employer. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed.

The measuring device shall be calibrated to read to within 0.005 g/ml. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite used in the works.

4.3.2.5 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.

4.3.2.6 Reinforcement

Any reinforcement used shall be made up into stiff cages sufficiently well wired or welded to withstand handling without any distortion or damage. The bars shall be so placed as not to

impede the placing of the concrete. They shall be placed correctly in position and be supported away from the sides of the pile shaft by means of spacer blocks to assume concentric alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the piles without any distortion or displacement. Care shall be taken to preserve the correct cover and the alignment of the reinforcement throughout the whole operation of placing the concrete.

Normal lap between reinforcement cages shall be as per I.S. Specifications. The main reinforcing steel shall project for a length sufficient to develop bond above the cut-off level of the pile. The clear concrete cover to main reinforcement shall be 75 mm and suitable spacer blocks shall be provided at intervals not exceeding 2 m and wired to the main reinforcement.

4.3.2.7 MS Liners/Casing

For River piles (all Jetty piles deemed to be Jetty 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 river bed level.

4.3.2.8 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.

4.3.2.9 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.

4.3.2.10 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.

4.3.2.11 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.

4.3.2.12 **Load Tests**

Vertical load tests shall be carried out on the specially constructed test piles. In addition to vertical load tests, the Contractor shall carry out horizontal load test on bored piles specially constructed for the purpose. Maximum test loads shall be as determined by the Employer according to I.S. Specifications considering the design horizontal loads.

One static load test shall also be carried out on a routine pile taking help from the adjoining permanent Piles/additional tension piles or installing soil anchors.

A) Vertical Load Test

- a) The test shall be carried out by applying a series of loads on the test pile. The load shall be preferably applied by means of hydraulic jacks reacting against a symmetrically erected loaded platform which shall be preloaded to not less than 1½ times the design load carrying capacity of the pile. The hydraulic jack shall be of adequate capacity and shall have a pressure gauge and remote control pump.

The Contractor shall arrange all the necessary equipment and kentledge with platform at his own expense well in advance of the load test. Detailed proposal together with a sketch for the load test arrangement shall be furnished by the Contractor to the Employer for the latter's checking and approval.

- b) The pile to be tested shall be chipped and dressed to a well-levelled surface. It is important that reinforcing bars of the pile do not project beyond the top surface of the level pile top.
- c) A round plate of suitable thickness and always greater than the diameter of the pile that is to be tested, shall be placed over a fine layer of sand spread over the top of the pile.
- d) A jack or two jacks, depending on the capacity of the jacks and the ultimate test load shall be inserted between the gap formed by the top of the plate resting on the pile and the lower flange of the main RSJs of the loaded platform. The jacks should preferably be connected and operated by one pump.

The Contractor shall submit certificates showing the correctness of the calibration of the pressure gauges and the jacks before use. All jacks shall be fitted with locking devices.

- e) Another plate of suitable thickness shall be placed over the ram of the jack, which is later raised by operating the hydraulic pump so that the plate on the top of the ram butts against the bottom flange of the main RSJs of the platform.
- f) Readings of settlement and rebound shall be recorded with the help of four dial gauges of 0.02 mm sensitivity and resting on diametrically opposite ends of the pile cap.

The dial gauges shall be fixed to a datum bar whose ends rest upon non-movable supports. The supports should be at least $5 \times d$ away clear from the pile where “d” is the diameter of the pile. Readings on the dial gauges are to be observed immediately before and after application of loads and immediately before and after release of loads.

- g) The test load shall be applied in equal increments of about $1/5$ of the design load until the test load is reached.
- h) Each stage of loading and unloading shall be maintained until the rate of movement of the pile top is not more than 0.02 mm per hour. Unloading shall be done as under:
 1. Test load to design load
 2. Design load to 50% of the design load
 3. 50% to 25% of the design load
 4. 25% of the design loads to complete unloading

The rebound reading for each decrement shall be noted. The final rebounding shall be recorded 24 hours after the entire load is released. The safe carrying capacity of the pile shall be estimated in accordance with IS:2911.

B) Lateral Load Test on Piles

- a) Two test piles shall be installed to the required depth and spacing as specified by the Employer. A hydraulic jack of adequate capacity shall be inserted in between them to apply the lateral load at the approximate cut-off level of the pile. Thrust pieces shall be inserted on either end of the jack to make up the gap. Lateral deflections shall be measured at the thrust level by means of dial gauges fixed to immovable supports.
- b) The loading shall be applied in one half tonne increments till the rate of deflection reduces to 0.02 mm/hour and a load deflection curve shall be plotted.
- c) The loading shall be continued till the deflection of the pile top reaches the estimated value or the estimated safe load whichever is earlier.
- d) When the full test load is applied it shall be kept on for 24 hours with observations made every hour and then released in 3 stages.

C) Plant and Equipment

All temporary work, plant equipment, kentledge for applying the load and all necessary instruments for measurement of loads, deflection, etc. shall be provided by the Contractor. The equipment provided shall be capable of slowly applying and maintaining the required test loads to within an accuracy of 0.02 mm. The Contractor shall submit for approval of the Employer his detailed proposal for carrying out the load test.

D) Cost of Delay

The Contractor shall be deemed to have allowed in the construction programme the time required for testing of piles. No claim shall be entertained for any delay due to the testing programme.

E) Records

The Contractor shall submit to the Employer the following records of the tests:

- a) Make and specification of jack, pressure gauge and dial gauges;
- b) Calibration of pressure and dial gauges
- c) Design load of pile, description of location and identification marks of pile

The readings for settlement and rebound shall be entered in the following form:

Time	Load	Dial	Settlement	Dial	Settlement	Mean Set	Remarks
1	2	3	4	5	6	7	8

F) Interpretation of Test Results

The pile shall be deemed to be acceptable under the following conditions:

Total settlement under the test load does not exceed 12 mm plus allowance for normal elastic deformation.

The increase in settlement between two consecutive increments of loading does not exceed 6 mm plus allowance for elastic deformation.

The elastic deformation is defined as shortening of the pile within the elastic limit of the materials forming the ingredients.

G) Standard of Acceptance

The piles shall be approved as satisfactory only when the work has been executed in accordance with the Specification and to the satisfaction of the Employer and the standards stated below.

- a) The head of the pile shall be within 75 mm of the specified position
- b) The pile shall not be out of plumb by more than 2%
- c) The toe of the pile shall be at the approved bearing level in each case
- d) The total volume of concrete shall not be less than 95% and not more than 120% of the calculated volume. The calculated volume for this purpose shall be cross sectional area inside the casing multiplied by the length of the shaft
- e) The concrete shall be of the design strength

Should a pile fail to meet the standard of approval specified above the Employer may take one of the following decisions:

- a) Instruct the Contractor to carry out additional tests to ensure the soundness of pile.

- b) Accept the work and allow the Contractor to make suitable alternation in the construction of piles/pile cap/and beams. The cost of modification in the pile/pile beams shall be borne by the Contractor.
- c) Reject the pile/piles and instruct the Contractor to install additional piles at Contractor's expense.

The piles which fail to fulfill the standard of approval specified under Para (f) above shall be rejected and the Contractor, at his own cost, shall install additional piles as directed by the Employer.

H) Integrity Testing

Non-destructive integrity testing of bored piles, for 100% of piles, shall be conducted using the low strain sonic diagnostic system consisting of hammer, low 'g' accelerometer with amplifier, pile integrity tester, portable computer system, graphics printer etc. all complete. The test shall be conducted by the qualified and experienced specialists in this field. Employer's decision shall be final regarding approval of piles passing integrity test but of questionable workmanship.

4.3.2.13 *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.

4.3.2.14 *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.

4.4 **SITE GRADING**

4.4.1 **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.

4.4.2 Material

4.4.2.1 *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

4.4.2.2 *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.

4.4.2.3 *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.

4.4.2.4 *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)

4.4.2.5 **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.

4.4.3 **Compaction**

4.4.3.1 **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.

4.4.3.2 **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 m ²
Moisture content/maximum dry density relationship	2000 m ²
Particle size distribution	2000 m ²
Atterberg limits	2000 m ²
Linear shrinkage	2000 m ²
CBR	2000 m ²
Sulphate content	2000 m ²
Chloride content	2000 m ²

4.4.4 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 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.

4.4.5 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.

4.5 ROADS AND PAVEMENT WORKS

4.5.1 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 pavement 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.

4.5.2 Water Bound Macadam Layers for Roads & Flexible Pavements

4.5.2.1 General

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

4.5.2.2 **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

4.5.2.3 **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 grain 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 be 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 m² 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 be 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/Murum

Sand for filling shall preferably be locally available sand, clean and free from any chemical or other impurities. Murum for filling shall be clean and well graded. Sand/Murum shall not contain any vegetation, organic, clayey or other material and shall be obtained from a source approved by Employer.

Murum/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 be 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.

4.5.2.4 **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.

4.5.2.5 **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 Murum

The binding material shall be clean, dry murum 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 laid parallel to centre line of the road.

The WBM layer shall be tested by depth blocks. No segregation on large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pocket of fine materials.

The coarse aggregate shall not be spread in lengths more than 3 days average work in advance of the rolling, spreading murum and bonding of the preceding section.

4.5.3 **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 be done if required.

4.5.4 Screenings

4.5.4.1 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

4.5.4.2 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 be mandatory, in case either murrum or gravel is used as screenings.

4.5.4.3 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 bound macadam- courses.

4.5.4.4 *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.

4.5.4.5 *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.

4.5.4.6 *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.

4.5.4.7 ***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.

4.5.4.8 ***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.

4.5.5 **Flexible Pavements**

4.5.5.1 ***General***

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

4.5.5.2 ***Bitumen Premix Carpet***

i) **Material**

ii) **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.

iii) **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.

4.5.5.3 *Quantities of Materials*

Material	For Premix Carpet per 100 m ²	For seal Coat per 100 m ²
For Premix Carpet 20mm thick		
Coarse Aggregate 12mm	2.75 m ³	and down size
Bitumen 80/100	150 kg.	68.3 kg.
Coarse sand as sealing aggregate	-	0.6m ³
For Premix Carpet 25mm thick		
Coarse Aggregate 12mm and down size	3.5m ³	
Bitumen 80/100	185 kg.	68.3 kg
Coarse sand as sealing compound	0.6 m ³	
For Premix Carpet 50 mm thick		
Coarse Aggregate 25mm and down size. (For 35 mm thick carpet layer)	5.5m ³	
Coarse Aggregate 12 mm and down size (for 15 mm thick carpet layer)	2.0 m ³	
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	0.6m ³	
For Premix Carpet 75 mm thick		
Coarse Aggregate 25mm and down size (for 50mm thick layer)	8.5m ³	
Coarse Aggregate 12mm and down thick II layer)	3.5m ³	
Bitumen 80/100		
a) For 50 thick I layer	375kg.	68.3kg.

Material	For Premix Carpet per 100 m ²	For seal Coat per 100 m ²
b) For 25 thick II layer	185kg.	
Coarse sand as sealing aggregate	0.6 m ³	

4.5.5.4 **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°C 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.

4.5.5.5 **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 100m² 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 10 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.

4.5.5.6 *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, bladed with chippings and rolled.

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

4.5.6 *Lean Concrete Base*

4.5.6.1 *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.

4.5.6.2 *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.

4.5.6.3 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/mm². 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.

4.5.6.4 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.

4.5.7 Concrete Block Paving

4.5.7.1 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 contain 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.

vi) 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 : $\pm 2\text{mm}$

Width : $\pm 2\text{mm}$

Thickness : $\pm 3\text{mm}$

vii) 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.

4.5.7.2 **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 struck 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/m² at a frequency of 75-100 Hz and has a plate area not less than 0.25 m². 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.

1. Permissible tolerance on centre line of pavement construction relative to horizontal alignment: +10 mm.
2. 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.

4.5.7.3 **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.

4.5.7.4 **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.

4.5.8 Removal of Surplus Earth

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

4.5.9 Brick Pitching

4.5.9.1 Excavation

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

4.5.9.2 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.

4.5.9.3 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.

4.5.10 Traffic Markings

4.5.10.1 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.

4.5.10.2 **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 plasticised 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 21 ⁰ C	65 to 70 KU
Drying Time	Approx. 10 –15 min
Coverage	3 m ² per litre maximum
Brightness	80 minimum
Flexibility	Passes around 12 mm diameter mandrel
Chlorinated rubber content	9.0%

4.5.10.3 **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.

4.5.10.4 **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, striping, 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.

4.6 STORM WATER DRAINAGE

4.6.1 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 sea.

4.6.2 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

4.6.3 Materials

4.6.3.1 *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.

4.6.3.2 *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.

4.6.4 Execution

4.6.4.1 *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.

4.6.4.2 *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.

4.6.4.3 *Repair and Retesting*

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

4.6.4.4 ***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.

4.6.4.5 ***Tolerances***

Pipe Inverts: Plus 10 mm, minus 10 mm

Catch Basin Grates: Plus 0.00 mm, minus 10 mm

4.6.5 ***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.

4.6.6 ***Construction of Catch Basins and Trench Drains***

4.6.6.1 ***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.

4.6.6.2 ***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.

4.6.6.3 ***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.

4.6.6.4 ***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.

4.6.6.5 ***Cleaning***

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

4.6.6.6 ***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.

4.6.7 **Installation of Flap Gate**

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

4.6.8 **Rain Water Harvesting System**

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

4.7 **EARTHWORK**

4.7.1 **General**

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

4.7.2 **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.

4.7.3 **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.

4.7.4 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.

4.7.5 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.

4.7.6 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.

4.7.7 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.

4.7.8 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.

4.7.8.1 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).

4.7.8.2 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.

4.7.8.3 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.

4.7.8.4 *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.

4.7.8.5 *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.

4.7.8.6 *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.

4.7.8.7 *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.

4.7.9 *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.

4.7.10 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.

4.7.11 Existing Levels

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

4.7.12 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.

4.7.13 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.

4.7.14 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.

4.7.15 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.

4.7.16 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.

4.7.17 Anti-Termite Treatment

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

4.7.17.1 *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.

4.7.17.2 *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.

4.7.17.3 *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.

4.7.17.4 ***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.

4.7.17.5 ***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

4.8 **BRICK MASONRY WORKS**

4.8.1 **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.

4.8.2 **Materials**

Refer specifications under 'Materials'.

4.8.2.1 ***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.

4.8.2.2 ***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 bulking.

4.8.2.3 *Mixing*

The mixing of mortar shall be done in a mechanical mixer operated manually or by power. The Employer may, however, permit hand-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.

4.8.3 *Construction Procedure*

4.8.3.1 *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.

4.8.3.2 *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 with 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 part 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.

4.8.4 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.

4.8.5 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.

4.8.6 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.

- a) Sufficient sills or underpinnings, in addition to base plates, shall be provided, particularly, where scaffoldings are erected on soft grounds.
- b) Adjustable bases to compensate for uneven ground shall be used.
- c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.
- d) Horizontal braces shall be provided to prevent the scaffolding from rocking.
- e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.
- f) The scaffolding/staging shall be checked at every stage for plumb line.
- g) Wherever the scaffolding/staging is found to be out of plumb line, it shall be dismantled and re-erected afresh. Efforts shall not be made to bring it in line with a physical force.
- h) All nuts and bolts shall be the clamps/couplings are firmly tightened to avoid slippage.

- i) Erection work of a scaffolding/staging, under no circumstance shall be left totally to semiskilled or skilled workmen and shall be carried out under the supervision of Contractor's technically qualified civil Employer.

For smaller works or works in remote areas wooden ballies may be permitted for scaffolding/staging by the Employer at his sole discretion.

4.8.7 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.

4.8.8 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 filler shall be strictly in accordance with the manufacturer's printed instructions.

4.8.9 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.

4.8.10 Galvanised Mild Steel Butterfly Wall Ties

For all vertical joints between brick work and concrete galvanised mild steel butterfly pattern wall ties are to be cast in concrete at 400 mm vertical spacing and then built into the mortar bed joints of the wall.

Where specified, both skins of cavity walls are to be built in brickwall, the skins shall be tied together with galvanised mild steel butterfly pattern wall ties and spaced at the rate of one every 600 mm horizontally and 400 mm vertically, staggered every 400 mm vertically at ends jambs and quoins.

4.9 STRUCTURAL STEEL WORK

4.9.1 General

This section includes requirements of all structural steel work required for the completion of the Works, as shown on the drawings and as specified herein.

All structural steel used by the Contractor for the construction shall conform to relevant IS codes or equivalent as approved by the Employer and described in this specifications. If deviation or a substitution of material is sought, the Contractor shall submit written request to Employer along with necessary supporting documents including test results, manufacturer's certificate, etc. along with reasonable time for evaluation without disruption of the construction schedule. It shall be the Contractor's responsibility to satisfy the Employer that his proposed deviation or substitution will in no way be detrimental to the quality of the works intended in the Contract. In case of any doubt the Employer may ask for additional information, testing or retesting which the Employer may feel necessary, which

the Contractor shall carry out to the Employer satisfaction and with no impact on the construction schedule.

It shall be noted that site fabrication and painting of steel members shall not be allowed. The Contractor has to make his arrangements accordingly.

4.9.2 Structural Steel

4.9.2.1 Steel Grades

Unless otherwise stated all steel shall conform to one of the following grades.

- a) Carbon Steel: ASTM A 36 or approved equivalent (F_y=36 Ksi) IS 2062 Gr A
- b) Intermediate strength steel: BS 7191 Gr 355D, API Spec.2 H Gr 50 or

APPROVED EQUIVALENT (F_y=50ksi)

Steel supply to specifications equivalent to those listed above shall be considered as substitution and shall require written approval by Employer to this effect.

4.9.2.2 Structural Steel Types

Rolled Shapes and Plates

All rolled shapes and plates shall be carbon steel grades as defined and unless otherwise specified.

Tubulars

All Tubulars shall be fabricated in accordance with API Spec. 2B, from plates which should conform to one of the steel grades indicated in Clause (i) above.

Mill - manufactured line pipes, where acceptable shall be of prime quality and shall conform to API 5L Gr. B or equivalent, seamless.

The use of spirally welded and electric resistance welded pipes shall not be permitted for any load bearing structural member.

i) Usage

The usage of different grades of steels shall be as determined by design. For jacket type structures (if used by Contractor), the guidelines of API RP 2A shall be followed for material usage.

ii) General Requirements

a. Process

The steel shall be manufactured by the basic open hearth, electric furnace or basic oxygen process. No rimmed or capped steel shall be used.

b. Delivery, Storage and Handling

All rolled shapes and plates are to be delivered in accordance with ASTM A6, "Standard Specifications for General Requirement for Rolled Plates, Shapes sheet piling and bars for structural use".

Fabricated Tubulars shall conform to the dimensional tolerances of API Spec. 2B, "Specifications for Fabricated Structural Steel Pipe".

For mill manufactured pipes, where permitted for use, dimensional tolerances of API Spec. 5L, "Specification for Line Pipe", shall apply with additional requirements for straightness listed in API Spec. 2B.

All structural steel shall be stored and covered in a manner which will ensure that no damage shall occur to it from moisture, dirt, grease or any other cause which might impair bond with concrete.

a. Identification

A sufficient supply of approved structural steel shall be stored at the site at all times to ensure that there will be no delay of the work.

Steel will be reasonably free from defects, mill scale and rust.

Structural steel shall be bundled and tagged with grades, size and suitable identification mark for checking, sorting and placing size and mark numbers. Tags and markings shall be waterproof and shall not be removed until steel is placed.

b. Mill Tests

All mandatory inspection and testing listed in ASTM A6, "Standard Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet piling, and Bars for Structural Use", shall apply.

Supplementary inspection and tests when specified in individual specifications shall also apply.

In addition to above for all steel materials the following are mandatory requirements:

Product Analysis : One sample per heat. Acceptability standards as specified in ASTM designation A6 shall apply for all elements.

In addition, a field weldability test shall be performed in accordance with the requirements of relevant IS codes or equivalent with a heat input of 15–20 kJ/cm and the results of the test shall meet the requirements specified for the base material. This requirement shall be a prerequisite for the acceptance of the material.

c. Mill Certificates

Contractor shall supply the Employer with a certificate indicating the process of manufacture, results of chemical and mechanical tests including specified supplementary tests for the material. Each test certificate shall bear the heat number and other identification marks such that the same can be correlated with the material. These certificates shall be signed by manufacturer's representative and furnished along with material.

When any steel is supplied from stock, the Contractor shall satisfy the Employer that the steel has been manufactured and tested and complies with all the tests and requirements of the specification under which the steel is being furnished with necessary documentary proof of original manufacturers. The heat numbers on mill certificates should be correlated with markings on the material. Steel material without acceptable mill certificate shall not be used.

i. Special Requirements

a. Carbon Steel

All carbon steel material shall meet the following:

Max. Carbon (C_{max}) = 0.22%

Max. Carbon Equivalent (CE) = 0.45

(For CE formula refer 2.5.2)

b. Intermediate Strength Steel

The carbon equivalent shall be a maximum of 0.43 (ladle analysis) as determined from the following formula:

$$CE = \frac{C + Cr + Mo + V}{5} + \frac{Cu + Ni}{15} + \frac{Mn}{6}$$

V less than or equal to 0.08%

Nb less than or equal to 0.05%

V+Nb less than or equal to 0.10%.

i. Other Requirements

All plates shall be ultrasonically inspected for defects and discontinuities in accordance with ASTM A578. Acceptance Standard shall be level II.

If intended to use plates having defects requiring repair for welding procedure qualification, these plates shall be shipped clearly marked "For Welding Procedure Qualification Only".

ii. Heat Treatment

Heat Treatment shall be performed on all elements where properties have been degraded by forming and fabrication.

The use of furnaces is desirable for all heat treatments. When local heat treatments are deemed necessary, a detailed procedure shall be submitted to the Employer for approval prior to performing such heat treatments.

a. Stress Relief

Stress relief heat treatment shall be performed on all materials subject to the following conditions:

Elements subjected to press or roll forming where the temperature of the steel is above 38°C or less than 427°C during the forming operation.

Elements subjected to press or roll forming where the outer fiber strain exceeds five (5) percent as defined by the formula:

$$\text{Percent Strain} = \frac{100 \cdot t}{D}$$

Where t = thickness of element

D = outside diameter

Welded assemblies containing one or more elements with the thickness exceeding 65 mm.

Stress Relief Temperatures

All stress relief shall be achieved by thermal methods by heating the element or assembly to a temperature between 590°C to 620°C for carbon steel and intermediate strength steel.

4.9.3 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.

4.9.4 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".

4.9.5 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”.

4.9.6 Galvanising

Galvanising where specified shall be of the best quality conforming to IS:2629 “Recommended Practice for Hot Dip Galvanising of iron and Steel”.

4.9.7 Installation

Install in locations shown, as indicated on Contractor’s drawings, to line, plumb, and level, rigidly attached in place 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 accurately 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 correcting fabrication errors will not be permitted on any major member of the structural framing.

4.9.8 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.

4.9.9 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.

4.9.10 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 STEEL/ALUMINIUM DOORS, WINDOWS AND VENTILATORS

4.10.1 General

This section of the specification includes the requirements necessary to provide in place all steel/Aluminium doors, windows and ventilators.

4.10.1.1 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.

4.10.2 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 hardware 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 IS:2074 and painting on forming to IS:1477 Part (II) or by approved shade electrostatic powder coating (25 micron).

4.10.3 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 hardware such as tower bolt, aldop etc.

For double shutter doors, an M.S. angle 25mm x 45mm x 3 mm thick shall be welded to one of the shutters providing a minimum 25mm wide rebate for the other shutter at the meeting point during closed condition.

The shutter surfaces shall be painted with electrostatically powder coating/two coats of synthetic enamel paint over a priming coat of red oxide zinc chromate conforming to IS 2074/IS 1477 (Part-11). The shutters shall be fixed to the door frame by means of heavy duty MS butt hinges of 150mm size conforming to table 6 of IS 1341 @ 600mm max.

In case of air tight door shutters, approved quality continuous neoprene rubber beading shall be provided continuously along the door frame rebate fixed with neoprene rubber adhesive of approved make.

In case of partly glazed door shutter. Glass as 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 hardware as specified.

4.10.4 Steel Windows & Ventilator

Steel windows, ventilators shall in general conform to IS 1081, IS 1038, IS 7452.

4.10.4.1 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, 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 conforming 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.

4.10.5 Rolling Shutters

4.10.5.1 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.

4.10.5.2 **Galvanising**

All M.S. materials including lath sections, clips, guides, lock plate, guide channel, bracket plate, suspension shaft hood cover & other components shall be hot dip galvanised with a zinc coating containing not less than 97.5 percent 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).

4.10.5.3 **Shutters**

The shutters shall consist of M.S. lath sections conforming to IS 513-1986, 1.25 mm thick and 75 mm wide unless otherwise specified. The laths shall be machine rolled and straightened with an effective bridge depth of not less than 16 mm and shall be interlocked together throughout their entire length and joined together at the end with end locks by means of cast iron or galvanised mild steel clips conforming to IS 2108-1977 riveted at either end which shall prevent lateral movement of the individual lath sections. These shall be mounted on specifically designed pipe shaft. Each lath section shall be a continuous single strip piece without any joint.

4.10.5.4 **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.

4.10.5.5 **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.

4.10.5.6 **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.

4.10.5.7 Grilled Curtain

Wherever specified rolling shutter shall be provided with grilled curtain partly or fully, as required.

4.10.5.8 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.

4.10.6 Aluminium Glazed Doors/Windows/Ventilators

4.10.6.1 General

Aluminium glazed doors/windows/ventilators shall be of specified sectional size, dimension and profile as per Contractor's drawing.

4.10.6.2 Materials

All Aluminium sections shall be extruded sections of INDAL aluminium alloy as per IS:733 and 18:1285. Aluminium sections shall be anodised 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)

4.10.6.3 Workmanship

Frames shall be square and flat, the corner 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 aluminium alloy hinges. For fixing the hinges, slots shall be cut in the fixed frames and the hinges inserted inside may be riveted to the frame. The hinges shall normally be of the projecting type conforming to IS designation A-5-M of IS 617, IS 733. In which case Peg stay of 300 mm long complete with Locking bracket and conforming to IS codes same as for hinges shall be provided. Friction hinges may also be provided in which case peg stays are not required.

The handles for side hung shutters shall be of cast aluminium conforming to IS designation A-5-M of IS 617 and shall be mounted on a handle plate rivetted to the opening frames. The handle shall have anodised finish with minimum anodic film thickness of 25 micron or electro colour finish. The handle shall have a two-point nose which shall engage with an

aluminium striking plate on the fixed frame. The striking plate shall be finished in the same manner as for the handle.

In case of top hung shutters, aluminium alloy cast hinges and peg stays (same as per side hung shutters) shall be provided.

Centre hung shutters shall be hung on the two pairs of cup pivots of aluminium alloy of IS designation NS-4 of IS 737 and IS designation A-5-M of IS 617 or chromium/cadmium plated brass/bronze cup pivots riveted to the outer and inner frames to permit to swing through an angle of 85°. Cast aluminium (conforming to IS designation A-5-M of IS 617) or chromium/cadmium plated bronze spring catches shall be fitted in the centre of the top bar of the shutter. The spring catch shall be secured to the frame by screwing/riveting to the frame and shall close into an aluminium catch plate riveted/welded to the outside of the outer shutter frame bar. Aluminium or cadmium plated brass chord pulley wheel in an aluminium bracket shall be fitted at the sill of the shutter with Aluminium or galvanized/cadmium plated steel screws.

The door shutters shall be fitted with pivots as specified. The handle for doors shall be of Aluminium and as per design. The door shutters shall be provided with locking device, floor spring, O/H door closer and any other hardware, 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 aluminium beading. Glass panes shall be provided with rubber lining before fixing.

The aluminium frames shall be fixed to the masonry by means of aluminum lugs fixed to the frame (by counter sunk 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 aluminium shall be galvanized.

The windows/ventilators/doors shall be checked to ensure smooth operation, perfect level and plumb.

4.11 STEEL SHEET ROOFING AND SIDING

4.11.1 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: Galvanised steel sheet (plain& corrugated)
- IS 730: Hook bolts for corrugated sheet roofing.
- 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 rain water pipes upto 100 mm nominal size gutters, fittings and accessories.

4.11.2 Materials

4.11.2.1 Corrugated GI Sheet Roofing / Cladding

Corrugated GI sheet

G.I. sheets shall be of specified thickness and of class-3 galvanised as per IS 277 and shall be of approved brand by the Employer. The thickness of the sheets shall be worked out based on the wind speed expected in the project area.

GI Ridges and Hips

These shall be of specified thickness and of class 3 plain galvanised and shall be bent to the required shape and dimensions as per Contractor's drawings without damaging the sheet in the process of bending.

GI Valleys and Flashings

These shall be of specified thickness and of class 3 plain galvanised and shall be bent to the required shape and size as per Contractor's drawings without damaging the sheet in the process of bending.

GI Gutters

These shall be of specified thickness and of class 3 plain galvanised and shall be constructed to the required shape and size as per Contractor's drawings.

Wind Ties

Wing ties of mild steel shall be as per requirement of the design.

4.11.3 Workmanship

4.11.3.1 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 bolts. 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 galvanised iron seam bolts and GI washers. Ridges and hips shall fit squarely on the sheets.

Valleys and Flashings

The edge, wherever the roof sheeting or valley gutter is turned up against a wall shall be made weather proof with flashing. Flashing shall be bent to shape and fixed as specified. Lap over the sheet shall be minimum 150 mm. End laps between flashing sheets shall not be less than 225 mm.

Flashing shall be inserted into brick work or masonry joints to a depth of 50 mm and shall be filled with cement mortar (1:3). When flashing has to be laid at a slope, it shall be stepped at each course of masonry. The steps shall be cut back at an angle of 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 roof 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 to 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 bolts which secure sheets to the purlins. Slot holes shall be cut in the wind ties to allow for temperature variations.

4.11.3.2 Precoated Galvanized Sheet Roofing / Cladding

Material

The base metal of the roofing shall be Cold Reduced Steel Sheet conforming to IS-513. It shall be galvanised by Hot-dip process as per IS-277. The bottom unexposed surface shall then be coated with alkyd backer of min. 7 microns. Top exposed surface shall have epoxy primer of min. 7 microns followed by polyester top coat of min. 16 microns of specified colour.

Properties

The precoated galvanised steel sheets shall meet the following performance standards:

- Pencil Hardness : H-2H
- Formability : 2-3 t
- Impact Resistance : 40"/lb.
- Salt spray test : 750 hours
- QUV-Weatherometer Test : 1000 hours
- Humidity Test : 1000 hours
- Temperature Resistance : 150°C
- Fire performance : Class 1

Profile

The profiles shall have a depth of not less than 35mm and pitch of 190mm. Overall sheet thickness shall be 0.65mm min. and weight shall be 5.72 kg/sqm.

Accessories

All roofing accessories like ridge, gutters, north light curves etc. shall be fabricated out of the approved pre-coated sheet.

Metallic Fasteners and Fixing accessories shall be corrosion proof. Non-metallic fasteners shall be of neoprene. Sealants shall be neutral cure type and cold setting variety

4.12 **WOOD WORK**

4.12.1 **General**

This section of the specification includes requirements for furnishing and installing all wood work including iron mongery as specified for the completion of all of the work of the Contract.

The Contractor shall supply all timber, fittings, ancillary materials for fixing such as glue, screws, bolts, hold fasts etc. required for the works all in accordance with dimensions and sizes required.

The Contractor shall ensure that any timber entering the site for incorporation in the permanent works is of an approved quality.

Pre-fabricated & assemble doors, windows and / or any other unit shall on arrival at the site, be subjected to a thorough inspection and approval by the Employer.

Timber for joinery work shall be wrought to the exact sizes and all surfaces shall be rubbed down and left clean for painting or staining.

4.12.1.1 **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

4.12.2 Material

4.12.2.1 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 IS:4021 of good quality, well-seasoned and free from defects such as dead knots, cracks, sapwood etc. No individual hard and sound knot shall exceed 6 sq. cm in size with no dimension more than 50 mm and the aggregate area of such knots shall not be more than 1% of the area of the piece. There shall not be less than 5 growth rings per cm, width in cross-sections.

Moisture Content in Timber

The maximum permissible percentage of moisture content for well-seasoned timber shall be as per IS 287.

Workmanship of Wood Work

Workmanship for wood and joinery shall be as per IS:1200 and IS:4021.

Painting / Polishing of Wood Work

Painting/polishing of wood work shall be in accordance with specifications under 'Painting'.

4.12.3 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 frame work shall be perfect with square edges and shall be pinned with hard wood/bamboo pins of 10 to 15 mm dia.

Wood work shall be painted/polished or otherwise treated as specified. All exposed portions shall be coated with wood primer and concealed surface by bituminous paints as per specifications under 'Painting'.

Before any surface treatment is applied, the wood work shall be got approved by the Employer. The frames shall be fixed only after acceptance by the Employer. The frames shall be fixed to the masonry by 300 mm x 25 mm x 6 mm MS hold fasts embedded. In M-15 grade concrete block of 350 mm x 100 mm x 100 mm in the hole of the masonry. In case of concrete, frames shall be fixed by 96 mm long 12 mm dia metallic dash fasteners.

4.12.3.1 **Shutters**

Particle Board Flush Shutter

Particle board flush shutter shall in general conform to IS:2202.

Materials

i) Particle Board

Particle 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 of IS: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 properly 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.

4.12.3.2 **Medium Density Fibre Board Panel Shutter**

MDF board panelled shutter shall in general conform to IS: 1003.

Materials

i) MDR-board

Medium density fibreboard shall conform to IS: 12406 Exterior grade (EGSB). It shall be dense, homogeneous and manufactured from agro based lingo-cellulosic fibres bonded with BWP type phenol formaldehyde synthetic resin conforming to IS:848. It shall be categorised as class I for Surfaces of very low flame spread as per IS-1642.

ii) Teakwood

Specifications of Teakwood shall be same as specified in Clause 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 top coat and undercoat of shade to match the top coat as recommended by the manufacturer and specified under 'Painting'.

iv) Hinges Specification of hinges shall be same as specified in Clause 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 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 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.

4.12.3.3 **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 IS: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.

4.12.3.4 **Flymesh Shutter for Door and Window**

Specifications for Flymesh shutter shall be similar to specification for wooden glazed door, excepting following features:

- i) In place of glass, net of galvanised MS wire-mesh of IS gauge designation 856 wire and dia 0.56 mm shall be fixed to the shutter frame with teakwood beading.
- ii) Flymesh shutter shall be for both doors as well as windows.
- iii) All wooden surfaces shall be painted with synthetic enamel paint of approved shade in two coats over a priming coat in place of French polishing.

4.12.3.5 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 recognised laboratory to the satisfaction of the Employer.

Asbestos free composite fire/smoke check shutters of 60 min, fire resistance rating, conforming to BS:476 part 22/IS:3614 Part 2) and shall comprise two non-combustible boards each 12 mm thick sand-witching 20 mm thick fire resistant insulation faced with 3 mm commercial ply veneering on both faces and seasoned teak wood lipping around the shutters with heat activated intumescent fire seal strips of size 12 mm x 4 mm mounted in the grooves in the shutters/panels on all sides except bottom.

Seal

A heat activated intumescent seal of approved quality and make conform to BS:476 (Part 8) shall be provided on all edges of doors to check the spread of smoke in case of fire.

Paint

The door frame and panel/shutter shall be treated with ready mixed silicate type fire retardant anti-terminal primer & paint of approved shade and manufacturer as per IS: 162 (BS:476-Part I)

4.12.3.6 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 galvanised. 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.

4.12.3.7 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.

4.13 ROOFING TREATMENT

4.13.1 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.

4.13.2 Material

The material shall consist of 2 pack clear / pigmented aliphatic polyurethane using polyurethane using polyether polyols (polyester or Castor Oil based polyols not acceptable), with iso-cyanurate for rendering flame resistant characteristic. The 2 pack system, consisting of pigment and the solvent (Xylene/Toluene, 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 upto 3 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

4.13.3 Workmanship

4.13.3.1 *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.

4.13.3.2 *Primer Coat*

It shall consist of 2 pack polyurethane. Primer coat shall be mixed in the ratio as per manufacturer's specification. A single coat 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:

4.13.3.3 *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 be 200gms/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°C)

The finishing coating shall be continued up the parapets/walls for a min. of 150mm over the finished roof surface. It shall be continued into rain water pipes by at least 100mm.

4.13.3.4 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/rain water pipes by suitable rounding, filling and sloping of PCC. At the junction of the roof and parapet or any other vertical surface, a fillet of 75mm radius shall be formed in cement mortar (1 cement: 4 coarse sand).

4.13.4 Guarantee

The applicator shall execute a form of Roofing Treatment Guarantee.

4.14 PLASTERING AND POINTING

4.14.1 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.

4.14.2 Materials

4.14.2.1 Cement

Cement shall conform to specifications under 'Material' unless otherwise specified.

4.14.2.2 Sand

Sand for plastering and pointing shall conform to IS 1542. Sand shall be hard, durable, dean and free from adherent coatings and organic matter and shall not contain any appreciable amount of silt, day balls or pellets. Sand shad not contain harmful impurities such as iron pyrites, coal particles, lignite, mica shale etc.

Sand whose grading falls outside the limits of IS 460 due to excess or deficiency of coarse or fine panicles shall be processed to comply with the standards.

Fine sand shaft be obtained from river beds not affected by tidal water of the sea and shall be clean, sharp and free from excessive deleterious matter. The sand shall not contain more than 8 per cent of mud and silt as determined by field test with a measuring cylinder.

4.14.2.3 Water

Water for plastering and pointing shall conform to specifications under 'Material'.

4.14.2.4 **Cement Mortar**

Preparation of cement mortar shall conform to specifications under 'Brick Masonry' unless otherwise mentioned.

4.14.3 **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.

4.14.4 **Workmanship**

4.14.4.1 **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.

4.14.4.2 **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.

4.14.4.3 ***Scaffolding/Staging***

Scaffolding/staging for plastering/pointing shall be as per specification under Brick Masonry, Clause no. 4.8.6 of Specification.

4.14.4.4 ***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.

4.14.5 **Plain Cement Plaster**

4.14.5.1 ***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.

4.14.5.2 ***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.

4.14.5.3 **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.

4.14.6 **Sand Face Plaster**

4.14.6.1 **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.

4.14.7 **Exposed Aggregate Finish Plaster**

4.14.7.1 **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.

4.14.7.2 **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 white/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 face 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 12mm 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.

4.14.7.3 Curing

Curing shall be as described above in Clause No. 4.14.5.3.

4.14.8 Pointing

Pointing shall be of the type specified such as flush, cut or weather struck, raised and cut etc.

4.14.8.1 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

4.15 FLOOR FINISHING

4.15.1 General

This section shall cover all flooring and wall tiling work and specified herein. No work under this section shall be started until specifically allowed by the Employer and until all other major works such as plastering, embedding of conduits and pipes channels, window fixing etc. have been completed. Samples of basic materials and work of adequate size representing the nature of variation including quality, size, texture after finishing to be used in the flooring work shall be prepared for all work and got approved by the Employer sufficiently prior to ordering. The approved samples shall be retained upto the end of the project. The works shall be got done by skilled and specialised workmen experienced in the respective trade of work.

Reference shall be made to the 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

4.15.2 Cement Concrete Flooring General

4.15.2.1 General

Cement concrete flooring shall in general conform to IS 2571. Cement concrete flooring shall consist of a sub base (laid on the compacted earth or sand fill In case of ground floor only) a base course laid on the sub-base and then finishing layer of floor finishing. Where the cement concrete flooring is to be laid directly on the RCC slab, the surface of RCC slab shall be cleaned and the laitance shall be removed and a coat of cement slurry at 2 kg. of cement per sq.m. shall be applied, so as to get good bond between RCC slab and concrete floor. In

case of ground floor, the filled and compacted bed on which the sub-base is to be laid, shall be as per specifications.

The bed for flooring shall be prepared either level or sloped as instructed by Employer.

4.15.2.2 **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 shall 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 corners of the room and intermediate joints shall be in straight line with panel joints.

The panels shall be bound by MS strips/PVC strips etc. These shall be fixed in position with their top at proper level, giving slope 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.

4.15.3 Cement Concrete Granolithic Flooring

4.15.3.1 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.

4.15.3.2 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.

4.15.4 Heavy Duty Flooring

4.15.4.1 General

Heavy duty Flooring in workshop shall consist of a sub-base, a base course and a finishing layer of floor finish.

4.15.4.2 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 down size in the ratio of 1 hardener and cement mixture : 2 stone grit by volume. Just enough water shall then be added to the mix.

The mixture so obtained shall then be laid on the base course within 2 to 4 hours 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.

4.15.5 Precast Hydraulically Pressed Cement Tiles Flooring

4.15.5.1 Materials

Cement Concrete Tiles

Cement concrete tiles shall conform to IS 1237 and shall be of approved shade, with 10 mm down size stone aggregates and using a 1:6 or as directed mixture of white and ordinary cement and shall be of specified thickness and 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 properly wetted without allowing water pools. Cement mortar of specified thickness shall then be spread over the base for two rows of tiles and 3-5 metres in length. The mortar shall be laid in slope as per requirements and thickness of mortar shall not be less than 10mm at any place. The top of the mortar shall not be less than 10mm at any place. The top of the mortar shall be kept rough so that cement slurry can be absorbed. Laying shall be from centre & proceed outwards in the two directions at 90°. Cut tiles of uniform sizes shall be laid along periphery, if necessary. Neat cement slurry @ 4.4 kg. of cement per Sq.M. shall be spread over the mortar bed laying 20 tiles 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.

4.15.6 Cement Plaster Skirting

4.15.6.1 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.

4.15.6.2 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.

4.15.7 Cast-In-Situ Terrazzo Flooring

4.15.7.1 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 specfrdied 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.

4.15.7.2 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 white 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 spreaded uniformly over the surface and no part of the surface is left without the chips.

Curing

The surface shall be left dry for air curing for a period of 12-18 hours. Thereafter water shall be allowed to stand overnight in pools for a period of minimum four days.

Grinding and Polishing

Grinding and polishing shall be done 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 as 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 gms per square metre of floor surface. After the finishing works are over, the surface shall be washed with dilute oxalic acid solution and dried. Floor polishing machine fitted with felt on hessian bobs shall then be run over it until the floor shines.

In case of polishing, wax polish shall be applied on the surface with the help of soft linen over a clean and dry surface. Then the polishing machine fitted with bobs shall be run over it. Clean saw dust shall be spread over the floor surface and polishing machine again operated to remove excess wax.

4.15.8 Cast-In-Situ Terrazzo Skirting and Dados

4.15.8.1 *Material*

Refer Clause 4.15.7.1 above.

4.15.8.2 *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.

4.15.9 Precast Hydraulically Pressed Terrazzo Tile Flooring

4.15.9.1 *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.

4.15.9.2 *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.

4.15.10 Terrazzo Tiles in Risers of Steps, Skirting and Dado

4.15.10.1 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.

4.15.10.2 Workmanship

In case of brick masonry wall, the joints shall be raked out to a depth of at least 15mm while 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.

4.15.11 Glazed Tiles Work

4.15.11.1 Material

Tiles

Glazed tiles shall conform to IS: 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.

4.15.11.2 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.

4.15.12 Glazed Tiles in Risers of Steps, Skirting and Dado

4.15.12.1 Materials

Same as in Clause 4.15.11.1 above.

4.15.12.2 Workmanship

Same as in Clause 4.15.11.2 above.

Curing

Same as in Clause 4.15.7.2 above.

4.15.13 Kota Stone Flooring

4.15.13.1 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.

4.15.13.2 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.

4.15.14 Kota Stone in Risers of Steps, Skirting and Dado

4.15.14.1 *Materials*

Same as in Clause 4.15.13.1 above.

4.15.14.2 *Workmanship*

Same as in Clause 4.15.13.2 above.

Curing, Polishing and Finishing

Refer Clause 4.15.7.2 above.

4.15.15 Marble Stone Flooring

4.15.15.1 *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.

4.15.15.2 *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.

4.15.16 Marble Stone in Risers of Steps and Skirting

4.15.16.1 Materials

Same as in Clause 4.15.15.1 above.

4.15.16.2 Workmanship

Same as in Clause 4.15.13.2 above.

Curing, Polishing and Finishing

Same as in Clause 4.15.7.2 above.

4.15.17 P.V.C. Flooring

4.15.17.1 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.

4.15.17.2 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 shall 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.

4.15.18 Acid Resistant Tiles in Floors

4.15.18.1 *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	

4.15.18.2 *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 conform 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.

4.15.19 Epoxy Floor Coating

4.15.19.1 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.

4.15.19.2 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.

4.15.19.3 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

4.16 PAINTING

4.16.1 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 whitening for paint and putty.

IS 427 Distemper (dry), colours 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, aluminium brushing priming water resistant for wood work

4.16.2 White Washing

White washing in general shall conform to IS 6278.

4.16.2.1 Workmanship

Scaffolding

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be white/colour washed. For white washing of ceiling, proper stage scaffolding shall be erected.

Preparation of Surfaces

The surface shall be thoroughly cleaned of all dirt, dust, mortar dropping and other foreign matter before white wash is to be applied.

Surfaces already white/colour washed shall be broomed down to remove all dust, dirt, loose scales of white wash or other foreign matters.

All damaged portions of the surface plaster shall be removed to full depth of plaster in rectangular patches and plastered again after raking the joints in masonry properly. Such portions shall be wetted and allowed to dry before any operation.

All holes, cracks, patches etc. not exceeding 0.1 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 White Wash

The fat lime conforming 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 in hot water shall be added to each cubic metre of lime cream. Approved quality ultra 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

White wash shall be applied with 'Moonj' brush to the specified number of coats. The operation for each coat shall consist of stroke of the brush from the top to down wards, another from the down to upwards over the first stroke. Similarly one stroke horizontally from right and another stroke from the left. Each coat shall be allowed to dry before the next coat is applied.

The white washing on ceiling should be done prior to that on walls.

Protective Measures

Surfaces of doors, windows, floors etc. which are not to be white washed shall be protected from being splashed upon. Such surfaces shall be cleaned of white wash splashed if any.

4.16.3 Colour Washing

4.16.3.1 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 white wash 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 white wash solution in proportions as directed by

Employer. Solid lumps etc. in the colour powder shall be ground to fine powder, sieved and mixed evenly and thoroughly to the white wash solution.

Application of Colour Wash

Application of colour wash shall be in accordance with above Clause 4.16.2.1.

Protective Measure

Same as in Clause 4.16.2.1 above.

4.16.4 Dry Distempering

4.16.4.1 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.

4.16.5 Oil Bound Distempering

4.16.5.1 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 conform 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.

4.16.6 Waterproof Cement Paint

4.16.6.1 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 shall 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.

4.16.7 Acrylic Emulsion Painting

4.16.7.1 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.

4.16.8 Acrylic Copolymer Aggregate Finish

4.16.8.1 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.

4.16.9 Painting to Woodwork

4.16.9.1 *Preparation of Surface*

Preparation of surface shall conform to IS 2338 (Part-1) in general. All wood work shall be dry and free from any foreign manor. Nails shall be punched well below the surface. The surface shall be smoothened off with abrasive paper used across the grain prior to painting, with the grain prior to the staining. Any knots, resinous, or bluish sap wood, cutting out of which is not justified shall be covered with red lead conforming to IS 103.

Plywood and block board shall be treated in the same manner as for wood work.

Particle 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 shall 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. Filler 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 clear finishes, the following procedures shall generally be adopted in accordance with IS 2338 (Part-I)

i) Filling

Fillers shall be applied to prevent the excessive penetration of the finish to the surface for obtaining a smooth finish. Fillers shall be conforming to IS 345.

Fillers shall be heavily applied to the wood surface by hand, using hessian or jute rag across the grain. It shall be rubbed when still wet to get better penetration. After 5-10 minutes it shall be wiped off by and across the grain followed by a height wipe with the grain. The filled surface shall be dried preferably overnight and smoothened with abrasive paper.

ii) Staining

a) Spirit Stains

Spirit stains are solutions of spirit soluble dyes in Industrial methylated spirit.

b) Oil Stains

Oil stains are solutions of oil soluble dyes in 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 corners 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 while 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 flattening varnish which shall be allowed to dry hard and then be flattened 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 or flattening varnish shall first be applied and shall be allowed to harden thoroughly. It shall then be tightly rubbed down before the flat varnish is applied. On larger areas, the flat varnish shall be applied rapidly, and the edges of each patch applied shall not be allowed to set, but shall be followed up whilst in free working conditions.

b) French Polish

French polish shall conform to IS 348. Suitable pigments shall be added to get the required colour.

The surface to be French polished shall be rubbed down to smoothness with sand paper and shall be well dusted. Pores in the surface shall be filled up with fillers.

A pad of woolen cloth covered by a fine doth shall be used to apply the finish. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil may be used on the face of the pad for the purpose. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly dampened with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

4.16.10 Painting To Steel and Other Metal Surface

4.16.10.1 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 galvanised surfaces are to be painted, they shall be cleaned and washed with a solution of Copper Sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Employer.

iv) Schedule

- a) One coat of Organic Zinc Rich Primer (thickness, 60 m DFT).
- b) Strip coat on each weld joint and edge of structure by surface tolerant Epoxy – 75 m DFT by Brush – One Coat
- c) Two coats of High Build Abrasive Epoxy (DFT 100 m for each coat)
- 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 Rich 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.

4.16.10.2 Preparation of Surface

The surface, before painting, shall be cleaned of all rust, scale, dirt and other foreign matter with wire brushes, steel wool, scrappers, sand paper etc. The surface shall then be wiped

finally with mineral turpentine, which shall then be removed of grease etc. The surface then shall be allowed to dry.

In case of GI surface, surface so prepared shall be treated with Mordant solution (5 litres for about 100 sqm) by rubbing the solution generously with brush. After about half an hour, the surface if required shall be retouched and washed down thoroughly with clean cold water and allowed to dry.

4.16.10.3 ***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.

4.17 **SANITARY AND PLUMBING WORKS (BUILDINGS)**

4.17.1 **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.

4.17.2 Bye-Laws and Regulations

The installation shall be in conformity with the Bye-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 than those required by any of the above regulations and standards, then these specifications and drawings shall take precedence over the said regulations and standards. However, if the drawings and specifications require something, which violates the Bye-laws and Regulations, then the Bye-laws and regulations shall govern the requirement of this installation.

4.17.3 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.

4.17.4 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.

4.17.5 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.

4.17.6 Water Supply

4.17.6.1 G.I. Pipes & Fittings

G.I. Pipes

All pipes for water supply inside the building shall be genuine galvanised steel tubes conforming to IS:1239 Part I (heavy grade 'C' class pipe).

The GI pipes shall be of approved make as per the list of approved makes.

G.I. Fittings

All fittings shall be malleable cast iron fittings as per IS:1879 (or as revised). All fittings shall have manufacturer's trademark stamped on it. Fittings in G.I. pipelines shall include elbows, tees, bends, reducers, nipples, union, bushes, G.I. Clamps of approved design, G.I. flanges with 3 mm rubber insertion, nuts, bolts, washers, etc. All fittings shall be tested at manufacturer's works. Contractors may be required to produce certificate to this effect from the manufacture.

Laying and Jointing of G.I. Pipes (External)

a) Trenches

The galvanised iron pipes and fittings shall be laid in trenches. The widths and depths of the trenches for different diameters of the pipes shall be as in Table below:

Dia of Pipe	Width of Trench	Depth of Trench
15 mm to 50 mm	30 cm	60 cm

At the joints the trench width shall be widened where necessary. The work of excavation and refilling shall be done true to line and gradient in accordance with general specifications earthwork in trenches.

b) Cutting and Threading

Where the pipes have to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be carefully threaded conforming to the requirements of IS:554-1964 with pipe dies and tapes in such a manner as will not result in slackness of joints when the two pieces screwed together. The screw threads of pipes and fittings shall protected from damage until they are fitted.

c) Jointing

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped around the screwed end of the pipes. The end shall then be screwed in the socket, tee etc. with the pipe wrench. Care shall

be taken that all pipes and fittings are properly jointed so as to make the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing. Burr from the joints shall be removed after screwing. After laying, the ends of the pipes shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

d) Pipe, Coating & Wrapping

All underground pipes shall be protected by pipecoat primer and pipecoat wrapping. The pipe coat primer shall have a density of 0.92 gm/cc and drying time of 24 hours at RH 70% and temp 30 deg. C. Viscosity shall be 1000 – 2000 cps.

The pipe coat shall be a puncture resistant non-woven polyester mat 4 mm thick of high mechanical strength. The mat shall be in 7 layers. The layers shall be so arranged as to also give extra protection to high molecular high density polythene core which is the main permeable agent in the system.

Pipecoat primer shall be applied on the pipe in a uniform coat leaving no drop runs.

The entire surface of pipe shall be primed without any patch left out. Unprimed surfaces shall reprimed immediately. Any uncleaned pipe shall be scraped down to surface of pipe and reprimed pipecoat primer shall essentially be in a layer for quicker drying.

The surface shall be dry at the time of applying pipecoat primer. Freshly primed pipe shall be placed on clean square cut skids and shall not be allowed to come in contact with ground or any foreign matter. It shall remain on skids until lifted or cradled after coating and wrapping operation.

All primed pipes which have excessive coat of dust accumulated over them before primer is dry or where primer has become dead, shall be primed. Drying time shall be minimum 245 hours. The application of pipecoat membrane shall be taken up soon after primer coat has dried up completely and in case within three days after priming. Otherwise fresh coat of primer shall be applied.

Membrane shall be blown under tension by means of a blowtorch. In this process, the inner surface of the membrane, being 10 micron thick polyethylene layer is burnt while at the same time the polymeric mix under it is softened taking care that the centre core is not over heated. This molten polymeric mix is then pressed over pipe surface so that no air is entrapped or voids formed underneath.

Pipecoat primer shall be applied with brushes after cleaning the pipe thoroughly. Pipecoat membrane shall be wrapped as mentioned above.

No wrinkling of the wrapper shall be allowed and all overlaps shall be firmly fused to secure a firm wrapping. Coating shall be absolutely free from pinholes, bubbles and holidays.

4.17.6.2 **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.

4.17.6.3 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.

4.17.6.4 Laying and Jointing G.I. Pipes (Internal Work)

Cutting, threading and 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.

4.17.7 Soil, Waste, Vent and Rain Water Pipes and Fittings

4.17.7.1 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 rain water pipes used at basement in exposed condition or where specified shall be centrifugally cast spun iron class (LA) pipes conforming to IS 1536. These shall be with spigot 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 galvanised flat 32 x 1.5 mm thick and 12 mm dia. M.S. bar and 6 mm nuts and bolts. Holder bat clamps shall be fixed in cement concrete (1:2:4) blocks 100 x 100 x 100mm.

M.S. Stays and Clamps

The clamps shall be made from 2.0 mm thick MS flat of 32 mm width, bent to the required shape and size to fit tightly on the socket, when tightened with screw bolts. It shall be formed of two semi-circular pieces with flanged ends on both sides with holes to fit in the screws, bolts and nuts, 40 mm long. The stay shall be minimum one metre long of 10 mm dia MS bar. One end of the stay shall be bent for embedding in the wall in cement concrete block of size 20 x 20 x 20 cm in 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone

aggregate 20 mm nominal size). The concrete shall be finished to match with the surrounding surface.

Floor Traps

Floor taps shall be cast iron deep steal type P or S traps with a minimum seal of 75 mm. they shall be with or without vent. All traps shall be set in cement concrete blocks 1:2:4 mix without additional cost. Traps shall be provided with CP brass screwed down or hinged grating. Traps shall be provided with suitable extension piece where required with CP brass grating to flush with the floor without any extra cost.

Paintings

All pipes in ducts and exposed positions shall be painted with two coats of synthetic enamel paint of any colour approve by the Employer over a coat of primer of approved quality.

4.17.7.2 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.

4.17.7.3 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.

4.17.7.4 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.

4.17.7.5 **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 a clear pungent smoke easily detectable by sight as well as by smell if there is leak at any point of drain.

4.17.8 **Sanitary Fixtures and Fittings**

4.17.8.1 **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.

4.17.8.2 **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.

4.17.8.3 **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.

4.17.8.4 **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 in 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 of 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 hole confirming to IS:2556 Part –IV. This shall be fitted on CI or MS brackets conforming to IS:775. Brackets shall be given two coats of white enamel paint or enamel paint or aluminium paint, over a coat of primer.

The wall side shall be fixed well flushed with the plaster of wall and the joint if any, shall be properly stopped with mortar and painted white. Pillar cocks, PVC connecting pipe with

brass union, a CP brass bottle trap with union, CP brass chain and rubber PVC stopper, 32 mm dia, GI waste pipe shall also be supplied and fitted with the wash basin, the top of rim of the wash basin shall be fixed at 800 mm above finished floor level unless otherwise specified.

Mirrors

The mirror shall be of the best quality of 'Atul'/'Swastic' or equivalent approved make of size 600 mm x 650 mm x 5.5 mm thick. The mirror shall have ½" thick commercial board backing and shall be provided with aluminium beading all around. It shall be fixed to the wall on wooden blocks with CP brass screws and CP washers.

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 aluminium/C.P. brass pipe with suitable brackets. The tower rail shall be 20 mm dia and 1.25 mm thick 600 mm long. It shall be approved by the Employer. It shall be fixed at specified locations shown in the drawing or as directed by the Employer.

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.

4.18 WATER SUPPLY AND DISTRIBUTION SYSTEM

4.18.1 General

This specification covers the installation and commissioning of the complete water supply distribution system with in the port area including the supply of potable water to cargo vessels and buildings and the supply of raw water for landscaping and greenery.

4.18.2 Material

4.18.2.1 Pipe

Piping for supply and distribution lines shall be HDPE pipes conforming to IS: 4984.

4.18.2.2 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.

4.18.3 Execution

4.18.3.1 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.

4.18.3.2 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 kilometre, per bar of test pressure per 24 hours.

Any defect or visible individual leak observed during the hydrostatic pressure testing shall be repaired by the Contractor at his own expense in the manner directed by the Employer.

Should losses from the main exceed the specified amount, testing shall be repeated until the main is deemed satisfactory and is accepted by the Employer. All labour, material and equipment for testing shall be deemed to be included in the rates.

These tests shall be conducted on the entire water distribution system by sections of 500 meters as a maximum on the general circuit, and by building, for the distribution from the main network.

All of the installations must undergo the pressure tests.

4.18.3.3 *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

4.19 **SEWERAGE COLLECTION & TRANSFER SYSTEM**

4.19.1 **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 and sheds.

4.19.2 **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.

4.19.3 **Material**

4.19.3.1 *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.

4.19.3.2 *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.

4.19.3.3 **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 water tight, single storeyed, underground, rectangular in shape, single or double tank having roof. In case of double tank, the first compartment is usually twice the size of the second. The liquid depth is 1 – 2 m and the length to breadth ration i.e. 2.3 to 1. 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.

4.19.4 Execution

4.19.4.1 *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.

4.19.4.2 *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.

4.19.4.3 *Repair and Retesting*

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

4.20 BERTH APPURTENANCES

4.20.1 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

4.20.2 Fenders

For the jetty, suitable type 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.

4.20.2.1 **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			
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 815-1 BS 903 A6*1	DIN 53517
TEAR RESISTANCE	JIS K6252	CRESCENT TYPE	70N/MM MIN	D624	BS ISO 34-1 BS 903 A3*1	DIN 53507

PROPERTY	TEST STD & CONDITION		CRITERION	EQUIVALENT INTERNATIONAL STD		
				ASTM	BS ISO	DIN
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 CHANGE +/- 10 MAX	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 padeyes 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% NaCl (weight change)	-	Max 1%
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.

4.20.2.2 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 $23C \pm 5C$
- 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.

4.20.2.3 **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

4.20.2.4 **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.

4.20.2.5 **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.

4.20.2.6 **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.

4.20.2.7 **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.

4.20.2.8 Dimensions

Fenders shall meet manufacturer's specified dimensional tolerance.

4.20.2.9 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.

4.20.3 Bollards**4.20.3.1 General**

Cast Steel bollards to be installed on the Jetty as required for the spectrum of vessels to be berthed at Jetty 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 30 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.

4.20.3.2 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 - methods	Code of practice for ultrasonic Pulse Echo Testing by contact & Immersion
IS 1599 -	Method for bend test for steel products other than sheet, strip, wire & tube
IS 1608 -	Method of tensile testing of steel products

4.20.3.3 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 analysed shall be as follows:

Sulphur : 0.05% max.

Phosphorous : 0.5% max.

4.20.3.4 *Specifications for Casting*

4.20.3.5 *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.

4.20.3.6 *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.

4.20.3.7 *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.

4.20.3.8 *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

4.20.3.9 **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.

4.20.3.10 **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.

4.20.3.11 **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.

4.20.3.12 Bolts, Nuts and Washers

All anchor bolts, nuts and washers shall be of stainless steel conforming to AISI 304 or equivalent.

4.20.3.13 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.

4.20.4 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.

4.20.5 Rubbing Strip

Wooden / Galvanised iron rubbing strip complete in all respects shall be provided as instructed by the Employer at relevant locations of the berth suitably. Painting of the same shall be done.

4.20.6 Edge Angles

Galvanised iron edge angles shall be provided at the edges of the berth and painting of the same shall be done.

4.20.7 Drain Holes

The Contractor shall provide drain holes in the deck to drain surface water. Drain holes shall be by pipes of sufficient diameter through the deck.

4.20.8 Mooring Rings

Mooring rings at suitable locations on jetty face shall be made from 20 mm dia stainless steel to AISI 304 or equivalent with an outer diameter of 150 mm. Suitable eyebolts of

stainless steel to AISI 304 or equivalent shall be used with the mooring rings for fixing to the berth face.

4.20.9 Expansion Joints

Expansion Joints at suitable interval shall be provided to the satisfaction of the Employer.

4.20.10 Information Technology Systems

4.20.10.1 *IT Architecture*

For Project Facilities the IT architecture will have the following components:

Business systems for Terminal.

TAS- Terminal Administrative System/ERP System.

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, bus-bars, cable compartment, auxiliary control devices etc., shall be housed in separate compartments within the cubicle. The design shall be such that failure of one equipment shall not affect the adjacent units. The circuit breaker and bus voltage transformers shall be mounted on withdrawable trucks. In case breaker truck rolls out on telescopic rails suitable trolley shall be provided. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on a control cabinet built on the front of the cubicle.

The trucks shall have distinct 'Service', 'Test' and 'Isolated' positions. The switchgear assembly shall be designed to achieve IP54 degree of protection, with the truck in any position 'Service', 'Test' and 'Isolated' and all doors and covers closed. Relaying and Metering compartment shall also have degree of protection IP54.

Enclosure shall be constructed with rolled steel sections / sheets of not less than 2mm. The switchgear shall be cooled by natural airflow. Forced cooling shall not be accepted. The Breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Breaker compartment doors shall have locking facility.

5.1.1.3 **Bus and Bus Taps**

Main buses and connections shall be of high conductivity aluminium, sized for specified current ratings with maximum temperature limited to 90°C. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/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 Hexafluoride (SF₆) 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/contactors from being closed when it is open.
- Pressure relief device
- Safety shutters for power contacts
- Inter-pole insulators
- SF₆ gas pressure low alarm/trip relay (In case of SF₆ type Switchgear)
- Auxiliary Signaling contacts

For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to the motor. SF₆ breakers shall be provided with SF₆ 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 pick up sensitivity of 10 A primary ground fault current for all the outgoing feeders. Facilities for easy shorting and grounding the terminals shall be provided at the terminal block. All terminal blocks shall be of stud type with marking strip.

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 lamicaid 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 socket. The space heater shall be located at the bottom of each switchgear compartment. Cubicle heater, Motor heater, Plug/socket circuits shall have individual MCB units. In addition, motor feeder cubicle shall be wired-up for feeding the motor space heater through suitable rated breaker auxiliary NC Contact and/or contactor.

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°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 $\pm 10\%$ 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°C over 45°C 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°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, weather proof, air filled type complete with all hardware such as undrilled gland plates, etc.

The design of the box shall be such as to preclude the access of water to the box. An adequate space shall be provided within the box so that the cable cores may be formed into the lugs without undue bending or stress on the lugs, and adequate clearance shall be preserved between live metal and frame such that the electrical pressure tests specified in Indian Standard are satisfied. Flexible links shall be provided between transformer terminals and cable lugs. Cable box shall have IP 55 degree of protection.

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-energised 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 45°C. Switchgear shall be designed for natural air cooling. No forced cooling is acceptable.

Auto/Manual/Planned Changeover scheme with synchronizing feature for various incomers and bus couplers shall be provided in Power Control Centre (PCC) / Motor Control Centre (MCC) for interlocking of Incomer breaker with upstream breaker. Incomer, bus-coupler & Outgoing breakers shall also be controlled from PLC (only provision to be provided since there is no PLC envisaged at this stage) in addition to Local operation from the panel.

- Short circuit withstands rating of the switchgear shall be as given in the attached SLD.
- 415V normal system shall be solidly grounded. 110V DC system shall be ungrounded.

Busbar, breaker and other components shall be designed for continuous operation at rated current considering temperature inside the cubicle. The continuous current rating of the bus bars, incomers, bus couplers of the MCC shall be the maximum load on the bus due to all the running auxiliaries during any operating condition plus 20% margin rounded off to the next higher standard rating. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/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 on line starter. 90kW and above capacity motors shall be fed from ACBs. Less than 90kW capacity motors shall be fed by MCCBs and contactors. However, the duty of the drive/application, i.e. high impact loading, etc. to be considered as criteria for selecting ACB operated motors even for rating < 90kW. Wherever applicable, priority shall be given to the use of Motor Protection Circuit Breaker (MPCB) with Contactor.

Operating height of the handles/switches shall be limited to a maximum of 1800 mm and a minimum of 300 mm.

For PCC changeover shall be provided. If there is an under voltage (dipped to 30-40% voltage) on any one of the buses, sensed through under voltage relays, the respective incomer breaker shall trip automatically and the bus coupler shall close, if the voltage is available on the other bus section, thereby establishing voltage at 415V motor terminals before motor reaches standstill condition. The auto changeover shall be blocked if any of the following condition exists:

- Any of the involved breaker is in the test or withdrawn position.
- Source voltage is not available.
- Source breaker is tripped due to bus fault.

No release is acceptable for Breaker feeders. Only CT operated relays shall be provided for protection. MCCB, Contactor and overload relay shall meet type-2 co-ordination as per applicable standard.

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 break, electromagnetic type rated for uninterrupted duty. Contactors shall be double-break, non-gravity type and their main contacts shall be silver faced. Direct-on-line contactors shall be of utilization category AC3. Reversing starters shall comprise of Forward and Reverse contactors mechanically and electrically interlocked with each other. These contactors shall be of utilization category AC4. The contactor shall operate satisfactorily from 85% to 110% of the rated voltage. The contactor shall not drop out at 70% of the rated voltage but shall definitely drop out at 20% of the rated voltage.

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**

Push-buttons shall be of spring return, push-to-actuate type. Where specified push buttons shall be stay put type. Their contacts shall be rated to make, continuously carry and break 10A at 500V AC. All push-buttons shall have two normally open and two normally closed contact, unless specified otherwise. The contact faces shall be of silver alloy. All push-buttons shall be provided with integral escutcheon plates marked with its function. All emergency push-buttons shall be stay put/latching type. To detach, master key provision shall be provided.

The colour of the button shall be as follows:

- Green for motor START, breaker CLOSE, valve / damper OPEN /CLOSE commands.
- Red for motor TRIP, breaker OPEN.
- Black for all annunciator functions, overloads reset and miscellaneous commands.

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/contactors 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 aluminium conductor, PVC / XLPE insulated, armoured and FRLS PVC sheathed cables. All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS:8309. All lugs shall be insulated / sleeved.

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 aluminium alloy for PCC/MCC and Copper for DB of adequate size. The cross-section of the busbars shall be uniform throughout the length of switchboard. Interleaving of PCC busbar arrangement shall be envisaged. All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fibre glass moulded insulators. All busbar joints shall be provided with high tensile steel bolts, belleville/ spring washers and nuts. All

copper to aluminium joints shall be provided with suitable bi-metallic washers. All busbars shall have HRPVC sleeves and colour coded.

Contact surfaces at all joints shall be silver plated or properly cleaned and anti-oxide grease applied to ensure an efficient and trouble free connection. Suitable bimetallic connectors shall be used for dissimilar metal connections.

The continuous rating of the main busbars shall be same as that of the incomer breaker, and busbar shall carry this continuous current without exceeding the temperature of 90°C. For silver plated joints, temperature shall not exceed 105°C. 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 Push-buttons shall be stay put/Latching type, requiring master key for de-latching.

Following shall be provided for each breaker feeders

- Electrical anti pumping feature (94)
- Hand reset High speed lockout relay (86)
- Trip circuit supervision relay (95)
- Aux relay for breaker contact multiplication (52X)
- Aux relays as required for contact multiplication
- Indicating lamps for ON, OFF, Auto trip, spring charged, Trip circuit healthy, DC supply fail etc.

- Breaker control switch
- Local / Remote / Test selector switch
- Test Terminal blocks

ACB incoming feeders for PCC from transformers shall be provided with the following as a minimum.

- TPN Air Circuit Breaker
- Current transformers for metering & protection
- Digital Ammeter & Ammeter transducer
- Fuse/MCBs for control circuits
- Voltage transformers, Digital voltmeter & voltage transducer
- Under voltage relay with timer
- Microprocessor based Multi-function meter with communication facility
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

ACB Bus coupler for PCC from transformers shall be provided with the following as a minimum:

- TPN air circuit breaker
- Current transformer for protection & metering
- Fuse/MCBs for control circuits
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

Unidirectional motor feeders rated less than 10 kW shall be provided with the following as a minimum:

- Triple pole motor protection circuit breaker (MPCB)
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit
- Interposing relays

Unidirectional motor feeders rated 10kW and up to 30kW shall be provided with the following as a minimum.

- Triple pole MPCB
- Triple pole contactor

- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit
- Current transformer for metering
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated above 30kW and less than 125kW shall be provided with the following as a minimum.

- Triple pole MCCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons
- Indicating lamps LED cluster type
- Numerical Motor protection relay
- MCB for 240V AC space heater circuit
- MCB for control circuit
- Current transformer for metering
- Current transducer
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated 125 kW and above shall be provided with the following as a minimum.

- Triple pole Air Circuit Breaker
- Current Transformer for metering & Protection
- Numerical Motor protection relay
- Fuse/MCBs for control circuit
- Indicating lamps LED cluster type
- MCB for 240V AC space heater circuit
- MCB for control circuit

- Current transducer
- Digital Ammeter
- Interposing relay

Bi-directional Motor feeders shall be provided with the following as a minimum. (Not applicable for Integral Actuators)

- Triple pole MCCB
- Triple pole mechanically interlocked, open / close contactors
- Auxiliary contactors
- Local/Remote/Test switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons.
- Indicating lamps LED cluster type
- MCB for space heater circuit
- MCB for control circuit
- Interposing relays

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 other Charger. Each Battery charger should meet the Trickle requirement of both banks (under emergency) and boost requirement of each bank.

During boost charging, battery charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50 to 100 % of the rated output current for boost charging mode. During boost charging, the Boost charger shall recharge the completely discharged battery to full capacity in 12 hours.

When on automatic control mode during float charging, the charger output voltage shall remain within $\pm 1\%$ of the set value for AC input voltage variation of $\pm 10\%$, frequency variation of $\pm 3\%$, a combined voltage and frequency (absolute sum) variation of 10 % and a continuous DC load variation from zero to full load. Uniform and step-less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire float charging output range specified. Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether float or boost charging.

All Battery chargers shall be provided with facilities such as automatic voltage regulator (AVR) for both automatic and manual control of output voltage and current. The chargers shall be self-regulating, natural air cooled, static type provided with suitable double wound transformer, full wave thyristor type rectifiers, filter circuits, DC & AC Switchgear. Chargers shall be metal enclosed, fixed type, suitable for indoor mounting on floor. Panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by cold rolled sheet steel of thickness not less than 2.0 mm. Suitable synthetic rubber gaskets shall be provided to achieve a degree of protection of IP54.

Rectifier transformer shall be continuously rated, dry type, class F insulation, epoxy resin impregnated, Air Natural (AN) cooling and with adequate number of taps. The rating of rectifier transformers shall correspond to the rating of the associated rectifier assembly.

All the Charger panels shall be provided with an illuminating CFL lamp, a 5 Amp socket and space heaters with thermostat. Toggle switches and MCB's shall be provided separately for each of the above fittings. Space heaters "ON" indication to be provided. Two separate grounding pads shall be provided.

Locking facilities shall be for locking float / boost selector switch in the float position only.

Digital type Window annunciator shall be provided for alarm annunciation with acknowledge, test & reset push buttons and a buzzer for the following conditions:

- SCR fuse fail
- Battery / DC system under voltage
- DC system over voltage
- DC over load
- Output fuse blown
- AC supply fail
- AC under voltage
- Battery earth fault
- Filter fuse failure
- Battery on Float / Boost
- Charger fail/Battery on discharge
- Any other annunciation, as required

Remote alarm contacts for hooking up to PLC shall be provided. For each charger, current & voltage transducer shall be provided for remote monitoring of DC voltage and Current at PLC.

Protection features, indications, meters and alarms shall be provided for each charger. Protection features shall include the following as minimum.

- Overload Protection
- Phase failure protection
- Voltage unbalance protection
- Fuse failure protections for SCR and filter circuit

Suitable potential free contacts for remote indication of above abnormal conditions shall be provided. However the requirements/design shall be firmed up during the detailed engineering stage.

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 drop limits under steady state/transient state as applicable.

Power cables shall withstand fault current of the circuit for the duration not less than the maximum time taken by the primary protective system to isolate the fault. Cables shall be sized for the following short circuit rating.

Outgoing cables from 11kV Switchboards	: 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 within desirable limit, it is proposed to limit the voltage drop in the cables within the following limits:

Steady state Voltage drop (Continuous running condition): 2.5%

Transient state voltage drop (During Motor Starting) : 10 %

All cables shall be suitable for laying on racks, in ducts, trenches with chances of flooding by water and shall also be suitable for directly buried installation. All the cables shall be flame retardant low smoke (FRLS) type designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.

The minimum size of LV power cable shall be of 2.5 Sq.mm for Copper. Power cables shall have copper conductor for sizes up to 10 sq.mm. For higher sizes, aluminium conductor shall be provided. The minimum size of control cable shall be of 1.5 Sq.mm copper. For CT/VT circuits, minimum 2.5 sq.mm copper cable shall be provided. Conductor of Copper cables shall have plain annealed copper. All the conductors shall be multi-stranded.

Power cables shall be XLPE insulated. Control cables shall be PVC insulated. PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit

conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90°C and short circuit conductor temperature of 250°C.

The cable cores shall be laid up with fillers between the cores wherever necessary. All the cables shall have distinct extruded PVC inner sheath. For single core armoured cables, armouring shall be of aluminium wire. For multicore armoured cables, armouring shall be of galvanised steel strip/wire as per applicable IS.

Outer sheath shall be of PVC black in colour having following FRLS properties.

- Oxygen index of not less than 29.
- Acid gas emission of max. 20%
- Smoke density of not more than 60%

The cables shall meet flammability test as per IEEE-383. All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added in to the PVC compound of the outer sheath.

5.1.6.1 **Construction**

- **HT cables**

Cables shall be XLPE insulated, screened, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-II. 11kV cables shall be suitable for unearthed system. The conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process. The metallic screen of each core shall consist of copper tape with minimum overlap of 20% copper screen which shall be capable of carrying the system earth fault current for 2 seconds. Outer sheath shall be FRLS PVC.

- **LV Power cables**

LV Power cables shall be of 1.1 kV grade, XLPE insulated, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-I.

- **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 energised from 3-phase, 4-wire, 415 V main lighting distribution board. These MLDBs shall feed Lighting Distribution Boards (LDB) for each individual area. Dry type lighting transformers of voltage ratio 1:1 shall be provided for reducing fault level in MLDB. The single phase voltage level considered for lighting system & fixtures shall be optimally arrived to achieve energy efficiency without sacrifice in the illumination level. Lighting transformer tap range & tap step to be designed accordingly.

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 $\pm 10\%$, 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 phase, 415 volt AC welding receptacles shall be provided. Welding receptacles shall be placed near all major equipment and minimum 2 numbers on each floor in all the buildings.

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 Fixtures: 2.5 sq.mm copper
- Switch box to lighting Fixtures: 2.5 sq.mm copper
- Lighting Panel to Sockets : 4 sq.mm copper

For Area lighting, PVC insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed Copper conductor cables shall be provided.

Wiring for lighting circuits of Normal AC system and DC system shall run in separate conduits. Wiring for Lighting fixtures and receptacle units shall be fed from different circuits and shall run in separate conduits. Two different phase circuits shall not be laid in the same conduit.

All conduits shall be surface mounted in general. In Office rooms & Control rooms conduit shall be concealed type. Conduit fill criteria shall be 40%. Conduits should have the minimum number of bends in their run with pull boxes at suitable locations. Conduits shall be sloped & drained to avoid water accumulation & draining into the equipment at its end. Conduits shall be galvanized steel except in corrosive areas, where it shall be epoxy painted.

- **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 High Mast Lighting System

5.1.7.1 General

High Mast at the proposed locations in the plant area shall have adequate height to achieve the required illumination. Top level of high-mast foundations shall be as per the approval from the engineer-in-charge. All High Mast of similar height shall be identical in construction to allow possible future relocation of High Masts within the area. A High Mast Switchboard is required to be installed at the base of each High Mast. The High Masts are expected to be fabricated out of steel.

The High Mast shall be designed for the number of light fittings determined by the Lighting Design based on the average 30 lux (with minimum 20 lux) of illumination plus two additional fittings to allow for possible future modifications/expansion. The High Mast shall be designed for the worst sail area resulting from the most adverse configuration. The High Mast shall be designed to withstand loads from fabrication, handling, erection, and for the dynamic loading outlined below.

5.1.7.2 Design Criteria

The lighting design shall be in accordance with IS:3646. The selection of lamps and luminaire types shall be based on high efficiency, good glare control and illuminance level required. Luminaires, mast and brackets shall be selected to suit the harsh environmental conditions specified. Luminaires shall have high power factor (0.85 or higher) control gear. Any apparatus, appliance or material or services which may be necessary to make the system complete and perfect in all respects even if not particularly specified shall be furnished, without any additional expense to the Employer. Details not usually shown or specified, but necessary for the proper installation and operation of the work shall be included.

5.1.7.3 Fittings

Lighting fittings selected shall be High Pressure Sodium type. Lighting fittings shall be full cut off type to prevent stray light above 90 deg. Light fixtures shall be provided with Power factor correction capacitor to achieve high power factor.

5.1.7.4 Light Switching Philosophy

Each High Mast shall have following separate circuits.

Security Lighting Circuit, controlling 20% of the light fittings on High Mast. This circuit shall be controlled by a photoelectric cell located in substation so that the security lights turn on automatically depending on preset solar radiation level. Manual over ride facility shall also be available in the switchboard located at the base of the high mast.

Main Lighting Circuit No. 1, controlling another 40% of the light fittings on High Mast. This circuit shall be push button controlled from the system control panel. Manual override facility shall be available in the Switch Board located at the base of the High Mast.

Main Lighting Circuit No. 2, controlling another 40% of the light fittings on High Mast. This circuit shall be push button controlled from the system control panel. Manual override facility shall be available in the Switch Board located at the base of the High Mast.

5.1.7.5 ***Location of High Masts***

High Mast locations shall be as shown in the **Drawing I-525/HT/1021** attached with these specifications. High Mast number, height and location are indicative, final details as per the detailed design shall be submitted to the Employer for approval. It is anticipated that the high mast positions as shown on the Drawings will provide sufficient coverage to obtain the specified illumination.

5.1.7.6 ***Detailed Lighting Plan***

Detailed lighting distribution plans of the entire area along with Lux level plot plan shall be provided for approval of the Employer by the successful contractor.

5.1.7.7 ***High Mast Head Frames***

Each High Mast shall be fitted with a head frame, which shall be capable of being lowered and raised by means of a winch or other similar mechanical mechanism. The winch shall be able to be operated by use of a power tool. Each High Mast shall be provided with internal power tool complete with drive motor and drive assembly of suitable rating. The power for the drive motor of power tool shall be from the respective high mast switchboard. The head frame shall be of durable steel construction fitted with light and gear fixings and junction box. It shall be in single piece for maximum strength. The head frame shall also act as an electrical conduit with cable holes protected by grommets. The head frame shall incorporate arrangements to prevent damage to the galvanizing of the High Mast.

5.1.7.8 ***Mechanical Arrangement – Lowering and Raising Headframe (Ring) System***

For installation and maintenance purpose, it is required that the headframe (ring) be able to be raised or lowered using a winch or approved lowering device to the base of the High Mast. The steel wire rope supporting the headframe shall be kept in balance and horizontal at all times. A device, suitably protected from corrosion, shall be incorporated to ensure that the tension rope cannot accidentally or manually be released without a service tool.

5.1.7.9 ***Top Pulley Assembly – Lowering and Raising Headframe (Ring) System***

The pulleys for the lowering and raising of the headframe system shall be of non-corrodible material and shall run on self-lubricating bearings with stainless steel axles. They shall be of sufficient diameter so as to enable multicore flexible cables to be used. Arrangements shall be provided to ensure that the electric cables and steel wire ropes are separated before passing over their respective pulleys and close fitting guides shall protect the pulleys to prevent ropes and cables leaving the pulley grooves. It is intended that there will be 2 cables from the High Mast Distribution Board at the base of the High Mast to the junction box on the headframe. Individual cables will then run from the junction box to each light fitting. This cabling arrangement will need to be considered in the design.

The pulleys shall be housed in a chassis integral with a sleeve which slips over the top of the High Mast and is secured axially and in azimuth. Guides and stops shall be provided for locking the headframe and an anchor point shall be securely welded to the assembly to receive the safety maintenance equipment. The complete chassis assembly shall be hot dip galvanized after fabrication. The pulley assembly shall consist of safety brakes capable of immediate stopping of the raising and lowering device even in the extreme case of hoisting cables breaking.

The pulley assembly shall be protected by a galvanized steel/aluminium or other approved weatherproof cover.

5.1.7.10 *Winches – Lowering and Raising Headframe System*

Winches shall be completely self-sustaining without the need for brakes, springs or clutches which require adjustment and shall be designed to be installed or removed through the door opening. Termination of the winch ropes shall not involve distortion or twisting of the rope structure. A minimum of four turns of the rope shall remain on the drum when the lantern carriage is fully lowered. Winch drums shall be grooved to ensure a tidy rope lay. A test certificate issued by an independent test house shall be supplied with each winch. The capacity and operating speed of the winch shall be clearly marked on each winch on an indelible label together with the Specification of the recommended lubricant. Each winch shall be supplied with a fitted canvas cover.

5.1.7.11 *Lightning Protection and Earthing System of High Mast*

Each high mast shall be provided with lightning protection and earthing system which shall be installed and tested as per BS:6651, BS:7430 and TR7, ILE, UK, and IS:2309, IS: 3043 & IEEE:80-2000.

5.1.7.12 *Openings*

Any openings in High Mast for feeding of cables/stainless steel rope in and out of the High Mast require coverings/cappings so as to prevent the intrusion of rain water into the High Mast.

5.1.7.13 *Dynamic Loading*

All High Masts shall be designed for maximum reaction arising from basic wind speed of 180 km/hr and factors K1, K2, K3 as per IS:875 (Part III) for design wind speed. The minimum design life shall be 30 years. High Masts shall be designed in accordance with relevant Indian earthquake standard. The design shall be such that wind excited oscillations are damped as much as possible and an adequate allowance shall be made for the stress due to these oscillations. The method of damping shall be stated. Full calculations of the forces involved shall be submitted for approval. The analysis shall show the resultant loadings, deflection and stresses in all three principal axes at a minimum of 500 mm increments over the total length of the High Mast. In addition, High Mast structures shall have adequate strength to resist fabrication, handling and erection loads without becoming overstressed or deflecting excessively.

5.1.7.14 **High Mast Construction**

All steel used in the construction of the High Mast, including welding shall comply with relevant Indian or British standards for Structural Steelwork. High Mast shall be constructed from mild steel plates, of grade and thickness as determined in the design. The minimum steel plate thickness shall be 6 mm. An appropriate corrosion allowance shall be used in the design. High mast shall be cut and folded to form a polygonal/circular section. Adjoining sections of the High Mast shall be joined by taper slip fit jointing. No site welded joints will be permitted.

All High Masts shall have a close fitting weatherproof door at the base with hinges and a heavy duty lock. The lighting distribution board shall be placed inside the High Mast base at this location. The size of the door is expected to be approximately 1.00 m x 0.50 m in size but may vary according to each design. The bottom of the door shall be located at a height of 0.50 m from the underside of the base plate of the High Mast. The door opening shall be reinforced where required to prevent buckling. The reinforcement being designed to suit the width of the door opening under the designing loading specified. Ten (10) sets of keys shall be provided for each type of lock.

The baseplate shall be free from laminations and the welded connection to the High Mast shall fully develop the strength of the section. In addition supplementary gussets shall be provided between bolt holes. On the completion of fabrication, all High Masts and headframes shall be hot dipped galvanized both internally and externally to a minimum thickness of 100 microns.

5.1.7.15 **Foundations**

The design and layout of each type of High Mast shall be furnished. The design shall be based on the foundations not resting on bedrock & shall be carried to a depth of at least 2.0 m below final grade. Settlement shall not exceed 25 mm, unless specified otherwise and the structural arrangement and design shall be such as to withstand such settlements. The top level of the concrete pedestal shall be as per the approval of the engineer-in-charge. The footings for the High Mast including holding down anchor bolts with nuts and washers shall be supplied and installed under this contract.

5.1.7.16 **Wire Ropes**

Wire rope system shall be suitable for maintaining the lighting fixtures/control gear from the ground level in spite of crash barriers around the mast. Wire ropes shall be flexible stainless steel type. Thimbles and terminals shall be of compatible material. Ropes with hemp cores will not be permitted. In the event of failure of one rope the other rope shall hold the lantern carriage.

5.1.7.17 **Materials**

All materials shall comply with relevant Indian or British Standards. All steel conduits, metal work, angle iron brackets, suspension rods etc. shall be hot dipped galvanized to a minimum thickness of 100 microns. Where galvanizing has been damaged this shall be repaired with an approved two pack zinc rich epoxy finish.

5.1.7.18 Luminaires

Luminaires shall be standard industrial type suitable for high pressure sodium vapour SON-T lamps of 2x400 W/1x1000 W/1x400 W and shall have not less than 55000 lumens per 400 W lamp. Lighting fixture shall be waterproof, dust proof and suitable for highly corrosive atmosphere. It shall be manufactured with die-cast aluminium, MBV treated reflector, electronically brightened and anodized, IP 54 degree of protection and confirm to relevant IS specifications. The lamp shall be easily replaced from rear without disturbing the aiming position. It shall be provided with stainless steel toggles, heat resistant & toughened glass cover. Hardware used to install the fittings, control gearboxes and for other purposes shall be of stainless steel. The luminaires shall be tested as per Indian Standard and shall be suitable for installation on high mast.

5.1.7.19 Aviation Light

LED type aviation light shall be provided at each mast.

5.1.7.20 Power Tools

This is a geared motor with suitable torque limiter, industrial duty type. The motor is mounted on MS hot-dip galvanized plate inside the mast with a possibility of adjusting its position. However, the adjustment shall be so arranged that it cannot be altered easily during normal use of tool at site.

5.1.7.21 High Mast Switch Boards (HMSB)

These boards shall be free standing pad mounted type. The boards shall be designed for the number of circuits as required. The boards shall include miniature circuit breakers/ELCB, Contactor, ON-OFF Control Switch and all other required accessories as required. The cubicle shall be designed for mounting over RCC pad of 300 mm thickness minimum and shall be capable of withstanding the vibrations normally experienced due to vehicular traffic. The top cover of the enclosure shall have slope to prevent accumulation of rainwater. A gland plate shall be provided at the bottom of the switchboard. An incandescent lamp shall be provided inside the switchboard, with door switches on both doors, so as to switch 'ON' when the door is open.

The circuit wiring shall be as required. System control panel shall be fabricated out of CRCA sheets – 2 mm thick for structural components and 1.6 mm thick for covers and doors & hot dip galvanized after fabrication. HMSB shall be fabricated out of stainless steel of grade 316 to prevent corrosion. HMSB shall be sized to allow for heat generated and design includes for dissipation of heat and shall be IP 65 degree of protection plus canopy, whereas system control panel shall have minimum IP54 degree of protection. Each board/panel shall be provided with hinged door with gaskets.

230V AC auxiliary and control supply aluminium bus bars shall be provided through control transformer of adequate capacity in HMSB. The Board/Panel shall have earth bus bar running through the whole length of the board. All equipment mounted in the board shall be directly connected to this earth bus.

5.1.7.22 **Wiring**

Wiring shall be complete in all respects so as to ensure proper functioning of control, protection and interlocking schemes. Control wiring shall be PVC insulated stranded, copper conductor of 2.5 sq.mm cross section. Each control wire shall be identified at both ends with wire designations in accordance with the relevant Indian Standards. All wire terminals shall be with compression or clamp type connectors. Wires shall not be spliced or tapped between terminal points. Designation ferrules shall be interlocking type with designation engraved with indelible ink. Not more than two wires shall be connected to one terminal. Power and control wires shall be neatly bunched, separately and adequately supported so as to prevent sagging and strain on termination. Terminal blocks for power and control wiring shall be provided with adequate clearances.

5.1.7.23 **Component Specification of HMSB**

- **Contactors**

Contactors for AC shall be 3 pole air-break electromagnetic type suitable for making and breaking locked rotor current of the motor which is equal to around six (6) times the full load current. Contactor shall have minimum 2 Nos. auxiliary contacts. Minimum rating of power contactor shall be 16 Amps. Contactors shall be suitable for uninterrupted duty as per IS 2959 and utilization category shall be AC3 as per IS:4064. The contact material of the contactors shall have anti-weld properties. Insulation class of the operating coils shall be class E or better. Operating coils of AC contactors shall be suitable for 240 V $\pm 10\%$, 50 $\pm 3\%$ Hz, AC supply. The contactors in general shall not drop out at voltage on and above 65% rated control supply voltage.

- **Photo Electric Switch**

A photo electric cell/switch operating on 240 Volt AC shall be provided for automatic group control switching operation based on solar radiation levels.

- **Auxiliary Contactors**

The auxiliary contactors and no volt relay will be provided as per circuit requirement. The contact rating shall be 10 Amp for AC. The auxiliary contactors shall have at least 8 contacts in contact combinations as per the requirement.

- **Control Terminal Blocks**

Control terminal blocks shall be of 650 volts grade, rated for 10 amps and in one piece moulding. It shall be complete with insulation barriers, clip on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. At least 20% spare terminals for connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks. All terminal blocks shall be suitable for terminating on each side, two (2) Nos. of 2.5 mm² size stranded copper conductors. All terminals shall be numbered for identification and grouped according to the function. Engraved white-in-black labels shall be provided on the terminal blocks. Wherever duplication of a terminal block is necessary it shall be achieved

by solid bonding links. Self-aligning, spring loaded, silver plated, sliding contacts for proven design shall be provided as control terminals for withdrawable / drawout modules. Detachable plug and socket type control terminals shall also be acceptable.

- **Indicating Lamps**

The indicating lamps shall be panel mounting large industrial cluster LED type and shall be interchangeable. Indicating lamps shall be with translucent lamp covers. The lamp covers shall be mounted flush on the front panel door and shall be replaceable from the front of the cubicle.

5.1.7.24 **Installation of Light Fittings**

Mounting height of center-line of the various lighting equipment from FFL/Working platforms or finished grade level shall be as noted below unless otherwise specified in corresponding lighting layout drawings:

Lighting panels/control gear boxes	:	1500 mm
Switch boxes	:	1500 mm
Receptacle boxes (Indoor)	:	500 mm
Receptacle boxes (Outdoor)	:	1000 mm
JB on poles/Masts	:	750 mm

Lighting fixtures to be mounted on ceiling/platforms having considerable vibrations which can cause damage to the fixtures shall be suitably supported with rubber pads to limit vibrations in the fixtures. Where conduit wiring is adopted, an earth continuity conductor of 12 SWG galvanized steel wire shall be provided for earthing the lighting fixtures, switch boxes, etc. The earthing conductors shall be run along the entire length of the conduits and shall be securely connected and terminated at the junction boxes/control gear boxes/lighting panels. The earth connection shall be properly secured with bolts, nuts and washers. For outdoor lighting installations, an earth continuity conductor of at least 25 x 3 mm galvanized steel flat shall be used for earthing the lighting masts/poles.

While designing the lighting circuit, the cables shall be sized such that the farthest loop from the supply receives no less than 95% of its nominal voltage, in addition it must be assumed that all the light fittings are energized while this design calculation is made. LED lights should be chosen & located carefully where they illuminate rotating shafts, so as to avoid stroboscopic effect. Fittings made from Aluminium and its alloys should be avoided because the oxide that invariably forms after a time is considered as a potential source of sparks caused by mechanical impact. All fittings shall be installed at a safe height for maintenance & effective illumination. All lighting controls shall be from a non-hazardous area, using double pole, switches, the supply neutral should be switchable along with the phase.

5.1.7.25 *Testing and Inspection*

Equipment of Illumination system should be type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Equipment shall be subjected to routine tests as per applicable Indian Standard. Test reports shall be submitted for approval.

5.1.7.26 *Spares List*

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.8 **Cable Trays and Accessories**

This specification covers the requirements of cable trays, support structures, cable laying, termination, earthing and lightning protection system.

While finalizing Cable routing layouts, consideration shall be given to the requirements of Safety, Reliability and Convenience of cable laying and termination. Where duplicate drives/auxiliaries are provided for reliability, cable routing shall be segregated to the extent practically possible.

In cable trenches, distance between bottom most tier and bottom of trench shall be 150 mm and clearance from top most tray to top of trench cover shall be 400 mm. Distance between two tiers shall be minimum 250 mm. PCC flooring of built-up trenches shall be sloped in longitudinal and also in transverse direction for effective drainage system. Cables should not be laid directly in the trench floor. Cables trenches should be provided with strong & effective covers with water & fire proof sealing arrangement at trench entry & exit points.

Other than cable vault & cable trenches, Cable trays shall be laid in vertical formation to avoid dust accumulation. In cable spreader room a clear access passage of at-least 800 mm wide shall be provided along the cable ways. Wherever passage is through cable routes, a clear height of not less than 2.0 M shall be provided.

Cables of different voltages shall be laid in separate racks. Minimum distance of 250 mm shall be maintained along the routes between various types of cables. In case of horizontal formation, the highest voltage cables shall be laid in the top most position in the tray stack followed by other grades as follows in the descending order.

- 11 kV Power cables (Top Tier)
- 1.1kV Power cables (Below HT Tier)
- Electrical Control Cables (Below LT Tier)
- Instrumentation/Signal cables (Bottom most tier)

On cable trays all the multicore power cables can be laid in touching formation. Single core cables shall be laid in trefoil formation with the spacing equal to twice the diameter of the cable. Control cables shall be laid in not more than two layers. Power & Control cables shall be laid on ladder type trays. Instrumentation & Signal cables shall be laid on

perforated type trays. Cable trays shall be supported at an interval of 1500 mm approximately. Vertical runs shall be supported at an interval of 1000 mm approximately. Cable tray support system shall be site fabricated, welded and painted steel supports. Cable tray support system shall consist of ISMC channel as vertical support & ISA as horizontal arm. Horizontal arm is welded to the vertical support MS channel.

Cables shall be terminated using double compression cable glands suitable for the voltage grade of cables. Cable glands shall be heavy duty brass. Cable lugs for power and control cables shall be tinned copper solderless crimping type conforming to IS 8309. 11 kV cable terminations shall preferably be of heat shrinkable type kits.

Fire barriers/ Fire stops shall be provided for all fire rated wall and floor penetrations and for all direct cable entries into electrical Switchgear / Panels from Cable Vault. Fire barriers/ Fire stops shall provide a fire endurance rating of at least 2 hours. The fire sealing material shall be non-hygroscopic, mechanically steady, non-toxic and physically & chemically stable under fire conditions.

Fire barriers/ Fire stops shall be either of the following methods:

- a) Panel sealing method comprising Encasing Panels, Cavity fill material & Sealant
- b) Mortar Sealing method comprising Mixing Mortar curing with water

5.1.8.1 ***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.

5.1.8.2 ***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.

5.1.8.3 ***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 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor. Tray covers shall be provided for overhead cable trays on top most tier. The cable risers or vertical raceways shall also be covered by cable tray covers upto 1.5 metres from respective floor for mechanical protection. The sheet cover shall be of removable type.

5.1.8.4 ***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.

5.1.8.5 ***Spares List***

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval.

5.1.9 **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: 45°C
- Relative humidity : Above 90%
- Altitude : Sea-level

5.1.9.1 **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 cooled 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 conform 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 (20°F to 110°F) atmosphere to assist in quick starting. The battery system shall be of lead acid automotive type.

Flywheel Guards shall be provided as required.

An **engine control unit** free from vibrations comprising of the following devices with sensors (mounted at engine) shall be provided as minimum:

- Water temperature gauges for jacket water temperature
- Water pressure gauge
- Tachometer for engine speed
- Lubricating oil, pressure and temperature gauges
- Automatic shutdown and indication for low lubricating oil pressure, over crank, low coolant level, high cooling water temperature and engine over speed.

5.1.9.2 Engine Auxiliaries**5.1.9.3 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.

5.1.9.4 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.

5.1.9.5 Fuel Oil System

- a) The fuel-injection system shall be complete with PT fuel pump, injectors, fuel filters and self-contained piping.
- b) The system shall generally comprise of

Day tank capacity for 10 hour running at 75% load.

Pumps required for conveying fuel from day tank to engine. Critical pumps should be provided in sets (1 working + 1 standby)

The day tank shall also act as a relief and by-pass tank for fuel oil that is circulated to the injectors whereupon any excess fuel is by-passed back to the day tank.

5.1.9.6 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.

5.1.9.7 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.

5.1.9.8 **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.

5.1.9.9 **Alternator**

Alternator shall be air cooled, brushless, 3 phase, fan ventilated, synchronous type fitted with heavy duty, long life ball or roller bearing with forced lubrication or lubricant packed for approximately 4000 hours of running without attention. The alternator shall be manufactured in accordance with BS 2613 IEE-341 or as per relevant BIS, ISO, DIN, NEMA, standard. The unit shall be horizontally mounted.

Enclosure shall possess minimum IP23 degree of protection.

Insulation throughout shall be class H, temperature rise by resistance. All windings shall be impregnated to allow operation in climatic conditions specified in this volume.

The Alternator shall be provided with following minimum accessories:

- Resistance temperature detectors
- Bearing temperature detectors
- Space heaters.

The basic ratings of the Alternator shall be as follows:

- | | | |
|------------------------|---|--|
| a) Rated voltage | : | 415 Volts |
| b) Speed | : | 1500 rpm |
| c) Rated power output: | | As specified (Continuous rating) |
| d) Frequency | : | 50 Hz |
| e) Number of phases: | | Three |
| f) Power factor | : | 0.8 |
| g) Type | : | Brushless, synchronous, self-excited self-regulated |
| h) Neutral earthing | : | Solid grounding |
| i) Voltage regulation | : | +1% of rated voltage from no load to full load at any power factor between 0.8 lagging and unity |
| j) Type of cooling | : | Self cooled fan ventilated |

5.1.9.10 **Metering and AMF Control Panel**

This is intended for operation of DG set in auto mode. The panel shall be sheet steel construction and arranged for free standing, floor mounting and bottom entry with front and rear access. The interior wiring of the cubicle shall be looped and clipped and all wire ends are to be clearly identified. Any printed circuit boards shall be tropicalized.

Following metering and protection devices as a minimum requirement shall be included in each panel:

A) Metering Instruments (Digital)

- Voltmeter
- Ammeter
- Frequency meter
- KW meter
- Battery voltmeter
- Power factor meter
- Hours run indicator
- KWH meter
- KVAR meter
- Excitation current ammeter
- Excitation voltmeter
- Engine Speed Indicator

B) Push Buttons

- Engine start PB
- Engine Stop PB
- Lamp Test PB
- Reset PB
- Emergency Trip PB

C) Indication Lamps (Cluster LED type)

- DG set on
- Load on DG set
- Set running
- Mains available
- Mains failure
- Start failure
- Generator over current
- Generator high voltage
- Generator low voltage
- Earth fault

- High engine speed
- Low engine speed
- Low fuel level
- High fuel level
- Charge failure
- Generator winding temperature high
- High bearing temp
- Low lubricating oil pressure
- High lubricating oil temperature
- Engine jacket water temperature high
- Engine jacket water pressure low
- Reverse power
- Low fuel oil pressure
- Rotor diode failure

D) Protective Relays

- IDMT relay (Over current and earth fault)
- Over voltage relay
- Under voltage relay
- Reverse power relay
- Field failure relay
- Differential relay
- Phase failure relay

E) Multi-function Meter with Transducer

- Voltage – Ph-to-Ph & Ph-to-N
- Current – line to neutral
- Power – kW, kVAH, kVAR (Avg. & Ph. wise)
- Energy – kWh, kVAH, kVARH
- Power Factor – Average & Ph. wise.
- System frequency
- Import & export kWh & kVARH.
- RS 485 MOD BUS

5.1.10 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.

5.1.11 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.

5.1.12 Telephone System (EPABX)

5.1.12.1 *General*

The design shall be in accordance with the basic requirements described in the Tender Document and the best current engineering practice, together with the following general design 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) Care shall be taken so that materials and equipment are the standard Catalogued products of manufacturers regularly engaged in the manufacture of such products and shall be of the latest standard designs that conform to the specification requirements. Design shall also be based on similar type of equipment supplied from one manufacturer, utilizing interchangeable parts, wherever practicable.
- d) The design shall comply with relevant codes and regulations listed.
- e) All apparatus, equipment and works shall be so designed that they provide satisfactory service and without any harmful effects for prolonged and continuous periods in the worst climatic conditions.

- f) The reference design ambient temperature for all electrical equipment shall be taken as 45°C and appropriate derating factors should be considered for equipment as applicable.
- g) Suitable derating 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.
- h) Tentative number and location of the Telephone system is shall be decided during detailed engineering in consultation with the Employer.

5.1.12.2 **Main EPABX**

The proposed EPABX shall be 100% Non-Blocking, Electronic, ISDN native. The topology shall be totally distributed so as to support and configure the Remote Units flexibly as per the changing and evolving requirements on Optical Fiber as well as copper cable.

The system shall be based on High Speed, i3 CPU and with at least 2 GB RAM. It shall be equipped with Duplication of complete Control section (viz. CPU, Signaling circuits, Tone generators, Memory, Hard Disk – 1TB, RS232 ports, DTMF resources, conference circuits and other essential circuits) and common Power Supply & Ringer section in 100% Hot Standby mode. The system shall enable automatic changeover in case of failure in any of these without disrupting the existing calls in progress. The Operating system software shall be Unix based.

The system shall have RISC processor, RAM capacity of the system explicitly mentioned. It shall also specify the different control system elements duplicated in the offered system.

EPABX system shall be equipped with Ethernet port (30/100 Base T) and shall have provision to connect a TCP/IP LAN for management and metering application, which shall facilitate system management from any LAN node without using modems.

It shall be equipped with storage devices to save the data, as well as software necessary for its operation. For security reasons, these devices shall be of Flash ROM type, easy to duplicate and shall not cause any disturbance to the system. The Contractor shall specify whether information concerning variable data (forwarding, screenings) is automatically saved in real time, so that if the system goes down and comes up for any reason it doesn't lose data integrity.

5.1.12.3 **Trunk Interfaces**

The EPABX shall have all the following types of Interfaces:

- Analogue Interface to PSTN lines
- Interface to Leased Lines
- Paging System Interface
- Interface to VSAT Equipment
- BR and PR interface to Public ISDN Network

- Digital Interface for DID
- IP FOR VoIP & Data transfer

5.1.12.4 **Extensions**

A) Analogue Extensions

The system shall be compatible with both Pulse & Tone Dialing Instruments.

Contractor shall clearly specify the DTMF receivers available on the system whether they are centralized or distributed, if they are centralized. Contractor to mention number of such receivers on each board. The number of DTMF Receivers shall be 50% of the ultimate capacity to handle peak traffic conditions. The Contractor shall specify the number of such boards equipped in the system offered.

B) Digital Extensions

The Digital phones shall have an Alphabetic Keyboard with "Dial by Name" facility from the central database of the PABX system and a user-friendly operation of the PBX internal services and of the services provided by the ISDN trunk. These terminals, as well as lower-range terminals shall be equipped with keys, which can be directly programmed by the user. The keys enable the user to change several functions (for example: call forwarding code + external number, etc.)- An option shall allow the number of keys on certain terminals to be extended. It is desired that all programming information on digital sets to be centralized and saved in the PBX to enable simple replacement.

The Contractor shall offer his range of digital terminals giving detailed specifications of their features:

- Voice sets
- Voice and data sets for ISDN & VoIP..
- For each type of terminal, the Contractor shall specify the following characteristics:
- Type of terminal,
- Remote power supply or not,
- Maximum distance of connection on 0.5mm cable (min. 1000meters)
- Number of pairs necessary for the distribution,
- Capacity of data transmission,
- Interface for ISDN & VoIP,
- The features, which have to be systematically accepted by digital terminals, are:
- Connection of VDU terminals
- Additional ISDN services
- IP services

The Digital telephone sets with Display panels and Dynamic Soft keys as a part of this display panel shall be quoted. These shall be equipped with Text Messaging facility. The digital telephones shall have keys along with LCD display with associated icons / LEDs.

5.1.12.5 **Attendant Console (Operator)**

The operator console shall have the following features:

A) General

The attendant shall provide call presentation, chaining process, call-back shall be entirely managed by the PBX. However, it shall be possible to put certain calls on individual hold on keys that have been reserved to that effect. The capacity of the various queues shall have to be unlimited. The information displayed on the terminal shall have to be explicit enough to facilitate unambiguous call handling and shall give maximum details about the communication (normal call, urgent call, queue status, name of the internal called-party, status of the telephone set etc.).

B) Supervision of the Installation's Stations

An add on unit with attendant console shall be provided to enable single touch dialing and to supervise the status of certain extensions and trunks. A minimum of 48 terminals shall be supervised.

C) Manual or Automatic Answer

The operator shall be able to modify the call answer mode from his/her attendant console. In "automatic answer", calls must be presented and connected without any intervention from the operator.

D) Calling Internal or External Correspondents by Name

To facilitate the operation of attendant consoles, operators shall be able, whatever their communication position (direct call, transfer), to call internal and external circuits according to surname, first name or initials. To assist searches, the system shall be equipped with a spelling and phonetic approximation utility program. User-friendliness being a requirement, the user shall access the service via an alphanumeric keyboard, either integrated or external to the attendant console. The Contractor shall describe in detail the access modes and the number of subscribers serviced.

E) Text Messaging

The system's telephone application shall enable the operator on transfer call status to send a text message to a selected internal subscriber. The operator shall have the choice between sending the message immediately onto the display panel of the subscriber if his/her line is engaged, or sending it to a text mailbox linked to the terminal, whether the latter is free or busy. This service shall only be provided if the internal subscriber's terminal is compatible with the service (digital terminals with text messaging feature). To facilitate the operation of this service, the operator shall have the choice between several types of messages:

- Pre-programmed messages to answer most common cases (example call back the switchboard, a visitor is waiting for you in reception etc.),
- Pre-programmed messages to be completed (example: call back number XYZ),
- Free messages to be composed entirely by the operator.

The Contractor shall describe clearly all the characteristics of the service and the size of messages, which can be sent in the various communication positions.

F) Hands-free and Amplifier

The operator can freely modify the operating mode of the attendant console and answer calls either in hands-free with the amplifier or with the telephone handset or headphones. When using the latter, the user can operate the amplifier with volume adjust.

G) Ringing levels

The operator shall be able to modify the melody and the ringing volume of the attendant console.

H) DTMF Frequency Transmission

The operator shall have the possibility to use servers controlled by Q23 coded frequencies.

I) Withdrawal of an Attendant Console

There must be a simple procedure to withdraw an attendant console from the group and switch it into a "night service" position. The status of his/her terminal should be clearly indicated to the operator. Calls shall be forwarded to a particular station or a group distributed within the premises.

J) Automatic Transfer of Calls to Attendant Consoles

Then the attendant consoles that are present do not answer calls, the system should, after a time delay, automatically switch to "night service" mode. Calls must be routed towards dedicated stations, the status of the installation shall be clearly indicated to the operators and a simple procedure should enable return to normal situation.

K) Routing Calls to Individual Operator

Incoming calls on Specific trunks shall be possible to route to a particular operator or extension.

L) Additional Services

Attendant consoles enable the user to manage some operation parameters of the system, in particular the following points:

- Create, change or delete a subscriber's attributes,
- Manage service classes (automatic dialing and call transfer etc.)
- Manage the external abbreviated dialing.

All of these operations shall have to be protected by a password programmable by the head administrator.

5.1.12.6 **Telephone Features**

- **General**

Following features shall be available without restriction to all the subscribers or freely programmable:

- Routing of an external bundle on a group or individual user
- Calling an attendant console
- External call barring
- Local calls
- Simultaneous 6 party Conference
- Consult a pending call
- Broker's call
- Recording and transmission of external numbers
- Transit function
- Bundles of external lines
- Call pick-up
- Call pick-up: group
- Put on hold
- Abbreviated external numbers - Minimum 200 numbers
- Directory database in the system - minimum 1000 numbers
- Call parking
- Direct Outgoing Dialing (DOD)
- Direct Outgoing Dialing per cost center
- Direct seizure of external line,
- Dedicated incoming station,
- Dedicated outgoing station,
- Station with direct routing to another station, to an abbreviated number, to an attendant console,
- Station with delayed routing,
- Protection against intrusion,
- Automatic call-back to a busy or free station
- Appointment call-back,

- Storing last dialed number,
- Last number redial,
- Call forwarding - no answer, busy, no answer/busy, fixed
- External call forwarding
- Remote call forwarding
- Night answering service,
- Call diversion on ringing,
- Moving service - without any intervention by the maintenance people, subscriber must be able to move to a new location and by dialing codes at the new locations, he should retain his existing number.
- Padlock with password protection
- Substitution -to temporarily avail all the features of the subscriber extensions at another extension.
- PIN dialing - Each extension should have a PIN dialing, through which one could make calls from a different extension and the metering must be made to the subscriber's extension.
- Call ID on Analogue Extension
- **Push Button Telephones Features**
 - Feather touch push buttons for quick and sure dialing.
 - Memory storage, upto 22 digits for purposes of redialing.
 - Facility for redialing the last number called by pressing the repeat
 - Push button just once.
 - Ringing facility with adjustable volume.
 - Digital pulses during dialing to be muted to eliminate harsh sounds.
 - Compatible with P&T network.
 - Built in automatic gain control.
- **Specifications**
 - System voltage : 48V DC + 10 %
 - Pulse Rate : 10PPS
 - Break make rates : 66:33/60:40
 - Inter-digit pause : 800m secs. (minimum)
 - Loop resistance from the exchange: 1 K ohms (maximum)

The push button telephones must confirm to CCITT standards.

The telephone offered shall be approved by the TRO for interface with P&T network. A copy of the certificate shall be enclosed.

Following Additional Features shall be built-in the System:

- Multi Line Digital Stations

This function shall enable a user to simultaneously establish, from a station answering only one number, several outgoing or incoming communications. Only one communication is active at a given time, the other engaged communications being on hold; the user shall be clearly informed of the status of the pending communications.

Each key on the station can be allocated to a different call number, hence allowing differentiation of the calls. Contractor to mention how many multiline numbers can be programmed on one digital set.

- Multiple Keys and Number Stations

Combining the two previous functions, each directory number can have several keys. The Contractor shall specify the number of manageable keys per station, a minimum of 6 keys which can be allocated to the multiple key / multiple number function would be desirable.

- Executive/Secretary sets

Call Filtering - Certain calls on the Executive set should be programmed to reach directly, whereas all other calls shall be routed to the secretary

Real time diversion without picking-up the call

- Work Groups

Status to be supervised (Visual and audible) on a digital set by associating a key to an extension and monitor for the following status:

- i) Free station
- ii) Busy station
- iii) Station receiving a call (ringing)
- iv) Hunt Groups of stations - sequential / cyclical / parallel
- v) Utilization of ISDN Additional Services

The Contractor shall submit the list of ISDN additional services to be used on proprietary stations. The main requirements are as follows:

- Identification of an ISDN Caller

Some external subscribers must be identifiable by their name or the name of their company upon display of the calls on the attendant console or on proprietary stations. The caller's name shall be maintained after pick-up and shall reappear during all communication modes (back-and-forth, conference, and transfer).

- List of unanswered calls upto 8 calls

Automatic forwarding to Night-mode

Night-mode shall be automatically activated by the clock system and it is required to have night service based on the time of the day.

- Additional Features

Following features shall be available with the EPABX system in addition to the above.

- Music-on-hold

The system shall be equipped with in-built music-on-hold device that shall have a capacity of 10-15 seconds and shall have good acoustic quality.

- Automatic Attendant

The proposed telecommunications system shall be equipped with 4 port P.C. "automatic attendant" feature allowing, the reception of external calls and offering to direct them interactively to a pre-defined service or subscriber. The interactive dialogue shall be based on DTMF. Errors (incorrect codes) shall be handled by an information message and return to the current message. If no Q23 code is received, the call shall automatically flow over to a dedicated number, after a pre-set delay.

- Computer Telephone Integration

CT1 shall support for following computer environment- Digital, IBM, Microsoft, etc.

The physical interfaces supported shall be on V.24, RS232, SO, TCP/IP. Both first party and third party CTI solutions shall be supported.

- IP Components

The EPABX shall have in-built interface for IP functionalities. The Contractor shall enclose the detailed implementation schematic for VoIP and shall quote price for 10 VoIP users. It shall support the following:

- Connection of a server via LAN-LAN router and LAN-WAN (ISDN)
- Voice over IP and Frame Relay.

5.1.12.7 **System Administration - Management terminal**

The proposed system should

- Offer GUI based windows software with user-friendly access to the various proposed services
- Be protected by an overall access code and offer several secondary access levels
- Enable overall management of the system

- Provide menus in English, without obligation to answer questions with hexadecimal characters or mnemonics. A Windows-compatible application would be desirable

5.1.12.8 **Main distribution frame**

The main distribution frame for Field side and Exchange side shall be housed in a metal cabinet and shall be equipped with Krone modules for 200 Pair terminations. An Intermediate Distribution Frame shall also be provided for 200 Pairs with Over-voltage and over-current protection for all the Trunk lines. The interconnection between MDF and IDF shall be done using Jumper Wire. The Contractor shall do all termination of cables and jumpering at the MDF.

5.1.12.9 **Power Supply**

A) FCBC

The Float cum Boost Charger shall be sized to supply power to the PBX for the required capacity and it shall simultaneously allow re-loading of the battery within 10 hours maximum. FCBC shall also be provided for the Remote units also.

B) Battery

Sealed Maintenance Free Lead Acid battery shall ensure automatic standby for the PBX in case of failure of the electric power supply or the rectifier. A minimum back-up of 6 hours is required.

5.1.13 **List of Approved Makes**

S. No.	Equipment / Component	Preferred Makes
1.	HT Switchgear	Adlec (Schneider) / SPC Electrotech (L&T) / RISHA (L&T) / NITYA (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

S. No.	Equipment / Component	Preferred Makes
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 / Caldine / 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
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 / Rishabh / 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	L&T / Siemens / BCH / Telemachanique

S. No.	Equipment / Component	Preferred Makes
	Reset Type)	
34.	Protective / Auxiliary Relays	Areva / Schneider / Siemens / EasunReyroll / ABB / Telemecanique / L&T
35.	Time Delay Relays	BCH / Siemens / L&T / English Electric
36.	Power Contactor with 2NO+2NC	L&T / Siemens / Telemecanique
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
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

5.2 CONTROLS AND AUTOMATION WORKS

5.2.1 System Description

A Central Control System is proposed as shown in the **Drawing I-525/HT/1021, Control Architecture** to ensure safe and reliable operation of conveyors, dust extraction system and other facilities. PLC system shall read the inputs, perform all system logic, conduct online diagnostics, sequencing control and control the outputs. The processor based central control system is envisaged to control and monitor the material handling operations in the Inland Water Transport (IWT) Terminal so as to carry out the operation in an integrated mode from "Control Room".

The Control Network shall be used for providing automation functions, interlocking, sequence starting, monitoring and supervisory functions with Belt conveyors, Pipe Conveyors and Dust Extraction System for Fly Ash Handling facility.

The Control Network shall also be used for providing monitoring and supervisory functions, interconnection with Equipment/Machines having its own Control Systems like Mobile Harbour Crane, Barge Loaders, Weigh Bridge, Gantry Type Grab Cranes etc..

At the highest level - the Management Network shall include colour graphic processors, network servers, PC work-stations, printers, communication and data interfaces, software(s) etc., to provide planning, inventory management, data acquisition/communications and other management functions.

At the lowest level of automation System, the individual drive motor controllers with their associated control devices (limit switches, sensors, local control devices, brakes, metal detectors, magnets, belt scales, local control stations and other sub-systems (as per the details given in this specification and Control Architecture) shall be controlled in groups or individually by the PLCs.

The core of the system shall consist of Operating stations, Programming Station and Server Stations (all the computers shall be latest version of the Industrial PCs – IPC as on the date of bidding) with printer and along with centralized real –time redundant PLC system (One online and the other in hot standby excluding I/O modules), sharing a RAID 6 (redundant array of independent disk) data storage system and a data network, with shared high-capacity data backup and off-site data archiving as per attached Control Architecture.

The control system would incorporate all safety interlocks to ensure complete safety to operating personnel and to avoid any damage to equipment due to mal-functioning.

The control system shall generally be based on the following principles:

- i) To start equipment in either of the two modes i.e. 'Local' or 'Remote'.
- ii) To trip off minimum equipment in the desired sequence during abnormal operating conditions, leaving all the other equipment running, which may safely be permitted to continue the operations.
- iii) To annunciate the fault which has tripped equipment along-with the cause for tripping?
- iv) To prevent restarting of the equipment until safe conditions have been restored.
- v) To retain maximum flexibility of operation consistent with safety.
- vi) To prevent mal-operation of equipment on interruptions.
- vii) To stop all the running equipment simultaneously by pressing Emergency Stop Push Button.
- viii) To stop running equipment in the reverse order with time lag during normal stop.

CDB's (Control Distribution Board) shall be furnished, manufactured and installed for feeding power supply to the field instruments.

5.2.2 Equipment Specification

Equipment Specification shall strictly adhere to the following general guidelines:-

- i. The makes and the specifications of every aspect and in totality of the Server, LED Displays (Large), Operating Terminals, LED monitors, Network Printer (A3/ A4), PLCs (including CPU, Communication Processors), Remote Input Output Panel (including communication processors/interface modules, DI/DO, AI/AO and RTD modules), Uninterrupted power supplies and all Network Components and accessories including Managed Network Switches, Media Converters, Cat5e (STP), Multicore Cables for Field Instruments etc. shall be of the latest available make and shall conform to applicable industry standard. The type, make and model of all bought out items supplied shall be subject to approval during detail engineering stage.
- ii. The enclosures for Control equipment i.e. RIO's, PLCs placed in substations and control rooms shall be of IP-54/55 and IP-66/67 standard for the ones placed in Fields.

5.2.2.1 Servers

The Servers shall be of industrial grade with high computing power, suitable for communication equipment networking and industrial automation. Server shall be with twelve processor execution cores. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking along with a hot standby system. The changeover shall be smooth. Hard disks shall mirror the data bases required. Standard keyboards, mouse controllers shall be included, with CD/DVD read/write drives, and tape backups.

Servers shall be commercial class with efficient computing power in order to maximize memory through unprecedented capacity and bandwidth for maximum performance, suitable for high speed communication equipment networking and industrial automation. Independent expansion of processors, memory, networking and storage I/O on the same scalable platform shall be possible and shall be a server-class computer with support up to 2 sockets with 10 cores of processing power. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking along with a hot standby system. The changeover shall be smooth. Hard disks shall mirror the data bases required. Standard keyboards, mouse controllers shall be included, with CD/DVD read/write drives.

Technical Data

Processor	E7-4850v3 with 14 CPU cores in a 2-socket
Clock Speed	2.8 GHz
Cache Memory Size	35 MB Cache
Memory Types	DDR4-1333 MHz
Hard Drive	2 TB (4X500GB) HOT PLUG SAS(with flexible hot-swap storage with up to 8 HDDs or up to 16 SSDs)
Communication Ports	Parallel Port-1 Serial Ports (Universal)-3.

	USB Ports-8
Power Source	240 V AC,50/60 Hz
Network card	4 ports of 10 Gigabit Ethernet (GbE) and DCB support with 4 Fibre Channel ports supporting 2, 4, and 8 Gbps full duplex
Permissible Humidity	20%-80%
Design Ambient Temperature	45°C
DVD	Min. 4.7 GB DVD RAM (R/W) drive
DAT	Min. 4 GB DAT as software media and storage

5.2.2.2 *The LED (VDU)*

Shall display all main conveyors data and sub-systems represented individually in approved manner. Each position/level shall be indicated. Other data/information as required (Selection, material flow, fault Indication, outputs of weighers, equipment locations and other information required shall be shown or displayed on demand in different colors. The graphic displays shall be subject to the approval of the Employer but shall be field programmable. The video graphic display unit shall be suitably placed in the Control room. The VDU shall be capable to display graphics or pictures in 1080p high-definition resolution, with the highest level of quality and reliability.

LED screen shall be used for displaying process flow mimics, with full high definition capability and using the latest in display technology. They shall have the highest level of quality, reliability and resolution.

Technical Data:

Power Source	240 V AC,50/60 Hz
Display Type	Compensated TN ,Full color LED Luminance :400 cd/m2
Resolution	At least 1920*1080
Size	64 inch Diagonal
Operating Condition	Temperature : 0°C - 40°C Humidity : 20% - 80%
Contrast Ratio	5,000,000:1
Viewing Angle	140°H, 140°V
Safety Standards	UL6500/C-UL

5.2.2.3 **Data terminal computers**

Data Terminal CPU shall be of Industrial grade having high computing power, suitable for communication equipment networking. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking. They shall be complete with standard keyboards, 21 inch LED color monitors, mouse controllers, CD/DVD drives, network cards.

Data terminal computers shall have high computing power, suitable for communicating equipment networking. Each processor shall have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking. They shall also include compatible standard keyboards and standard mouse and licensed operating system and other necessary licensed software.

Technical Data:

Processor	Intel Xeon i5, 3.00 GHz 12 MB cache
Random Access Memory	4 GB- DDR4, 1333 MHz
Hard Drive 1 Optical Drive	1000 GB SATA CD/DVD R/W
Operating System	Windows Server 2008
Communication Ports	Parallel Port: 1, Serial Ports (Universal): 3, USB Ports: 8
Power Source	240 V AC,50/60 Hz
Network card	Redundant Gigabit/10/100 MBPS Ethernet PCI-E Network Card
Permissible Humidity	20%-80%
Design Ambient temperature	45°C

5.2.2.4 **LED monitors**

LED monitors shall be used for wide range of digital applications, with full high definition display technology. They shall have the highest level of quality, reliability and resolution.

LED monitors shall be used for wide range of digital applications, with full high definition capability and using the latest in display technology. They shall have the highest level of quality, reliability and resolution.

Technical Data:

Power Source	240 V AC,50/60 Hz
Display Type	Compensated TN ,Full 1080p Display

Resolution	At least 1040*768 (NI)
Size	21 inch Diagonal
Operating Condition	Temperature : 0°C - 40°C Humidity : 20% - 80%
Contrast Ratio	10M:1 Dynamic contrast Ratio
Viewing Angle	140°H, 140°V
Safety Standards	UL6500/C-UL

5.2.2.5 **Network Printer**

At Control room, Scheduling and Planning Terminals shall be suitable for large work groups, and for high-quality, high volume printing. The printers shall enable high-speed color or monochrome printing of up to 40 pages per minutes for optimal productivity and shall have the capacity to print high-quality, complex documents quickly. Large work groups shall be able to produce professional, impressive-looking documents every time. Printers shall be equipped with paper feeders and paper cassettes for at least A3 and A4 paper.

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Technical Data:

Power Source	240 V Ac,50/60 Hz
Printer Type	Color Work Group Laser printer
Operating Condition	Temperature : 16°C-32°C Humidity : 8% -80%
Print Quality	Selectable up to 1200x1200 dpi
Communication Port	USB 10/100 Base Ethernet Port
Processor	300 MHz processor
Memory	64MB (320 Max)

5.2.2.6 **The Programmable Logic Controllers PLCs**

PLC's shall be Redundant and of rugged design and quality to meet the functional requirements, capable of withstanding/bypassing high electric noise, electromagnetic interferences, vibrations etc. The microprocessor based systems shall be of modular design and suitable for mounting in standard racks.

It shall be equipped with latest Processor modules, Communication Modules, Data processing software, Logic Implementation software, SCADA/HMI software for alarm management and other required interfaces complete with all accessories. It shall have adequate functional capacity for handling the I/O Unit's, external interfaces and data bus interfaces. It shall be enclosed in IP-54 degree of protection panels.

The microprocessor based systems shall be of modular design and suitable for mounting in standard racks. Each module including rack/mount base shall be individually metal enclosed dust and vermin proof for withstanding worst environmental and ambient conditions etc. Remote input/output cabinets shall be suitable for mounting on walls/columns.

The memory shall be RAM type and sufficient battery backup must be provided. The execution cycle of the PLC shall meet the functional requirement of plant. The memory capacity of the PLC shall be adequate to perform the required functions satisfactorily and with 100% spare capacity for use in the future. Redundancy (100% hot standby) shall be provided in the PLC's such that in case of failure of any of the processors, the hot standby processor shall take over automatically. The change over shall be smooth. Redundancy shall be provided for the complete Controller including CPU, memory, communication processor and power supply.

In event of power failure during battery replacement the memory contents shall not be lost for at least 30 minutes. Battery down alarm/indication shall be available at least 20 days in advance at the CCR.

Each CPU shall be complete with required number of modules, main power supply unit, marshaling box, interconnection cables etc. and shall have screw type terminals for I/O connections.

A processor failure condition shall be indicated in the control room and change over to redundant systems shall also be indicated. Extensive diagnostics shall be available for all intelligent modules of the system. The processor shall execute the programs for the plant operation at very high speed. Signals to each remote interface unit shall be transmitted by means of the network.

PLC power supply units must have self-test facilities for detecting under voltage and also must be able to give alarm and switch over to UPS mode in case the output voltage is + 20% above the normal value.

The status indications for power 'ON', control supply healthy, overloads, by means of LED's should be available on the power supply unit. The equipment must be capable of accepting wide voltage fluctuations + 10% voltage + 3% frequency.

The Contractor shall furnish the power load details of his system and shall keep 30% spare capacity in the power supply excluding allowances for transformers, cable losses etc.

Three Wire RTD signals shall be processed in the PLC through an analog input/RTD module which will be programmed for alarm and tripping the relevant motor in case of abnormal temperature of any RTD. Winding temperature shall also be available on color monitor

VDU (in the fault window) and in mimic panel of the control desk, when required by the operator.

The analog input module shall have provision to accept signals from the belt scales and 3D Level Scanner Inputs 4-20mA analog signals. Proper conversion to standard units shall be done by automation software.

Each Controller shall be complete with required number and type of modules, main power supply unit, marshaling box, interconnection cables etc. and shall have screw type terminals for I/O connections.

Input/output units shall be capable of accepting discrete, analog, RTD, digital input and output devices. If the number of slots for input and output modules in the controller rack is not sufficient expansion units shall be connectable to the CPU by means of interface modules. Signals to each remote interface unit shall be transmitted by means of the network.

I/O modules shall have status indications to indicate the proper functions of the modules and scanning of signals by the processor. Each Input and Output module shall be electrically isolated through opto-couplers or isolation transformers and shall withstand severe voltage transients without damage or adverse effect on the controller. Output modules shall incorporate self-contained damping networks and voltage limiting devices to prevent false triggering of outputs and to suppress line voltage spikes. Each output card shall have fuses to protect its circuitry from over current and overloads. PLC power supply units must have self-test facilities for detecting under voltage and also must be able to give alarm and switch over to UPS mode in case the output voltage is + 20% above the normal value. The status indications for power 'ON', control supply healthy, overloads, by means of LED's should be available on the power supply unit. The equipment must be capable of accepting wide voltage fluctuations + 10% voltage + 3% frequency. The Contractor shall furnish the power load details of his system and shall keep 30% spare capacity in the power supply excluding allowances for transformers, cable losses etc.

The Contractor shall provide separate grounding system for the PLC based automation system equipment supplied with independent earth pits and earth grid of 8 SWG G.I. wire with PVC sleeve.

Digital and Analog Input Output Modules which shall be required for future expansion of the Facility shall be procured at that time by the Contractor.

5.2.2.7 Remote Input Output (RIO)

Remote Input Output shall accept the command from main PLC; also it shall send and receive the data from Control Room PLC. It shall have RS-485 (Modbus RTU port interface to communicate with controllers) It shall have communication interface with necessary signal/baud rate converters. No redundancy required for I/O modules. The input modules circuit voltage shall match with Power control center voltage PCC's (MV Switchgear). It shall also have DI, DO, AI, AO and RTD etc. modules of suitable channel density, numbers and with appropriate spare channel capacity, Supply Voltage Rating, Current input/output

is 4-20mA DC for AI/AO .Voltage input/output of 24V DC and/or 240V AC for DI/DO to suit the functional requirements. Also include appropriate spare capacity on I/O rail/rack.

It shall be an intelligent Remote Input/output unit and shall have communication processors / interfaces to communicate with PLC system. It shall send and receive the data from PLC. It shall have Mod-bus-RTU, RS-485 port interface to communicate with addressable safety switches, Belt Scales and controllers. It shall have communication interface with necessary signal/baud rate converters. The input modules circuit voltage shall match with Power control center voltage PCC's (MV/LV Switchgear). They shall be suitable for field mounting with IP 55 degree of enclosure protection inside transfer towers or at outdoors.

5.2.2.8 **Digital Input Module**

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	3 mA
Isolation	Isolation should checked with 1000VAC (isolation by opto-couplers)
Dimensions(Max)	As per standards
Operating Condition	Temperature : 8°C-65°C Humidity : 8% -95%
Input Voltage For signal "1"	110 VAC Or other approved to meet the operational requirements
Input Current	5mA to 50 mA
No. of Channels	32/16 per module

5.2.2.9 **Digital Output Module**

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Short circuit protection of the output	As recommended per channel
Isolation	Isolation should be checked with 500V DC (isolation by opto-couplers)
Dimensions(Max)	As per standards
Operating Condition	Temperature : 8°C-65°C Humidity : 8% -95%
Output Voltage	110VAC or any approved to meet the

For signal “1”	operational requirement
Output Current For signal “1” max	2 A
For signal “0” residual current, max	3 mA
No. of Channels	32/16 per module

5.2.2.10 **Analog Input Modules**

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	225 mA
Isolation	Isolation should be checked with 1000VAC
Address space per module	4 byte
Dimensions(Max)	As per standards
Operating Condition	Temperature : 8°C - 65°C Humidity : 8% - 95%
Measurement Type/range	4 to 20 mA / 0 to 24 VDC
Overflow / underflow	Disable/enable
Resolution	13 bit or more
Temperature errors	+ 0 to 2% K
No. of Channels	16/8 input channels
Status information/alarms/diagnostics	Process alarm (yes)
Scan time (all channels)	25 ms

5.2.2.11 **RTD Modules**

Technical Specification:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	150 mA
Isolation	Isolation should be checked with 1000VAC
Address space per module	4 byte
Dimensions(Max)	As per standards
Operating Condition	Temperature : 8°C - 65°C Humidity : 8% - 90%
Overflow / underflow	Disable/enable

Resolution	13 bit or more
Temperature errors	+ 0 to 2% K
No. of Channels	8 Channel RTD
Temperature Sensor	2/3/4 wire RTDs (PT 100 type)
Scan time (per channel)	50 ms

5.2.2.12 **The UPS**

UPS shall be provided for components/locations wherever necessary with rated output powers to suit the load in each case. Redundant UPS shall be provided in the Control Room at Electrical Substation. The rating of UPS shall be based on the total load calculation of the equipment's in Control Room. The status of UPS shall be indicated at CR-VDU. Lead Acid maintenance free storage battery units with closed top cells of capacity to meet the 1 hour UPS backup requirements shall be complete with all accessories and devices.

Technical Specifications:

Rated output power	To serve the loads for 1 hour.
Input	415 Volts, AC + 10% at 50 Hz + 5%
Output	240/110 Volts, AC, 50 Hz
Static Output Tolerance	+ 1 %
Dynamic Output Tolerance	+ 5 % (without Battery)
Switch over Time	Less than 10 milliseconds
Design Reference Ambient Temperature	45°C

Stationary type Lead Acid storage battery units with closed top cells of capacity to meet the 1 hour UPS backup requirements shall be complete with all accessories and devices. While sizing each battery the following factors shall be taken into consideration:

- a) Aging factor as 0.8
- b) Temperature correction factor
- c) Backup period - 1 hour
- d) Power Factor - Unity
- e) Manual bypass option shall be provided

5.2.2.13 **Ethernet Switches**

Ethernet Switches should be of managed industrial-grade type that provides very high speed Fast Ethernet and Gigabit Ethernet with Copper and Fiber Optic media connectivity

for deployment in harsh environments. They should be able to operate in environments suitable for industrial networking.

The Ethernet Switch shall allow expansion of network securely. It shall be optimized for maximum system availability, with fully redundant stacking, redundant power options. Network security shall be provided through IEEE 802.1Q VLANs, IEEE 802.1x port authentication, access control lists (ACLs), denial-of-service (DoS) prevention, and MAC-based filtering. Web-based configuration shall be secured using SSL.

5.2.2.14 ***The Ethernet UTP cable***

Shall meet the EIA/TIA-568/569 and shall be suitable for use in noisy environment. It shall be of Cat5e/Cat6 type.

5.2.2.15 ***Fiber-Optic Cable***

As required, shall be 8 core Single Mode Armored Cable. FO Cable should be internally wrapped with dielectric tape and corrugated steel tape armoring and shall be suitable for outdoor laying.

5.2.2.16 ***Control and Instrumentation Cable***

Shall be suitable for laying in perforated trays, pipes, ducts, closed trenches and directly buried underground. All cables shall be armored type. Cables shall be provided with additional overall Shielding with Aluminum Mylar tape with 100% coverage and 25% overlap on laid up cores for shielding against static/ electromagnetic interference. The voltage rating shall be 1100V with an ambient temperature of 45°C. 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 conform to relevant IS specified. The insulation shall be chemically cross linked polyethylene XLPE conforming to the physical, electrical and ageing properties as required to relevant IS specified. Armoring shall be arranged over the inner sheath for the cable consisting of two or more cores. The armor of cables shall be either of galvanized steel wires or galvanized steel strips. A tough outer sheathing of PVC insulating material in standard colours shall be provided over the armoring 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.

5.2.2.17 ***The RS485 STP cable***

RS 485 Cable 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.

5.2.2.18 *Other Control Subsystems*

The Different Local Control Panels like Dust Extraction Local Control Panel, 3D Level Scanner Panel etc. with required Cabling and Accessories shall be provided by the Respective Contractors and shall be integrated with the Main PLC Control System.

5.2.3 **Conveyor System**

All conveyors shall be interlocked in flow-path selected including conveyors, stationary units and travelling equipment for sequential starting & stopping, safe operation and emergency shutdown.

- Once a flow-path is set-up from the Control Room, all Conveyors will start sequentially and stop sequentially in the reverse order.
- In emergency mode all conveyors including the equipment interfaced of the selected path would stop at a time.
- Each Conveyor can be run individually in 'manual mode' only for maintenance from the switches near the motor drive. The conveyor with material on belt will not be run in maintenance mode.
- If one or more of the drive units of any multi-drive conveyor fails during operation, the conveyor could be continued to run, if required with the remaining drives but at a lower capacity. This can be done after resetting the system-capacity from the Central Control Room.
- The conveyor drives with longer coasting time than that of the succeeding conveyor will be provided with mechanical brake(s) on conveyor. The brake will not be applied during stoppage of empty conveyors and planned stoppage of loaded conveyors.
- All safety devices will have to be re-set manually after actuation after taking the necessary corrective measures. Such safety devices include inter alia:
- Take up end travel limit switches for safety which will be actuated in case of excessive (beyond limit) belt elongation or belt snapping.
- Pull chord switches provided at both sides of each conveyor will generally be used to stop the selected path in 'emergency mode' from anywhere in the field. Similarly Belt Sway Switches shall also be present on both sides of the Conveyor.
- The Pull Cord and Belt Sway switches shall be connected to the Master Unit (One for each conveyor). All the Safety switches of the respective conveyors shall be connected to the Master Unit of that Conveyor. The Master Unit is further connected to the RIO Panel with Addressable Belt Watch System, which will indicate the address of switch which is operated on the field.
- The other Subsystems like Mobile Harbour Crane, Barge Loaders/Unloaders, Weigh Bridge etc. shall be interlocked and Programmed with the PLC to ensure Sequential operation.
- There are three types of stop for a sequential belt conveyor:
 - Emergency Stop – all conveyors will stop instantaneously.

- Fault Stop – all proceeding conveyors will stop instantaneously and subsequent conveyors will stop after clearing the material above them as per costing time.
- Normal Stop – all conveyors from the feeding end will stop one by one clearing material above them as per costing time.

However, during trial or testing in local de-interlock mode through local start/stop stations – the fluid coupling scoop in/out will take place allowing the motor to continue to run but the conveyor to stop after its own costing time.

5.2.4 Networks

The automation network shall be real-time Open universal network, requiring long time continuous operation. During normal operations, the system cannot be shut off and it shall be possible to replace the components without shutting off the power. It shall be feasible to program the system online. The redundant workstations shall be located in Control Room.

The response time of the system shall be such as to minimize the spillage of material on the belts under emergency stop conditions.

The management network shall be full duplex with full redundancy. Proper care should be taken in the data transfer in order to achieve quick response while transmitting control and management information. The response time should not be more than one millisecond. The network system shall have fault clearance functions, secure transmission of data through error checking routines on all data transmitted. The networks shall use open systems technology, support multiple industrial standards, allow a combination of multiple communications agreements, and shall have the capability to join wider networks in the future.

The networks shall use MODBUS RTU RS 485 Cable to connect PLC to RIO Panel. In general fiber optic cable shall be used for distances greater than 500 meters. The data cable shall be suitable to communicate between RIO (Remote Input Output Panel), other Control Subsystems like Dust Extraction LCP's, and Belt Conveyor JB's shall be connected to the Central Control Operator (PC/PLC) station to meet the functional requirements. The baud rate or transmission rate shall be 10/100 Mbps. It shall be a high-speed data access control type capable of handling critical time functions. This network shall be used up to 32/64/128/256/1024-devices. Redundancy in the control network shall ensure that at all times signals shall be available to all interfaced components. The management network shall exchange plant related information between various information and data terminals (PC consoles) and Control Room/Master Control Unit. Redundancy in the management/control network shall ensure that at all times signals shall be available to all interfaced components.

5.2.5 Software

5.2.5.1 *General*

Software provided shall be based to the maximum extent on standard packages to minimize complex programming tasks and facilitate support, maintenance and upgrading. Software shall be “user friendly”.

The development of the application software shall be done in consultation with the Engineer in a number of stages (requirements definition, functional specifications, design, implementation and testing, maintenance and training) with each stage to the Engineer’s approval. The final version of the software will be subject to the approval of the Employer.

The software shall meet the requirements of this specification for all of the management and control system functions and operations, and it shall be possible to develop it in further detail on site to meet the management and operating needs of the Employer.

Programs shall be rationally structured, well readable, easily revisable, and with man-machine interfaces displayed in English.

The software shall be suitable for use with multiple methods of English character input.

Manuals shall be provided for all software in English

Proprietary software packages forming part of the software provided will include permanent run-time licenses. If any part of the software requires annual license fees, the cost of such fees will be indicated in the bid.

In any case the Employer shall have the right to freely develop, modify, maintain the application software, and shall provide the source code and all relevant manuals and information needed for this purpose.

Utility program’s shall be included in the software supply, including network management, multi-level password protection, on-line help, virus protection, and back-up and archiving, word processing, statistics, simulation and data communication (like MS Office, Recommended(McAfee/Trend Micro/Windows one live) Antivirus, Adobe Reader). Whenever an operator input data, a text window will be prompted on the display.

The Software’s that are required for different field devices such as Belt Scale software’s, 3D Level Scanner software’s etc. shall be provided by the respective vendors, and it shall be the responsibility of the Contractor to install third Party software’s in respective Terminals

5.2.5.2 *Management Software*

Management software shall include system software, and application software based on the use of a commercial database Package.

All the operations, displays and print-outs in the management information system will be in the English Character.

The management system software will operate in parallel with the control system and will continuously and automatically poll the real-time control network database to acquire current data for the management system. To optimize the CPU utilization updating will be done on an exception basis whenever a data element is changed.

The system software shall ensure, that the two network workstations will always have identical databases, so that if one fails, the “stand-by” unit will be able to continue operations with the minimum of interruption feasible; and that the database of the failed unit is immediately updated when it is restored to service.

The application software shall be independent of the system hardware, and be easily transferable. It shall be capable of further developing and operating the management system.

The data required in the data bases shall be entered manually or transmitted from remote systems, or automatically obtained via the control network management network.

The goal of the system is to centralize information and planning for the Material Handling solution operations and to optimize the utilization of all facilities. The system shall also be a central clearing house of information on material and equipment. All records shall be cross-linked between inventory and shipping databases, with the intention that the source, destination, location and movement schedule of all current, previously and future stored material is known and movements can be planned as far in advance as possible. It should be possible, through the system, to know the position, type, Employer, consignee, quantity, age and any other relevant details of every quantity of material stored in the Plant. A maintenance database shall be provided to track equipment operation, faults and availability, and used to automatically schedule maintenance.

The software shall be customized off-the-shelf or custom as required to deliver the features described herein. Custom software shall be completed in an accepted and common programming language such as C++, VB, JAVA, MY SQL SERVER or equivalent approved by the Engineer and shall be provided complete with soft and hard copies of documented source code, development tools and program libraries, along with an undertaking by the manufacturer to provide a minimum of 10 years support. Off-the-shelf software shall also come with a manufacturer’s undertaking to provide a minimum of 10 years support.

Secure logons shall be used and users shall be grouped according to access needs, offering limited read-only, unlimited read-only, unlimited read and limited-write, and full read/write access, depending on user needs. The number of persons with full read/write access shall be kept to a minimum. Users input to the databases shall be tagged with the time, username and write made, in order to allow security auditing and error tracking.

Remote login shall be enabled to allow data to be added by persons who shall have business with the handling facilities. They shall be assigned unique secure logins and shall be allowed appropriate levels of access. Their entries shall also be tagged with time, username and data entered to allow security auditing and error tracking.

With regards to remote sessions connections, preference shall be given to systems providing a standard gateway, such as secure web-based or other, to eliminate the need to disseminate custom client software to remote operators. Tight security must be provided, with IP logging, and ideally remote sessions should be restricted to 'white-listed' remote IP's to reduce the change of inadvertent access.

5.2.5.3 **Control Software**

The control software shall be used mainly to:

- Control the process flow operations
- Process operating instructions
- Control operating cycles and interlocking sequence logic
- Collect data automatically on equipment status and fault indication
- Collect and process data in real-time
- Transmit data and communicate with RIO's/ Subsystems/associated control devices
- Automatically diagnose faults in the complete system
- To provide a human interface for the operators on SCADA
- Update the software programs.

The PLC programming language (**IEC-61131-3**) shall be of ladder type, functional block description, or other approved standard type. It shall be possible to program the system on-line. Facilities shall be provided to monitor the system on-line in addition to programming, using either mounted on PLC hardware or separately through a programming workstation so that forcing of I/Os, changing of timer/counter values, contact monitoring, error analysis etc are possible. The PLC/PCs shall read or write data from/to the RIO's, workstations, associated control devices indicated on the Control Architecture Drawing and elsewhere in this specification.

A Supervisory Control and Data Acquisition (SCADA) shall be part of the control software and shall communicate with the large VDUs and the operator's color graphics workstations/PC's required. The data bases shall be updated continuously in real time in not more than 1 second. All displays shall be dynamic and updated continuously, irrespective whether they are actually shown on the screens or not at the time. All page/graphic displays shall be programmable so they can be changed at any time to add additional information needed by a software engineer at the site off-line.

The software shall display the fault and alarm status of the plant components and shall be available in the data base at all times. The fault and alarm status shall be transferred to maintenance operator automatically.

The data base and data formats in the control system shall be identical to the management system databases.

Control Room and Related Rooms

The Control Room will be housed on the First floor of the Control Room at Electrical Substation **as per Control Architecture Drawing No. I-525/HT/1021.**

In Control room the following equipment will be installed:

- Servers cum SCADA Station;
- PC Operating Terminals;
- PC Programming Terminal
- PLC and associated control equipment
- Printers;
- Network Video Recorder for CCTV;
- CCTV Monitoring Terminal
- UPS;

The consoles shall be low profile, laid out ergonomically in an arc shaped pattern, to accommodate the equipment and the operators to permit efficient operations with a minimum of fatigue. The layout will be subject to the approval of the Engineer. Appropriate non-glare lighting shall be provided in the Control Room, which shall be fully air conditioned and shall have sound absorbing panelling ceilings and walls.

The control equipment room will house equipment such as PLC panels, I/O panels, distribution panels, control power panels. The computer room will accommodate the network file workstations, network devices; system engineers work stations and printers. The UPS and associated batteries will be in a separate room. The Control room & conference will be air conditioned. False floors shall be used in the control room & conference room to accommodate cabling and connections. The Contractor shall supply six revolving, ergonomic office chairs, media storage, bookcases for manuals, and filing cabinets.

5.2.6 Network Components & Accessories

5.2.6.1 Ethernet Switch

Ethernet Switches should be of managed industrial-grade type that provides very high speed Fast Ethernet and Gigabit Ethernet with Copper and Fiber Optic media connectivity for deployment in harsh environments. They should be able to operate in environments suitable for industrial networking.

The Ethernet Switch shall allow expansion of network securely. It shall be optimized for maximum system availability, with fully redundant stacking, redundant power options. Network security shall be provided through IEEE 802.1Q VLANs, IEEE 802.1x port authentication, access control lists (ACLs), denial-of-service (DoS) prevention, and MAC-based filtering. Web-based configuration shall be secured using SSL.

For Power over Ethernet (PoE), automatic load sensing in the power-control circuitry detects PoE on the end device before providing power. For safety, each port shall have independent overload and short-circuit protection, along with LED indicators to show

power status. The switch shall provide PoE power on up the Ethernet ports for powering PoE-enabled wireless access points.

It shall integrate into Supervisory Control and Data Acquisition (SCADA) systems, and any other facilities. The switches shall have industrial-grade components, a compact form factor, convection cooling, and relay output signalling to extend intelligent services such as enhanced security, high availability, and advanced quality of service (QoS). A large number of protocols supported make sure that the system will interoperate with other Ethernet-enabled devices and IP applications and enables integration between business office applications and industrial equipment.

It shall have device manager software which allows users to easily configure and monitor the switch using a standard Web browser. Customers can easily initialize the switch with Web-based set up. In addition a standalone network management application shall be provided so that operator can simultaneously configure and troubleshoot multiple switches. The bundled software shall reduce the cost of deployment by enabling less-skilled personnel to set up switches quickly.

Technical Specification

No of Ports	24 No's of 100/1000 Ethernet port copper modules and 4 Fiber Optic Ports
Managed	Yes
Power inputs	240 VAC at 50 Hz
Industry Specifications	IEEE 1588 Precision Time Protocol, IEC 61850-3 (substations), ODVA Common Industrial Protocol, IEEE 1588v2, NEMA TS-2 (ITS)
Mounting	DIN-rail, wall, rack mount option, desktop and Stackable
Intrusion protection rating	IP 20
Operating temperature	32 to 113°F (-40 to 70°C)
Operating relative humidity	10 to 95% (condensing)

5.2.6.2 **Patch panel**

Patch panel shall provide ultra-high density connection while facilitating cable routing and patch cord management. They shall be of Rack-mount and Wall-mount they should be totally modular and scalable to accommodate future fiber build-out.

Patch panel unit housings shall be of 1U, 2U and 4U or small, medium and large (depending on whether it is rack or wall mounted) size (as per the number of terminations), in titanium color. The front patch cord tray and rear cable tray shall be removable for easier access during the installation.

Technical Specification

Rack Mount	No of Adaptor Strips
a) 1U Rack Mount	2
b) 2U Rack Mount	4
c) 4U Rack Mount	8
Splice Trays	
a) 1U Rack Mount	1 x 8 in.
b) 2U Rack Mount	2 x 8 in.
c) 4U Rack Mount	4 x 8 in. or 4 x 12 in.
Wall Mount	
No of Adaptor Strips	
a) Small Wall Mount	2
b) Medium Wall Mount	4
c) Large Wall Mount	8
Splice Trays	
a) Small Wall Mount	1 x 8 in.
b) Medium Wall Mount	2 x 8 in. or 2 x 12 in.
c) Large Wall Mount	4 x 8 in. or 4 x 12 in.

5.2.6.3 **Media Converter**

Media converters shall be installed for use in optical field-bus networks. They shall allow the conversion of electrical interfaces (RS-485 level) into optical interfaces and vice versa. The modules shall be integrated in existing field-bus networks with the known advantages of optical transmission technology. A complete field-bus network shall be set up with modules in a linear (bus), star or preferably ring topology as well as any combination of these topologies. To increase the reliability of the field-bus network in case of failure, redundant ring wiring topology shall be supported.

Technical Specifications

Number of Ports	Device/Network Dependent
Operating voltage	24 V DC safety extra low voltage
Current consumption	Max. 200 mA
Output voltage for bus termination	5 V DC+5/-10%,

RS-485 (D-sub jack, pin 6)	
Signaling Contact Function	floating contact, opens in case of error
Signaling Voltage	Max. 50 V DC/30 V AC safety extra low voltage
Signaling Current	max 1.0 A
Signal transmission rate	Network dependent
Transmission rate setting	Device/Network Dependent
Electrical channel type	RS-485
Electrical channel voltage	-7 V... +12 V
Optical channel wavelength	Device/Network Dependent
Maximum Distance Transmitted	Device/Network Dependent
Connector	BFOC/2.5
Safety	IEC 60950
Hazardous Locations	ANSI/ISA-12.12.01-2000 compliant (up to CLASS 1, DIVISION 2, GROUPS A, B, C AND D, T4)
Operating temp	-25 °C...+60 °C
Storage temp	-40 °C...+70 °C
Relative Humidity	<95% non-condensing
Protection class	IP 42
Enclosure material	stainless steel
Installation position	Vertical
Mounting	DIN Rail Mounted/Rack Mounted

5.2.6.4 **Jack Panel**

- Performance should meet EIA/TIA 568.
- Highly compact with 24 information outlets.
- 19" Rack mountable.
- Size of Jack Panel should be 1 U.

5.2.6.5 **UTP Cable (Ethernet Cable)**

- Should meet the EIA/TIA-568/569 Category 6.
- Should meet the category 6 standard.

- Must be in minimum 4 pair, unshielded twisted pair cable.
- Suitable for use in factory (noisy) environment.
- Suitable tested till 600Mhz

5.2.6.6 **UTP Patch Cords**

- Unshielded twisted pair 100ohms multi standard and highly flexible.
- Should meet EIA/TIA 568 Category6.
- RJ-45 connectors with Resistance of 20 mega ohms.
- RJ-45 connectors are three piece two layer design connectors.
- Size of patch cords should be 2 meters

5.2.6.7 **UTP to OFC Converter**

- Converters to be directly connect to the 10/100 Mbps L-2 Switch.
- L-2 side connection is RJ-45 port and OFC with SC Port.
- UTP to OFC converter should suitable for the 19" rack mounting.
- Input power supply 240 VAC, 50 Hz also vendor can suggest with 24 VDC supply.

5.2.6.8 **OFC Cable**

Fibre optic cable shall be Single Mode (9/125 μ M) armoured, having 8 cores. These cables shall be perfect immunity to noise. These cables shall be suitable to communicate between Field Interface and PLC terminals to meet the functional requirement.

The core in fibre-optic cable shall be made from a combination of highly purified silicon and germanium. The cladding shall be made by pure silicon. Surrounding the cladding is a buffer material which acts as a shock absorber to protect the core and cladding from the damage. The outer jacket shall protect against abrasion and environmental damage. The fiber optic cable shall be armored.

The manufacturer shall be identified throughout the length of the cable by manufacturer's name or trademark 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.

Fibre optic cable shall meet all the functional and technical requirements in this specification

Technical Specifications for Single Mode Fibre optic cable:

Fibre Size	9/125 micro meter
Maximum Length	5km
Fibre Material	Glass
Permissible Temperature	-20°C to 60°C

Permissible Humidity	75% on average
Outer Sheath	Poly Ethylene
Bend Radius (Long Term)	10D
Bend Radius (Short Term)	20D
Tensile Load	2500N
Operating Wavelength (nm)	1310/1550
Jacket Type	Loose tube
Max Attenuation (db/km)	0.35/0.25
Zero Dispersion Wavelength (nm)	1312±12
Cable Cut off Wavelength (nm)	≤1260
Polarized Mode Dispersion (PMD)	≤ 0.2
Mode Field Diameter (MFD)	9.2±0.4/10.4±0.6
Number of Fibers	8
Strength Member	Aramid yarn / Steel music wire
Armour	Steel
Buffer	Gel filled and PBT tube
Compliance standards	TIA/EIA-568-C.3 IEC 60793 IEC 60794
Colour Code Standard	TIA/EIA-598-B

5.2.6.9 **OFC Patch cord**

- Should meet EIA/TIA 568.
- Patch cord should suitable for single/multimode fiber application.
- Plastic molded plug or metallic body connectors.
- Fiber patch cord SC-SC type duplex.

5.2.6.10 **UTP Information Outlets**

- Information Outlets should be of dual points.
- Surface mount box should fit single or dual information outlets.
- Should meet EIA/TIA 568 Category 6.

- Should have insulation resistance of 500 M-ohms minimum and contact resistance of 20 M-ohms max.
- Information Outlets should have cable entry points on all 4 sides and one in the center.

5.2.7 Associated Control Devices/Sub-Systems

Associated control devices (like Mobile Harbour Crane, Barge Loaders/Unloaders, Weigh bridge, etc.) are mainly individual equipment level control devices. The Contractor shall be responsible for the interconnection of all such devices/sub-systems with the control system under this specification and their integration with the software supplied by the Contractor. Please note that the interconnections shall be such that the status of all devices/sub-systems/Master unit for Safety Switches (PCS, ZSS& BSS) shall be transmitted to the control network irrespective of whether a motor is in the “local” or “auto” mode. All third parties interface shall be hooked to Control Room in RS-485 Port /Optical Data highway link (as applicable) compatibility

5.2.7.1 *Belt Take Up Switches*

These switches shall be provided and installed so as to be actuated by an extreme movement of the conveyor belt take ups, should the belt tension not be adequate for any reason. Each switch shall be dust and vermin proof and shall have a degree of protection IP65. Each switch shall have 2 NO + 2 NC potential free contacts suitable for 10 Amp at 110V AC/240V AC and shall be wired to an internal terminal block.

These switches shall be mounted on take-up pulley frame and shall be wired by 5 core 2.5 mm² copper control cable up to the conveyor Junction Box at the respective transfer tower.

5.2.7.2 *Control Wiring Installation*

Control wiring shall be done by Flame Retardant Low Smoke (FRLS) insulated stranded copper conductor wires. Terminals emanating from various control devices of conveyors like pull cord, belt sway, belt speed, belt take up limit switches, Local Control Station etc. shall be brought to a junction box by PVC insulated, control cables.

One ‘NC’ contact of all switches shall be interconnected in series by 2.5 sq.mm copper cables and brought to the junction box mounted at an interval of 200 M i.e. at crossover points for long conveyors or at head/tail end of the conveyors.

Also one ‘NO’ contact of all switches shall be interconnected in parallel and brought to the above referred junction box.

Similarly, control terminals (intended for sequential interlocking and/or indication in Control Room) emanating from each of the other system such as winches, dust control, belt-weighers, metal detector, magnetic separators, hoist, level detectors/controllers etc. shall be brought up to their respective junction boxes located suitably and terminated therein.

It is to be noted that individual cores from each safety device mentioned above shall be connected in the junction box properly identified by interlocking ferrules and no looping is permitted in this junction box.

The cables shall be laid over ladder type/pre-fabricated GI cable trays, which shall be mounted on short posts all along the conveyor.

5.2.7.3 **Local Control Panel**

The local control panels shall be mounted adjacent to the equipment and exposed to normal ambient environment and shall have IP65 degree of protection.

This panel shall house the essential monitoring instruments. Alarm/annunciation system, command station like control switches, start/stop push buttons, indicating lamps, ammeters etc. required for start-up operation/maintenance of the equipment/sub-system/system locally.

All panels shall be of free standing welded construction and shall be robustly constructed of cold-rolled sheet steel of thickness not less than 2 mm.

All panels shall have (left off type) doors, capable of being opened through 180 deg. A pocket shall be provided on panel door for cable termination charts which are also in the Contractor's scope. All doors shall be supplied with built-in locking facility. All doors, removable covers and plates shall be gasketed all around with 4 mm neoprene gaskets. The enclosure shall be vermin-proof, dust-proof and weather-proof.

The interior of each panel shall be suitably illuminated through fluorescent lamps operated by a panel door-switch.

Panel heaters suitable for 240 V, single phase, AC shall be provided on each panel bottom to prevent moisture condensation. Heater should be designed to maintain panel temperature 5°C above the ambient. Suitable miniature circuit breaker and thermostat for the heater shall be provided.

All panels shall be supplied complete with foundation and removable lifting eye bolts along with the panel base-frame for foundation.

Wiring, fuses, switches and terminal boards shall be properly color coded, routed and neatly run in insulated cleats/trays if required in such a manner that wherever practical it can be checked against the wiring diagrams. Wire sizes and layout shall conform to the relevant standards and to Employer's approval.

AC and DC bus-wires shall be kept separate from all other wiring and DC wirings shall be segregated from all other circuits. Supply to various equipment shall be directly tapped, from a through bus-bar and looping for the same shall not be used.

All wires shall be properly numbered and identified with ferrules at both ends to Employer's approval. Incoming and outgoing wires shall be suitably segregated wherever possible as per **relevant IS**.

One piece moulded 1100V grade terminal blocks complete with insulated barriers terminal studs, washers, nuts and identification strips shall be used. Terminal blocks may be of clip-on or insertion type. Individual terminals shall be suitably insulated and spaced apart to enable access to the same and preferably of Elmex/Jyoti make. Terminal blocks shall be numbered for identification and grouped according to function. Minimum clearance between rows should be 100 mm. In case terminal blocks are mounted vertically suitable slanting shall be provided for ease of termination. At least, 20% spare terminals shall be provided in each row of terminals, after all cable cores, including spare cores have been terminated. For incoming AC and DC supplies, separate terminal blocks shall be provided. These terminals shall be suitably shrouded.

Panel internal wiring shall be done with 1100V grade PVC insulated copper wire of size not less than 2.5 sq. mm. Insulation of wiring shall be flame retardant type and shall not deteriorate at ambient temperatures.

All wires shall be suitably terminated with solder less crimping type tinned copper lugs which firmly grips the conductor and insulation.

Tapping/jointing of wires is not permitted and looping of wires shall be avoided to the maximum. In no case, the number of wires per terminal shall exceed 2. All accessories such as packing glands, crimping type tinned copper lugs, supporting clamps and brackets etc. shall be supplied by the Contractor.

Undrilled cable gland plates and cutout covers for cable and pipe entry shall be provided. Cable entries shall be suitably sealed with an approved non-inflammable seal material. Cable gland plates shall be at least 250 mm above floor/ground. Necessary number of cable glands shall be supplied fitted on this gland plate and the same shall be specified by the Employer during detail engineering stage.

Suitable isolating switches and fuses, preferably HRC cartridge type mounted on plug-in-type fuse bases (both made out of moulded insulating material) shall be provided for incoming power supplies to the panel. It should be possible to change fuses with the circuit alive

Each electrical drive motor shall have two modes of operation; 'Local' and 'Auto', manually selectable by a three position selector switch "Local-Off-Auto' Each heavy duty selector switch shall be located close to and within view of each drive motor (except in the case of the multi motor for which see below). Start-Stop, Forward-Reverse push button shall be provided next to or integrated with each L-O-A as required. It shall be feasible to lock the L-O-A switch in the 'Off' position, so that the locking key can be retained by maintenance staff for working on the driven equipment in safety.

In the cases of conveyors with multiple motor drives, a single L-O-A switch shall be provided per conveyor near only one of the drive motors. However:

- A maintained contact emergency stop switch shall be provided near the other drive motor(s).

The emergency stop switch shall have at least three sets of NC/NO potential free contacts rated 10amp at 110V AC in an IP-65 protected enclosure. A red mushroom type of

actuator shall be used. There shall be two cable entries suitable for double compression glands (or better) for up to 10 x 2.5 sq mm copper conductor armored control cable. Earthing terminals shall be provided on the enclosure.

5.2.7.4 **Field Hooters**

These shall give an audible alarm before a conveyor, or movable head pulley commences to move; both in the auto and local mode. The hooters shall be capable of sounding continuously for a pre-settable interval. The alarm/ siren shall be motor driven. It shall work on 240V AC, 1 phase.

More than one will be need for long conveyors. Adequate numbers/conveyor shall be provided to ensure their audibility along-side the full conveyor length. The Contractor shall indicate the numbers required, the dB ratings and the spacing to suit the dB ratings proposed in his bid. The housing of the hooters shall be IP-65 protected and shall have the appropriate terminals, cable connectors and grounding lugs.

5.2.7.5 **Control devices**

“Control devices” generally consist of sub-systems complete with:

- Individual control panels (usually at or near the sub-system),
- Internal control logic,
- Internally wired components

These units shall be integrated with the Control System and shall be connected and interfaced to the System by the Contractor. Physical installation of such devices or sub-systems, their internal electrical connections. However the interconnecting cables between the control panels of such sub-systems and the components of the control system supplied under this specification shall be the Contractor’s responsibility. The Contractor shall coordinate with the suppliers of such control devices/sub-systems to ensure that the functional requirements are fully satisfied. In the case of such sub-systems as for rail and truck loading, the Contractor shall ensure smooth transmission of data to and from the workstations PLC or Controller / PC’s supplied. These shall be interface / interlocked / integrated with the control system through Modbus - RTU/hardwired Mode, etc.

5.2.8 **Cables and Wires**

5.2.8.1 **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°C.

5.2.8.2 **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 conform to relevant IS. The stranded conductor shall be clean and uniform in size and shape and its surface shall be free from sharp edges.

5.2.8.3 **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.

5.2.8.4 **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.

5.2.8.5 **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.

5.2.8.6 **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.

5.2.8.7 **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 be light grey.

5.2.8.8 **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.

5.2.8.9 **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.

5.2.8.10 **Junction Boxes**

All the JB's (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 960°C 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 JB's shall be dust and vermin proof and shall have IP-66/67 degree of protection as per relevant code. The JB's 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 channel in the JB's. 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 JB's.

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.

5.2.8.11 **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.

5.2.9 CCTV Surveillance System

5.2.9.1 *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 No. I-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.

5.2.9.2 **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 XGA 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, 21 inch XGA 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	50°C
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	21 inch Diagonal
Operating Condition	Temperature : 0°C-40°C Humidity : 20% -80%
Contrast Ratio	30000:1
Viewing Angle	140°H, 140°V
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	360° continuous
Tilt travel	0 - 90° 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 ° to 60 ° 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°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.

5.2.10 3D Level Scanners

3D Level Scanners are proposed to be installed in each of the Fly ash Silos. For power supply to the scanners and data communication from scanners to the PLC, local control panel (one number for 5/6 scanners as per the attached Control architecture) is proposed to be installed below the Silos. Multicore cables shall carry data from these Local panels to the PLC.

5.2.11 Recommended Equipment/Component Vendor List

Make of the equipment under supply items shall be selected as per the following list. Employer, however, reserves, the right to select the particular make during detailed engineering for uniform design and inventory. Approval of makes for items not mentioned in this list shall be obtained from Employer/Employer's Representative Engineer before initiating procurement action.

ITEM	RECOMMENDED VENDORS
Servers	Hewlett Packard / IBM / Dell
LED (64")	Samsung / Sharp / Panasonic / LG / Sony
Workstation Terminals	Hewlett Packard / Dell / IBM
LED Monitors (21")	Sony/Samsung / LG / AOC/ Hewlett Packard
Network Printers	Hewlett Packard / Canon / Epson / Samsung / Lexmark
UPS	APC / Eaton /Toshiba/Best Power /Emerson Hi-Rel
PLC	Siemens / Allen Bradley /ABB /Schneider/ Honeywell / Yokogawa / GE
CCTV	Honeywell/ Bosch
Network Components And Accessories	
Jack Panel	Molex / Signamax /Brand-Rex

ITEM	RECOMMENDED VENDORS
Cat5e Cable (UTP)	Amp / D-Link / ADC
Cat6 Cable (UTP)	Amp / D-Link / ADC
UTP To OFC Converter	Moxa / D-Link
LIU (Light Guide Interconnect Unit)	D-Link / Moxa
Ethernet Switches	D-Link / Cisco / Moxa / Siemens / Nortel
UTP Patch Cords	AMP / ADC / D-Link
UTP Information Outlet	D-Link / Molex / ADC
Instrument Cable	Cords Cables / KEI / Associated Cables / Universal Cables
Panel/Cabinets	Rittal / ICA / Pyrotech
JB/Cable Gland/Plugs	Hensel / Rittal / Emitter
OFC Cable	Molex / D-Link / Finolex / RPG Cables Ltd. / Sterlite Industries
Other Equipment	
3D Level Scanners	EIP Technologies Pvt. Ltd. /Emerson
RTD	Pyroelectric Equipment/General Instruments / A.N. Instruments
Relays	Omron / OEN / Jyoti

NOTE: Makes like 'or equivalent' are not acceptable. Other makes proposed shall be submitted to the Employer with back-up documents and PTR (Proven Track Record) for prior approval.

6 DRY FLY ASH STORAGE SILOS

8 Nos. storage silos each to store 1200MT of dry fly ash with adequate margins shall be provided. Storage silos shall be of conical bottom type with the provision of air slides/fluidising pads at the bottom. Storage silos shall be provided to store precipitator fly ash with adequate air space. This silo shall be used to collect dry fly ash from the bulk carrier and further loaded to barges by conveyor system.

The silos shall be Steel constructed, water tight and relatively air tight with minimum 12 mm thick MS plate conforming to relevant Indian Standards and Specifications. The silo shall be completed in all aspect including stairs case, civil foundations, lugs, supporting structures etc. and designed for minimum 30 year life.

Design shall be as per IS 9178 (Part 1 to Part 3).

All silo components shall have Zinc coating. ISO 12944 shall be followed for carrying out the painting job for taking care of Cleaning, Protective Coating and Painting designed for service life of 15 yrs.

The Silos are to be top loading and bottom discharge. The intake capacity of each Silo shall be minimum 40 Tons per Hour (TPH) and discharge capacity is about 200 Tons Per Hour (TPH).

Each dry fly ash storage silo shall be provided with following arrangement for loading and unloading the fly ash.

1. There shall be pneumatic unloading fly ash facility consist of electrically operated compressor, pneumatic pipe upto silo top with all necessary fitting.
2. Dust Extraction System shall be fitted on each silo to collect dust from the silo. The system shall be complete in all respect, the system shall be capable to collect the dust from bottom discharge conveyor also.
3. Bag filters shall be provided on the storage silos for cleaning the aeration and displaced air before venting out.
4. The dust loading from the outlet of the bag filters shall not exceed 50 mg/Nm³ under any operating condition with 10 per cent bags plugged.
5. The provision of a proven dust collection system in the storage silos that separate out bulk of the ash from the conveying air shall be provided before the air is extracted through the bag filters.
6. Each storage silo shall be provided with a separate and dedicated floor aeration system. This aeration should only be required during silo unloading and should not be in operation during storage periods.
7. Chute along with rotary feeder for unloading the dry fly ash into corresponding belt conveyor
8. The pressure/vacuum relief valves in the storage silos shall be provided.

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9. Flow controls for the ash shall be adjusted with the help of flap gate (electric operated).

6.1 COMPONENTS OF SILO:

1. Manhole for men for maintenance to be provided at top of silo.
2. 3D level scanner shall be provided at each silo top to monitor the level of ash in silos.
3. Silo roof to be equipped with peripheral walkway with railing at eave height and middle of the roof.
4. Roof step ladder with railing to be provided and it should also have access with overhead walkway.

6.2 INSTRUMENTS

Each silo shall be provided with following instruments as a minimum:

- | | | | |
|----|---|---|-------|
| a) | Silo ash level switches (High and Low) | : | 1 No. |
| b) | Differential pressure gauge across the bag filter | : | 1 No. |
| c) | Differential pressure switch across the bag filter | : | 1 No. |
| d) | Pressure gauge at the inlet of the bag filter | : | 1 No. |
| e) | Differential pressure gauge across the vent filter | : | 1 No. |
| f) | Differential pressure switch across the vent filter | : | 1 No. |
| g) | Pressure gauge at the inlet of the vent filter. | : | 1 No. |

7 ASH HANDLING FACILITY

7.1 GENERAL

- A. Requirement of fly ash handling facility at Haldia terminal is specified here for an ash Despatch from berth number 1 & 2. The scope of work includes design, manufacture, procurement, supply, transportation to site, installation, commissioning, warranty and guarantee of the specified equipment / system.
- B. The specifications, attachments and references shall apply to the equipment and materials and the Bidder shall confirm to all the requirements of this specification which shall be a part of this document.
- C. The specification outlines the conditions and functional requirements for the design, manufacture / fabrication / constructions, delivery at site, erection, testing, commissioning and handing over of the facility covering mechanical, structural, Civil and electrical / control works as applicable including furnishing of all labour, material and services required for the fly ash handling system.
- D. The specifications and attached drawings outline the functions and the operating characteristics, which the systems must fulfil. The Bidder may quote for an alternative system meeting the functional requirement and the same shall be brought out clearly specifying alternative to the equipment / system. In any case, the performance to the stipulated levels of the complete installation shall be guaranteed in every detail by the successful Bidder. Overall dimensions (Boundary dimensions) and functional requirements, as shown on drawings and / or specified shall be strictly adhered to.
- E. Notwithstanding the details furnished in this document, it shall be the responsibility of the contractor to complete the work in all respects, commission, complete the final trials and performance tests to the satisfaction of the Employer and hand over the equipment in operating condition to the Employer.
- F. The facility shall include the items listed in the sub-paragraphs in the subsequent sections and as shown in the drawings enclosed with this specification. These items shall be complete in all respects to meet the integrated functional requirements specified herein including the provision of future development.

7.2 WORK INCLUDED

- i. The Scope of Work includes design, engineering, manufacture, supply delivery to site, storage at site, erection, painting, testing, commissioning and handing over of Belt conveyor BC-1, BC-2, BC-3, BC-4, BC-5, BC-6, Pipe Conveyor PC-1/PC-2, Transfer Towers & mobile barge loader as specified herein, required for loading ash into a Barge. Work includes all Mechanical, Structural, associated Electrical, control and instrumentation work.

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- ii. Belt & Pipe Conveyors shall include but not limited to idler rolls, pulleys, drive units with motors, gearbox, couplings, belting, head frame, tail frame, drive base frame, take-up units, skirt boards, scrapers, transfer chutes, stringer frames, short supports, deck plates and shall be complete in all respects.
- iii. Maintenance Cranes / Hoists at the head end, drive unit and at take-up as required for maintenance.
- iv. Dust Extraction System for the facility covering all transfer point in the transfer towers, discharge point at the ash silo end and for the mobile barge loader end.
- v. Structural Work – Conveyor galleries, trestles and Transfer Towers complete with cladding, foundations for the trestles / towers are included in the scope.
- vi. Hardware including all anchor bolts/ fixing bolts for equipment/brackets/structure, etc., including all types inserts required for entire equipment/ system.
- vii. Erection, Painting, Testing and Commissioning including Performance Test and handing over of the above system.

7.3 LIST OF DRAWINGS

The drawings listed below form part of the specification. The arrangement shown in the drawings be adhered as far as possible, however, the Bidder may deviate if it can be demonstrated that more economical arrangement(s) will result with no sacrifice of performance, longevity and maintenance.

S. No.	Drawing No.	Title
01	I-525/HT/1015	General Arrangement of Fly Ash Silo and Profile of Pipe Conveyor – PC-1/PC-2
02	I-525/HT/1016	Cross-section of fixed type barge loader

7.4 GENERAL DESIGN REQUIREMENT

7.4.1 General

The ash handling system shall be designed and built for despatch of fly ash by barge through fixed barge loader at Haldia terminal.

7.4.2 Brief Description of the System

2 rows of ash silos consisting total 8 numbers of ash silo are proposed to store the fly ash collected from the bulk carrier through pneumatic arrangement. Each row have total 4 numbers of silos. Total 2 numbers of receiving conveyor BC-3/4 located below silos with proper dust tight arrangement receive ash from any of two silos. Discharge rate of each silo will be 200 TPH hence the rated capacity of the belt conveyor will be of 400 TPH. Each

receiving conveyor has a provision to feed either pipe conveyor PC-1 or PC-2 at transfer tower TT- 3 & 4. Pipe conveyor handle ash and dispatch to dispatch conveyor BC-5 & 6 which further transfer ash onto mobile barge loader at tower T-1 and T-2. Fixed Barge loader dispatch ash by telescopic dust proof spout to barge refer Layout drawing number **I-525/HT/1001**

7.4.3 Material Characteristics

Typical characteristics of the material to be handled are given below. Depending upon source, the characteristics may vary.

S. No.	Description	Fly Ash
1	Bulk Density	0.7 T/m ³
2	Angle of Repose	42°
3	Angle of Surcharge on the Conveyor	30°
4	Abrasiveness	Very abrasive
5	Size	1 to 100 micro meter

7.4.4 Duty

The system offered shall be designed and constructed for continuous duty at rated capacities and under climatic and ambient conditions outlined in this specification.

7.4.5 Standardization

The assemblies/components shall be standardized to the maximum extent possible to reduce the spare parts inventory to the minimum.

7.5 DESIGN STANDARDS

The materials and components shall be designed and manufactured in accordance with the requirements of Indian Standards rules and regulations as far as possible.

Unless mentioned otherwise latest edition of all applicable Indian Codes, Regulations, and Standards shall govern even when the requirement of the “specification” are less stringent than the codes, regulations and standards.

Where a suitable Indian Standard Code/Regulation mentioned herein is lacking, the equivalent including the material shall be designed and manufactured in accordance with International Standard.

The power of the Belt & pipe conveyor shall be based considering artificial co-efficient of composite friction factor not less than 0.022.

7.5.1 Wind Load:

Wind pressure and loads (As per IS:875, Part No-3) shall be calculated using the following values:-

- Operating Wind 24 m/sec at all levels
- Cyclone Wind Velocity (basic) Wind speed 55 m/sec. These wind pressure and loads shall be used in conjunction with shape and shielding factors AS PER IS:875.

Design Temperature: 45 °C

7.5.2 Material: Codes and Standards

Unless otherwise specified, materials shall be of the following specifications or better:

A.	Cast iron	IS 210, Grade 20 / BS-3468 Excepting counter weight.
B	Cast steel for gears	IS 2644, Grade 1.
	Cast steel for pressure pin assembly	IS 2644, Grade 4 / BS-1504.
	Cast steel for general use	IS 1030-1978/2707-1973 Grade 23 – 45 /BS-3100
C	Wrought steel	IS 1570, C40, Cold Drawn specified / BS-970 (Part 1 to 6).
D	Forged steel	IS 1875 / BS-970
E	Structural steel	IS 2062 (Fusion welding quality)
F	High tensile steel	IS 961 (Fusion welding quality)
G	Case hardened steel	IS 1570. C-14 / BS-970, EN-32 & 32C
H	Ductile iron	IS 1865, Grade 1 / BS-2789
I	Tubes & fittings	IS 1239, IS 1161 / BS-1387
J	Tubes for Idlers	IS 9295 / BS-1775
K	Bronze	
	Gunmetal	IS 306, G-2 / BS-1400
	Phosphor bronze	IS 28 / BS-1224
	Aluminium bronze	IS 305, Grade 2

	Stainless Steel	IS 6911
L	Manganese Steel Liners	IS:276

7.5.3 Components: Codes and Standards

Generally, items required to be manufactured / fabricated shall conform to IS Code of Practice unless otherwise specified. Following is the list of items which shall be included, but not be limited for such considerations.

Other standards and codes, which will ensure an equal or higher quality product, may also be accepted on written approval of Employer.

Component	Min. Specification
Wire Rope	IS 2266
Drum	IS 3177
Wheels	IS 3177, IS 1136
Sheaves	IS 3177
Screw Threads & Gearing Profiles	ISO/Metric
Steel Rails	IS 3443
Screw Threads & Gearing Profiles	ISO/Metric

Design shall be suitable for procurement of such components as above as spare from indigenous sources in future.

7.6 DESIGN REQUIREMENTS

7.6.1 Galleries

- a) Galleries shall be open type for receiving conveyor BC-3/4 and for pipe conveyor PC-1/2. However for Belt conveyor BC-5/6 and the receiving end of pipe conveyor galleries are close as specified in the enclosed drawings. The galleries along with supports shall be made of structural steel. Any other type of construction like pre-stressed / reinforced concrete for the galleries may be quoted as an alternative.

In conveyor galleries the walkway with a minimum clear width of 1.0 m on each side shall be provided. Where more than one conveyor is on the gallery in between the conveyors will have clear 1.0 metre walkway while on extreme side it will be 750 mm wide.

All open sides of walkway shall have hand rails.

Minimum clear height above walkway shall be 2.5m unless mentioned otherwise in the drawings.

- b) The minimum clearance between the ground and the bottom of the gallery shall be minimum 6.5m at all road crossing respectively unless mentioned otherwise in the drawings.
- c) In galleries the floor shall be made of gratings, sand blasted and painted. When over passing roads, buildings or work areas chequered plates (sand blasted and painted) shall be provided in the full width.
- d) The floor edges shall be provided with kick toe plates. Inclined/declined galleries having more than 15 deg slope shall have stepped walkways. Provision shall be made to run the cables along the conveyor galleries on cable trays.
- e) At all the points where equipment parts heavier than 200 Kg have to be handled; either cranes or monorail hoists of suitable capacity shall be provided unless specified otherwise.

In location where no hoist can be provided a lifting beam shall be sized for winch operation.

- f) Provision shall be made in all gallery to facilitate reeving of conveyor belts.
- g) Long elevated galleries wherever applicable shall have strong points (towers) located after every 3 or 4 spans or as approved by the Employer.
- h) Foundations for gallery supporting trestles and towers are excluded in the Bidder's scope. However, the uniform spacing of pedestals shall be adopted to as far as possible.
- i) Escape route(s) and cross over shall be provided at spacing not exceeding 200 meters. Advantage may be taken of the tower locations to provide the stairways.

7.6.2 Conveyor Framed Structure

- a) The belt conveyor structure shall consist of independent prefabricated tables. The length shall be 6.0 m about for the standard table for supporting idlers but when required special tables shall be provided. All standard tables shall be supported generally as shown in the enclosed drawing i.e. conveyor idlers shall not be directly mounted on the galleries.
- b) The Framed Structure for the piped portion shall be fabricated out of rolled steel sections and plate to support rollers, piped belt etc. The spacing of framed structure shall not exceed 2.0 metres
- c) The channel size for stringers shall be ensured that there are no vibrations in the structure during the operation.

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- d) Deck plates shall be provided under the loading points; extending 1.0 m before and after the end of the loading skirts and above the V plows protecting the return pulleys. For the reclaiming conveyors in Storage shed the deck plate shall be provided for the entire travel length of the scraper-reclaimer. Similarly for the berth conveyor(s) deck plate shall be provided throughout the travel length of the Unloading cranes.
- e) In no case shall minimum clearance between the floor and the lower most point of the return belt shall be less than 500 mm. In case of ground conveyor the conveyor vertical supports will be fixed on a minimum 300 mm high concrete pedestal.
- f) All anchor bolts required for fixing the conveyor frames are included in the scope of supply.

7.6.3 Take-up Units

7.6.3.1 *General*

- a) The take-up travel shall be 1.5% (Minimum) of the centre to centre distance for EP belting.
- b) Where space allows, an additional length of belt of up to two splices shall be added to the normal take-up travel to make provision for live storage of belting.
- c) Counter weights shall be precast concrete or metal. In all cases space shall be provided for an addition of 25% of the counter weight. Provision shall be made for dismantling the counter weight or relieving the tension in the belt.

7.6.3.2 *Vertical Take-up Units*

- a) Vertical gravity take-up units shall have a 0.75 m sand box provided under the counter weight at ground/floor level. The area below the counter weight shall be guarded to a height of 2.5m above any access level. Suitable guides shall be provided for take-up travel. The design of the vertical members (guides for take-up travel) shall be such that they can be removed between access platforms on the gravity take-up units.
- b) The design of the counter weight assembly shall have a self-cleaning top.
- c) Access platforms shall be located at every 3 meters through the travel of the gravity take-up units and consist of platforms on 3 sides (including access to both bend pulley bearings) and of minimum width of 1.0 m. Access between these levels shall be by vertical ladder.
- d) A lifting beam of capacity about twice the total weight of the gravity take-up unit shall be provided, located on the centre line of the take-up unit.

- e) The bend pulleys shall be located such that they can be easily removed onto the side walkways. Each bend pulley assembly shall be designed to 75 per cent of the total weight of the counter weight assembly.

7.6.3.3 **Horizontal Take-up Units**

- a) The pulley slide frame shall be self-cleaning type. The pulley slide carriage shall be equipped with Vee type wheels attached to shaft running on guide rails. Suitable guide wheels shall also be provided to arrest uplift of carriage. Buffers shall be provided at both ends of take-up travel to take the impact arising out of rope / belt snap.
- b) Counter weight tower of horizontal take-up units shall be similar to that of vertical take-up units.
- c) One end of the counter weight rope shall be reeved on a hand operated winch mounted at a suitable location for releasing the counter weight for belt repairs and other maintenance works. The winch shall be self-locking type.

7.6.4 **Towers/Transfer Towers and Drive Houses**

- a) Size of transfer towers shall be indicated by the Bidder and shall be subject to approval. Transfer Towers, towers and drive houses shall be sized for future requirements as required.
- b) The sizes / profiles shown in the enclosed drawings are indicative only and sizes of these transfer towers / drive houses may be suitably altered, if required, by the Contractor to suit the equipment and arrangement proposed by him.
- c) Working floors and equipment floors shall be enclosed with suitable claddings to ensure full protection from rain and strong wind. Also claddings shall be designed to provide sufficient day lighting and ventilation.
- d) There shall be a minimum 1.0 m wide clear walkway around drive equipment. Floor arrangement shall be such that free movement for maintenance and operation purposes is provided. Generally galvanized gratings (Say 25 mm x 25 mm, unless agreed otherwise) shall be used for walkway.
- e) Heavy concrete masses shall be provided as mounting platforms for drive units unless specifically exempted by the client.
- f) Suitable hatch openings shall be provided in each floor for lowering/hoisting equipment or part of the equipment. In exceptional cases handling through side opening may be permitted. All such side openings shall be provided with hinged doors and hand rails.
- g) All floor openings shall be protected by handrails and kick (toe) plates.

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- h) Monorails shall be provided at all towers/ transfer towers/drives houses for maintenance of equipment provided where equipment parts heavier than 200 kg have to be handled. Monorails shall be equipped with electric hoists having pendant control. Hoist speed of electrical hoists shall not be less than 4 m/min. Ladder with an elevated platform shall be provided for maintenance of each hoist.
- i) For handling equipment parts less than 200 kg, lifting beams shall be provided which shall be sized for winch operation.
- j) Monorails shall be able to reach vertically as far as possible above the components which require handling during maintenance.
- k) As far as practical all lifting tackles shall be standardised.
- l) All floors shall be connected from ground level through stairs having minimum width of 0.8 m. All staircases shall be provided with handrails on both sides. Circulation areas on floors shall be provided with grating. Minimum clear height between two floors shall be 2.5 m.
- m) Suitable lighting system shall be designed and installed at each floor.
- n) Arrangement shall be made in each building for collection of wash water at the ground floor for drainage.

7.6.5 Idler Assembly

7.6.5.1 *For Open Portion of the Pipe Conveyor & Belt Conveyor*

- a. Carrying idlers shall have troughing upto 35 deg.
- b. All impact idlers shall be 3 roll with heavy duty bearings and a cover of impact absorbing rubber. Distance between impact idlers shall be about 450 mm with a minimum of six sets at any feed point The quantity of impact idlers shall be adequate to cover the entire loading zone.
- c. Idler rolls shall be made of ERW tube and measured wall thickness on the finished idlers shall be minimum 4.85 mm for both carrying and return side. Mechanical properties of the idler tubes shall be equivalent or better than YSt 210 grade as per IS: 9295.
- d. Idlers shall be easily removable type.
- e. Transition idlers shall be used at the head end and at tail end of the conveyor. Transition length shall be as recommended by belt manufacturer.
- f. The belt working line shall be considered at the underside of the conveyor belt. The top of pulley at the head end and at tail end shall be lifted.

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- g. All idler bearings shall be 'Sealed & lubricated for life' type. Deep groove ball bearings shall be used. The bearings shall be chosen for minimum L-10 life equal to 60,000 hours. All bearings shall be protected by double labyrinth seals (taconite type). The bearing seals shall have minimum resistance to rotation. Lubrication fittings for the labyrinth seals shall be provided in the case of impact idlers for the purpose of occasional greasing to keep the dirt and dust out. Felt seals will not be accepted.
- h. Bracket for idlers for the open portion of the conveyor shall be of fabricated steel and shall have ample strength and rigidity to operate under all loading conditions without vibration or chatter. Use of cast iron support brackets is not acceptable.
- i. All Idler Rolls shall be free in rotation. Idler rolls shall have face run out (T.I.R) not greater than 1.0 mm on diameter.
- j. Idler Roll shall be tested for Dust proof & Water proof test as per QAP approved by Employer.
- k. Make of all bearings shall be SKF/FAG.
- l. The internal rolling friction co-efficient of the idler unit shall not exceed 20% to 30% of the composite friction factor of the Conveyor System taken as 0.022. Weight of revolving parts of the idlers shall be kept to minimum.

7.6.5.2 *For The Piped Portion of the Pipe Conveyor*

- a) The diameter of the idler tubes in the pipe forming zone shall not be less than 152.4mm.
- b) Spacing of idlers for the piped portion of the conveyor shall not exceed 2.0 m.
- c) At every section of each pipe six idlers shall be used for the carrying belt and six idlers for the return belt. The Bidder may quote alternate design of proven type.

7.6.6 Pulleys

- a) Pulleys shall be made of welded steel and stress relieved (In furnace with auto generated time & temperature curve from the furnace) before machining.
- b) All hubs and shafts shall be of forged steel. Hubs and end discs shall be accurately machined for concentricity.
- c) All pulleys shall be straight faced and pulley faces shall be lagged with hot vulcanized rubber lagging as mentioned below:
 - i. All drive pulleys shall have 20 mm thick herring bone/ diamond grooved lagging. The herringbone grooving shall be at 120o, 6 mm wide x 6 mm deep spaced at 30

mm centres around the circumference. The apex of the herringbone grooving should be in the direction of the belt travel. The rubber hardness shall be IRHD 60.

- ii. All non-drive pulleys shall have plain lagging of minimum 12 mm thick. The hardness of rubber shall be IRHD 60 for drive and discharge pulleys and IRHD 55 for all other pulleys.
- d) The use of approved type of clamping hubs (Imported 'Ring Feder' type of 'RING FEDER - Germany' make) allowing easy removal of shaft from the pulley assembly is required for all pulleys.
- e) Pulley assemblies shall be statically balanced and run concentric when mounted on shaft. Balancing weight shall not exceed 0.25 percent of the pulley weight, preferably.
- f) Pulley shall have face run out not greater than 1.5 mm on diameter on lagging.
- g) The pulley face width shall be min. 200 mm more than the belt width. The tolerance of pulley along the face width shall be + 3 mm on the nominal width.
- h) All pulleys shall be shop assembled with shaft, bearings, Plummer blocks etc. and shipped as complete assemblies.
- j) One longitudinal weld on pulley shell per pulley shall be permitted and the weld shall be ultrasonically tested.
- k) All pulley shaft shall be EN-8 or equivalent. Bidder may quote shaft with better material as an alternative.
- l) Shafts shall not protrude from pillow blocks with closed ends.
- m) Plummer blocks shall be 4 bolt centre split type, cast steel construction equipped with double row self-aligning spherical roller bearings with labyrinth seals and grease nipples suitable for use in saline atmospheric condition. The spherical roller bearings shall have two rows robust window type cages of pressed steel or brass with taper bore and adapter sleeve.
- n) Bearing shall be Spherical Roller bearing of SKF/FAG make having metal cage.
- o) All pulleys bearings will have a minimum life of 50000 hours.
- p) In case of shaft design based on strength, the combined shock and endurance factor for bending and torsion i.e., K_m and K_t shall be 1.5 and 1 respectively. All conveyor pulley shaft shall be checked for deflection i.e., slope of the shaft at two pulley disc shall not exceed $0^\circ 8$ minute.
- q) Maximum permissible stress for shaft design:

Shear stress : 600 Kg/cm²

Bending stress : 840 Kg/cm²

Bending stress for plates : 948 Kg/cm²

For Key Way reduce above values by 25%.

- r) All plummer blocks shall be supplied with machined base plates and locking screws. The base plates shall be minimum 16 mm thick with M16/M24 locking screws two number each side of each plummer block.
- s) Temperature detectors shall be provided on all pulleys bearing housing size more than 100 mm to indicate / stop in case of overheating.

7.6.7 Belting

- a) Belting for conveyors shall be EP / steel cord type and suitable for heavy duty application. It shall be able to withstand the tensions and support the load.
- b) The rated maximum allowable working tension shall exceed the calculated maximum running tension by at least 15%. Ratio of breaking strength to working tension shall be 9 for EP belting and 7 for steel cord belting.
- c) Cord/each fabric ply for all belting shall be rubber impregnated and provided with skim coat. Each ply shall and shall be adhesion tested.
- d) The belt covers shall be made of synthetic rubber. The belt covers shall be resistant to moisture, properly vulcanised and finished.
- e) Cover rubber thickness of EP Belt shall be minimum 6 mm and 3 mm for top and bottom respectively. For Steel cord belt the top and bottom cover thickness shall be minimum 8 mm and 6 mm. Minimum rubber cover grade shall be M24.

Bidder may quote as an alternative with different cover thickness as specified above meeting the requirement.

- f) The rubber used shall be of a quality which has a tensile strength of not less than 2.5 kg/mm² and an ultimate elongation of not less than 450%. All belting shall be pre-stretched.
- g) Belts shall not blister or separate in the plies or at the seams or stretch more than 1.5% and 0.5% in the case of synthetic and steel cord belts respectively belts of their original length within one year of installation and normal operation. Belt construction shall be such that in case of edge damage, ply separation and ingress of moisture shall not take place.
- h) Belts shall have hot vulcanized joints after erection. Vulcanizing shall be done on single setting.

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- i) Vulcanising chemicals, splicing tools and equipment shall form part of the belting supply.
- j) A length allowance for field joints and also for test samples shall be added to all belt lengths.
- k) Belting shall conform to latest revision of IS:1891 (Part-I), IS:11592 and other relevant Indian Standards.
- n) Tolerance on belt dimensions shall be as follows:
 - i) Width (mm) : +3 / -0
 - ii) Length : +2% / -0%
 - iii) Carcass Thickness (mm) : +0.5 / -0.0
 - iv) Composite belt thickness (mm) : +0.5 / -0.0
- o) Mechanical / optical probe shall be provided at the loading point of the conveyor provided with steel cord belt to detect ripping of the belt and stop the conveyor. Necessary interlocks with the drive of the respective conveyor are included in the scope of this contract.

7.6.8 Chutes and spouts

- a) The chutes shall be of Mild steel plates with welded steel fabricated section assembled by bolted joints. Minimum plate thickness of chutes shall be 8 mm. Surface of chutes shall be lined with minimum 3 mm thick abrasion resistant SS liner. The liners shall be removable type.
- b) The supports must be designed to withstand the weight of a plugged chute.
- c) Each section of the chute to have its own inspection door. It is mandatory to have the doors located and designed to allow the opening of the door during operation without spillage or danger to personnel. Doors shall be hinged and shall be dust tight when closed. The minimum size of one door opening shall be 500 mm.
- d) The chute and spout opening cross section to be adequate for the flow of materials. The minimum valley angle to ensure material flow to be 60 deg.
- e) All chutes shall be provided with plugging switches connected to the conveyor interlocking system. Switch protection and maintenance accessibility to be ensured.
- f) The discharge chute of a conveyor to extend backward to contain both belt scrapers and snub pulley if used, to collect the dribble released by the snub pulley, return belt if any.

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- j) Design and construction to be such that one side of any chute can be easily removed for cleaning purposes without dismantling any other member/equipment. The length of the removable side plate of chute / spout to be suitably sized for easy handling.
- k) Configuration of chute shall ensure smooth natural flow, central loading and material drop at transfer points shall be kept as minimum as possible.

7.6.9 Skirt Boards

- (a) The loading point on the conveyor portion to be equipped with skirt boards.
- (b) Distance between skirt-boards to be 2/3 of belt width.
- (c) Length of skirt-boards to be extended minimum 4 m after the end of the loading area. Skirt-boards to be flared towards the direction of belt travel for guiding the conveyed material and shall terminate above an idler.
- (d) It is desirable that the skirts/guide plates are independent of the chutes, being supported on the conveyor stringers.
- (e) The lower edge of the skirt-boards to have a minimum 40 mm clearance between the metal part of the skirt and the belt surface.
- (f) The gap between the skirt and the belt to be closed or controlled by exterior rubber strips of 50-60 durometer hardness. The rubber strip to be minimum 175 mm deep and minimum 20 mm thick. The rubber strips to be held in position by steel clamps. The rubber strips to be adjustable in height for minimum 100 mm.
- (g) Distance between steel clamps not to exceed 400 mm. The depth of the skirt board shall be 750 mm or to suit the requirement of dust suppression system whichever is more. Continuous covers with dust hood to be provided to reduce dust emission. Rubber curtain to be provided at the discharge ends of covered skirt-boards.
- (h) Skirt-boards to be provided with replaceable liner wherever material is likely to come in contact with chute. Lining material to be manganese steel (IS:276), minimum 16 mm thick with work hardening property.
- (i) The fastening arrangement of liners shall ensure that the liners are easily removable.
- (j) The gap between the liner plates shall be minimum and shall not exceed 10 mm.
- (k) Skirt Boards shall have adequate height and length for installation of water spray nozzle banks, where applicable.

7.6.10 Drive Unit

7.6.10.1 General

- a) The type and horse power rating of drive units for all the equipment shall conform to the load and duty requirements.
- b) Belt conveyor drives shall be designed for wet condition between belt and drive pulley.
- c) The composite friction factor (artificial friction coefficient) of the horizontal and inclined conveyor system shall be considered as 0.022.

7.6.10.2 Couplings

The type of high speed coupling between motor and gearbox shall be as follows:

(a)	For motor rating below 30 kW	Resilient type flexible coupling
(b)	For motors of 30 kW and above but less than 200 kW	Traction type fluid coupling wherever VFD is not considered.
(c)	For motors of 200 kW and above	Actuator operated scoop type fluid coupling wherever VFD is not considered.

For the scoop type fluid coupling, fan-cooling arrangement shall be provided. Geared couplings have been considered as low speed couplings for all the conveyors.

The service factor for selection of fluid coupling and flexible couplings shall be minimum 1 and 2 on the motor rating.

i. Fluid Coupling (High Speed Coupling):

Fluid couplings shall be used at the input side of gear boxes for the conveyors having motor ratings 30 KW and above wherever VFD is not considered.

Fluid couplings shall be suitable for providing controlled starting for conveyor driven by direct online squirrel cage induction motor. Starting torque applied to conveyor shall at no time exceed 140% of the torque corresponding to the full load belt kW. Actuator operated scoop type fluid coupling, shall be equipped with adjustable controlled torque transmission and remote/auto device. It shall have the facility to de-clutch the driven machine keeping the motor running. Casing material shall be suitably selected considering the chemical properties of material that is being handled in the belt conveyor.

Primary Speed - Stall Torque Curve of Fluid Coupling shall be such that secondary side of fluid coupling can start rotating only when motor speed reaches minimum 85% of rated speed.

Running slip vs. torque characteristic curve of fluid coupling shall be such that slip across the coupling is not more than 3%.

Impeller of the coupling shall be shaped member with radial vanes extending to the periphery. Runner shall be of similar proportioned bowl and shall be set facing the impeller and keeping adequate clearance yet providing acceptable efficiency. Housing of the coupling shall be robust design either of aluminum or of steel.

Housing shall be so designed that effective cooling can be ensured. Provision shall be kept so that amount of oil quantity inside the housing can be adjusted at site. For purpose of cooling no water can be provided.

Suitable fusible plug shall be provided for all fluid couplings. This shall be able to fuse away by the increase in oil temperature during prolonged overloading and allow oil to be disposed such that hydraulic connection between impeller and runner ceases.

Brake drums shall be provided for conveyors for brakes wherever required.

The equipment shall be suitable for full load, part load and no-load starting of the drive equipment without hampering safety of the motor and rate of acceleration.

ii. Flexible Couplings (Low Speed Couplings)

Couplings shall be able to absorb parallel and angular misalignment. These shall have crowned external teeth of the hub which shall engage with the straight internal teeth of the sleeve. The pressure angle, the amount of crowning and back-lash values shall be so chosen with a view to achieve the best results in the load carrying capacity. Lubrication arrangement shall be adequate to ensure silent operation and minimum wear of gear teeth. Coupling shall be dust proof and suitable sealing device shall be provided. Parallel and regular misalignment/permissive shall be minimum 3-5mm & ± 1.5 degree respectively.

7.6.10.3 Reducers

- a) As far as possible parallel shafts design with single or double helical construction shall be used.
- b) Reducer boxes shall be steel fabricated or steel cast, stress relieved and machined, oil and dust tight enclosures for gears and bearings. The housing shall be split on centre line of shafts.
- c) All reducers shall have inspection openings, lifting lugs, an oil filling cap, a visible oil level, a side located oil drain plug, an air breather and a permanent magnet plug.
- d) Reducer's durability service factor and strength factor shall not be less than 1.5 & 2.5 respectively based on motor power.
- e) All shaft bearings shall be antifriction type of capacity compatible with the class of equipment.

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- f) The base of the housings shall be machined level and shall be suitable for bolting to a base plate.
- g) There shall be no axial movement of the shaft of the reducers. Plain shafts can be of medium carbon steel. But pinion shafts shall be of alloy steel only.
- h) The thermal capacity shall be equal to or greater than the maximum motor power rating, thermal rating of the reducer shall in any case never exceed 80°C. Where justified, external fan cooling system can be provided.
- i) Shaft mounted drives of hollow axle type are acceptable. For shaft mounted drives the reducer hollow shaft mounting arrangement shall be easily removable type.
- j) All gears shall be of single helical, double helical or herringbone design. They shall be made from high quality alloy steel forgings or castings, heat treated for optimum combination of wear resistance and strength. Pinions will preferably be integral with their shafts.
- k) Bearings shall have labyrinth seals (Taconite type) to prevent oil leakage and ingress of contaminants into the bearings. All bearings shall be SKF/FAG make only.
- l) Gears and bearings shall employ the same lubricant. The method of lubrication shall be such as to supply continuous lubrication to gears and bearings when the reducer is in operation.
- m) Equipment shall be designed to operate with a noise level not exceeding 80 db measured at a distance of 1.2 metre from reducer at a height of 1.5 metres above floor level.
 - All gearboxes shall have permanent magnet plug.
 - Reducers shall be designed for transmitting torque in both directions and should not be self locking type.

7.6.10.4 **Back Stops (Hold Backs)**

- a) Back stops shall be selected for minimum service factor of 1.5 based on maximum torque from driven equipment. Thermal rating of back stop shall be such that there shall be no undue temperature rise while running in the direction of the pulley or when back stop is applied.
- b) Back stops for conveyors shall be provided wherever the force required to lift the load vertically is greater than one half the force required to move the belt and load horizontally.
- c) Hold backs shall be fully enclosed roller or sprag type. The design of the hold back shall be such that its operation is not affected by dust, grease, moisture and extreme

temperature conditions. Holdback may be mounted in the Gear Reducer. However, Holdback mounted separately on Pulley shaft shall be preferred.

7.6.10.5 **Base Plate**

- a) All drive units shall have common base plates of welded steel construction. They shall be designed with sufficient depth and stiffness to ensure rigidity of drive assembly.
- b) All machinery mounting surfaces shall be machined. Base plates shall be suitable for erection on both concrete and structural steel base.
- c) Base plates shall be provided with lockable adjustment screws to facilitate alignment of heavy gear reducers and motors in the horizontal plane.

7.6.11 **Bearings, Bearing Seals & Pillow Blocks**

- a) Wherever practicable, bearings shall be of the antifriction type, with a minimum life expectancy compatible with the class of the mechanism with which they are used, unless specified otherwise.
- b) On shafts supported by two bearings, one bearing shall be fixed type and the other floating type to allow for thermal expansion of the shaft
- c) All bearing housings and pillow blocks shall be fitted with multi labyrinth-type seals, suitable for operation in an atmosphere containing very fine and abrasive dust and saline water spray.
- d) All bearing for pulleys shall be spherical roller bearings in pillow blocks shall have taper bores and adapter sleeves for locating on shafts.
- e) Pillow blocks shall be of cast steel construction four bolt centre split type. Base plates for pillow blocks shall be provided with lockable adjusting screws for accurate bearing alignment.
- f) Plain bearings shall have bronze bushings. The bearing pressure on plain bearings shall not exceed the manufacturers recommended ratings for the material used and the application conditions.
- g) The plain bearing shall have grease grooves and preferably a labyrinth type of seal to prevent entry of dust particles to the bearing.
- h) All bearings shall be SKF / FAG Make.

7.6.12 Belt Cleaners & V-Plough

7.6.12.1 *Belt Cleaners*

- a) The Cleaners shall be located beneath the discharge pulley drum.
- b) Combination of primary and secondary cleaners shall be provided to ensure effective cleaning.
- c) The primary scraper (Pre Cleaner) shall be provided for removing the heavy residue of materials adhering to the belt surface on the return side of belt.
- d) The blades of primary scraper shall be made of abrasion resistant polyurethane material, inclined against the direction of belt travel, ensuring maximum cleaning with minimum wear and tear of belt surface.
- e) The primary scraper shall be self-adjusting, compatible with reversible belt, easy to install and minimum maintenance.
- f) The secondary scraper (Main Scraper) shall be provided with automatic adjustment function (Elastomount) which helps in maintaining permanent contact with the belt.
- g) The cleaning member of secondary scraper shall comprise of a series of scraper elements of tungsten carbide, threaded onto stainless steel flexible base. The scraper elements are separated by stainless steel spacer springs so that the scraper elements are kept perpendicular to the belt surface without snagging and damaging the belt or the scraper assembly.

7.6.12.2 *V-Plough*

- a) The V-Plough (internal) Scrapers shall be fitted in front of tail pulley and take-up pulley to prevent the material which is falling on the top surface of return belt. This scraper should be V-type with 60° included angle and vertex should point to the head-end of the conveyor. It should ride on and be supported by the conveyor belt.
- b) V-Plough (internal for cleaning the interior surface of the belt shall consist of following:
 - Elastomount arrangement fitted with an automatic locking device to prevent the rigid cleaner parts from coming into contact with the belt and damaging it after the cleaner blade is worn away.
 - Self adjusting torsion arms to maintain cleaning pressure.
 - Suspension arrangement to keep the plough parallel to the belt.
 - Easily replaceable cleaning blade – Polyurethane.
 - Provision of chain to maintain constant pressure and contact with the belt.

- Provision should be made so that the metallic part does not touch the belt in case of belt worn out.

7.6.13 Monorail Hoists/Cranes

- a) Monorail Hoists shall be provided as required, where equipment parts heavier than 200 Kg are to be handled for maintenance.
- b) Monorails shall have electric hoists with pendant control. The pendant control shall be operable from the nearest floor.
- c) The lifting hook of the cranes/hoists shall as far as possible be able to reach vertically above the components to be handled. The cranes/hoists shall be able to lift/lower the components from/to the ground up to/from the required floor. Hoist speed shall not be less than 4 m/min.
- d) As far as possible the lifting tackles shall be standardized.
- e) A table showing the location, type of hoist, capacity, etc., included in the offer shall be furnished with the tender.

7.6.14 Wire Ropes

- a) All wire ropes shall conform to IS:2266. The tensile strength of the wire shall be 175-190 Kg/sq.m.
- b) All wire ropes shall be pre-formed or IWRC, ordinary lay construction, unless otherwise specified.
- c) The fleet of the rope shall not exceed 1 in 12 for any relative position of the sheave/drum assemblies.
- d) All wire rope terminations shall be made with solid forged thimbles and splices shall be mechanical splices made with aluminium or copper ferrules.
- e) Unless otherwise specified, factor of safety for wire ropes shall not be less than 6, based on the nominal breaking strength and the working tension of the rope.

7.6.15 Wire Ropes Sheaves

- a) Wire rope sheaves shall be made of cast steel or fabricated with groove surfaces hardened to 320 BHN minimum.
- b) The sheaves shall have machined grooves of uniform diameter accurately turned and finished smooth. The groove depth, contour, angle and radius shall be as per recommendations in IS:3177.

- c) The diameter of the sheaves measured at the bottom of the groove shall be as per recommendation in IS:3177.
- d) It is wise to specify the minimum diameter of sheave with respect to rope dia for the various rope drive reeves. IS code covers the same.

7.6.16 Wire Rope Drums

- a) Drums shall be made of cast iron, cast steel or fabricated from structural steel conforming to the relevant materials specification.
- b) The size, length, diameters, grooving, anchorage and strength of the grooved drums shall be as specified and recommended in IS:3177.
- c) Grooved drums shall not have more than one layer of rope on the drum when the rope is in its fully wound position.
- d) The thickness below the rope groove in no case shall be less than the rope dia.

7.6.17 Shafts and Axles

- a) All shafts under 50 mm dia. shall be made of cold drawn wrought steel. All shafts over 50 mm dia. shall be of forged steel. Shafts shall be machined all over and the finish under the bearings shall be to the degree and tolerance required by the bearing manufacturer.
- b) Generous fillets or long taper shall be provided at each end of the swell.
- c) In the case of design of shafts and axles based on strength, the computed bending and torsional moments in the shaft or axle shall be multiplied by the load service factors K_m and K_t respectively.

	Load Service Factors		
Nature of Load		K_m	K_t
Stationary Shafts & Axles	Gradually Applied Loads	1.0	1.0
	Suddenly Applied Loads	1.5 to 2.0	1.5 to 2.0
Rotating Shafts & Axles	Gradually Applied & Steady Loads	1.5	1.0
	Suddenly Applied & Minor Loads	1.5 to 2.0	1.5 to 2.0
	Suddenly Applied & Heavy Shock Loads	2.0 to 3.0	1.5 to 3.0

- d) In addition to designing shafts and axles for strength as specified above, shafts and axles shall be checked for deflection and slope as specified below.

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- e) The deflection of shafts and axles shall not exceed 1/1500 of the distance between bearing centres.

7.6.18 Pins

- a) All pins except those used for rotation or oscillating duty shall be of wrought steel (cold drawn) and machined all over. All pins subjected to wear due to rotation or oscillation shall be case hardened, ground and polished. Surface hardness shall be 80 to 85 Shore and the depth of case hardening 1 mm minimum.
- b) The maximum permissible stresses in the design of pins shall be as follows:

Stress Mode	Permissible Stress
Bending Stress	33% of Yield Stress
Shear Stress	22.5% of Yield Stress
Bearing Stress	40% of Yield Stress

7.6.19 Wheels

- a) The diameter and strength of each wheel shall be dependent upon the total maximum wheel load imposed by static and dynamic forces on the equipment. However, tread diameter shall not be less than 630 mm.
- b) Wheels shall have cylindrical treads with double flanges. Tread diameter and flange dimensions shall be according to IS:1136 and IS:3177 respectively. Width of tread shall be as specified or shown on drawings attached to the specification.
- c) Wheels shall be of forged/cast steel. The treads shall be hardened to minimum 300 BHN. All wheels shall be tested ultrasonically and test certificates furnished to Employer.

7.6.20 Fasteners and Keys

- a) All gears, pinions, wheels, couplings, etc. subjected to torsion shall be keyed to the shafts using parallel keys and keyways in accordance with IS:2048. Idlers may be press fitted on the shafts. Fits and tolerances shall be in accordance with IS:919, IS:210 and IS:2709.
- b) Set screws shall not be used for transmitting torsion but may be used for holding keys or light parts in place.
- c) Unless otherwise specified all holding down bolts and machinery bolts shall conform to IS:1363 for bolts of 6 to 39 mm dia and to IS:3138 for all bolts larger than 39 mm.
- d) Friction grip bolts shall conform to IS : 3757.

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- e) Plain washers conforming to IS : 2016 shall be used under bolt heads and nuts, whenever the material is softer than the bolts themselves. Spring or lock washers shall be used throughout for assembly of all machinery subject to vibration loads.
- f) All bolts, nuts and washers exposed to atmosphere shall be of SS-316 quality (upto M24) and above shall be galvanized.

7.6.21 Castings

- a) All castings shall be sound and free from pin holes or imperfections. Outside surface shall be well sand blasted and smooth. Critical castings shall be checked for internal flaws by x-ray and/or ultrasonic methods.
- b) All castings shall have well-rounded corners and generous fillets to avoid stress concentrations.
- c) All boss facings under bolt heads shall be machined.
- d) Steel castings shall be stress relieved by suitable heat treatment.

7.6.22 Holes

- a) All holes for fitting bolts and pins shall be drilled / reamed. Flame cut or punched holes will not be accepted.
- b) Unless otherwise specified, clearance holes for metric bolts shall be as per IS:1821 (medium).

7.7 CIVIL & STRUCTURAL WORKS

7.7.1 Materials

7.7.1.1 *General*

- ***Quality***

All materials used in the Works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Employer and shall comply strictly with the tests prescribed hereinafter, or where tests are not laid down in the Specification, with the requirements of the latest issues of the relevant Indian Standards. Any material not fully specified herein and for which there is no relevant Indian Standard, shall be the best of their kind and to the approval of the Employer.

- ***Samples***

All materials used in the Works shall be subjected to inspection and test. Samples of all materials proposed to be employed in the Permanent Works shall be submitted to the Employer for approval, before they are brought to the Site.

Costs of all samples and tests, whether at the manufacturer's premises, at source, at Site or at any testing laboratory or institution as directed by the Employer shall be deemed to be included in the rates quoted and no extra payment whatsoever shall be made on this account.

- ***Test Certificates***

All manufacturer's certificates of tests, proof sheets, mill sheets, etc. showing that the materials have been tested in accordance with the requirements of this specification, the appropriate Indian Standard or other relevant standard specifications are to be supplied free of charge, on request to the Employer or his representative.

- ***Names of Manufacturers and Copies of Orders***

Before ordering materials of any description for the Works the Contractor shall submit for the approval of the Employer, the names of the makers and suppliers proposed and any other details required by the Employer and shall afterwards send to the Employer copies in quadruplicate of the order given by the Contractor for the materials.

- ***Approvals***

No material shall be used in the Works unless it has first been approved by the Employer / Engineer.

- ***Storage of Materials on Site***

All materials brought on the Site shall be stored and protected in such a manner that they remain in perfect condition until such time as they are incorporated in the Works. Methods of storage, protection and handling of materials shall conform to relevant Indian Standards and where such standards are not available it shall be stored to the Employer / Engineer's approval.

- ***Records and Usage of Materials***

The Contractor shall maintain a detailed record of all materials received on the Site or in his stores or storage and working areas in the vicinity of the Site and shall make such records available to the Employer at such times as the latter may reasonably require.

- ***Use of Permanent Materials for Temporary Works***

Materials for the Permanent Works shall not be used for Temporary Works unless otherwise approved in writing by the Employer. Granting of such permission shall not prejudice the right of the Employer to reject materials so used which have become unfit for use in the Permanent Works.

- ***Rejected Materials***

If any materials brought to Site are rejected by the Employer, the Contractor shall forthwith remove the same and replace them, at his own cost, to the entire satisfaction of the Employer.

7.7.1.2 ***Structural Steel***

- ***Mild Steel***

All structural steel used in the works shall comply with IS:2062 "Structural Steel" (Fusion Welding Quality).

- ***Supply***

Structural steel will be procured by the Contractor. It will be the responsibility of the Contractor to make timely procurement of all materials for both temporary and permanent works including pipes and structural steel, chequered plates, gratings and roof sheeting etc.

- ***Storage***

The structural steel shall be stored on Site on timber or concrete supports suitably spaced and of sufficient height to keep steel clear of the ground. The steel shall be stored separately section wise.

7.7.1.3 ***Roof and Side Cladding***

- ***Defective Materials***

Cladding sheets and other fitting shall be carefully examined immediately prior to erection and if any defects are discovered the piece or pieces are to be broken-up or removed from the site immediately.

- ***Mitring and Drilling***

Mitring shall be carried out carefully and accurately, using purpose made template to ensure flush fitting and butting of mitres. Drilling of sheets shall be carried out from the outer surface inwards and shall be carefully and accurately executed using template.

- ***Caps and Washers***

Sealing washers and caps shall be resilient plastic material conforming to IS:8869 "Washers for Sheet Roofing".

- ***Laying***

All corrugated sheets including roofing accessories shall be laid strictly in accordance with the relevant Indian Standard Codes of Practice. The eave course shall be laid first and work should start at the end of the building away from the prevailing wind. The end laps shall be minimum 150 mm and shall be sealed with an approved preformed mastic material.

- ***Safety Precautions***

Cat ladder or roof boards shall invariably be used to the satisfaction of the Engineer, by men working on the roofs for safety. This will, incidentally, avoid damage to the roofing materials also. Roof boards shall not be less than 250 mm wide and shall be well constructed to avoid tilting. The barren or cross pieces of roof boards shall be properly secured to the board.

- ***Maintenance***

The roof covering shall be periodically examined and any broken units shall be replaced promptly and flashings redressed if necessary. The roof covering which if have been painted or coated to protect them from chemically laden atmosphere, shall be re-painted from time to time

7.7.1.4 ***Threaded Fasteners***

- ***General***

All bolts and nuts shall comply with IS:1367 "Technical Supply Conditions for Threaded Fasteners".

- ***Black Bolts and Nuts***

Black bolts, nuts and screws shall be in accordance with IS:1363 "Black Hexagonal Bolts (6 to 39 mm) with nuts and Black Hexagonal Screws (6 to 24 mm)".

- ***Precision Bolts and Nuts***

Precision bolts, nuts and screws shall be in accordance with IS:1364 "Precision and Semi-precision and Turned Hexagonal Bolts (6 to 39 mm) with nuts and Hexagonal screws, nuts and lock nuts".

- **Countersunk Screws**

Countersunk screws, wherever specified, shall be precision grade, slotted, countersunk head, machine screws conforming to Type 'R' of IS:1365 "Slotted Countersunk Head and slotted raised Countersunk head screws".

- **High Tensile Special Quality Bolts and Nuts**

High tensile steel special quality bolts and nuts, wherever specified, shall comply with the provisions of IS:800 "Code of Practice for use of Structural Steel in General Building Construction".

- **High Strength Friction Grip Bolts**

High strength friction grip bolts, wherever specified, shall comply with IS:3757 "High Tensile Friction Grip Bolts Fasteners for Structural Engineering Purposes".

- **Washers**

All plain washers shall conform to the requirements of IS:2016 "Plain Washers".

Spring washers for bolts, nuts and screws, wherever specified, shall be in accordance with the provisions of IS:3063 "Spring Washers for Bolts, Nuts and Screws".

- **Rawl Plug and Expansion Bolts**

Rawl plug and expansion bolts of the best quality, as specified or approved by the Employer, shall be used.

7.7.1.5 **Cast Steel**

Cast steel shall comply with the requirements of IS:1030 "Carbon Steel Casting for General Employer Purposes". The steel shall, unless otherwise specified, conform to Grade 2 and shall cater for all tests as specified in the said standard.

7.7.1.6 **Stainless Steel**

Stainless steel where applicable shall conform to AISI 316 or equivalent I.S. Standard.

7.7.2 **Miscellaneous Steel Works**

7.7.2.1 **Gratings**

Gratings shall be of the best quality and make as approved by the Employer. Gratings shall have carrying capacity to withstand loading of 500 kg/sq. m for simply supported span of 2 M. All Gratings shall be galvanized a minimum of 100 micron thickness.

7.7.2.2 Chequered Plates

7 mm thick chequered plate manufactured by SAIL or equivalent approved by the Employer and conforming to IS:3502 shall be used.

7.7.2.3 Steel Tubes for Handrails and Handrail Posts

Steel tubes used for handrails and handrail posts shall be galvanised and of the specified nominal bore, medium class conforming to IS:1161.

7.7.3 Electrodes

Electrodes for metal arc welding shall be AWS:E6013 for all thickness below 12 mm and for thickness 12 mm and above low hydrogen type AWS:E7018 electrode shall be used. Manufacturer's instructions for use of electrodes shall be fully complied with.

7.7.4 Galvanised Steel Sheets**7.7.4.1 Standard**

All galvanized steel sheets shall conform to ASTM 798M-02 / AS1397.

7.7.4.2 Storage

All sheets shall be carefully handled, stacked and stored in accordance with the manufacturer's recommendations and to the entire satisfaction of the Engineer/Employer. All sheets shall be stacked on firm ground and suitably covered to prevent exposure to weather.

7.7.4.3 Fixing Accessories

Fixing accessories shall be of best quality self-drilling and self-trapping screws/bolts and nuts, neoprene and limpet washers, with 150 mm end laps wherever required.

7.7.5 Translucent Sheets**7.7.5.1 General**

Corrugated translucent sheets shall be of best quality available and shall be procured from an approved manufacturer only.

7.7.5.2 Inspection and Testing

Each consignment of translucent sheets shall be subject to inspection and testing. Material shall be procured with certification conforming to applicable IS Codes.

7.7.5.3 **Storage**

All sheets shall be carefully handled, stacked and stored in accordance with the manufacturer's recommendations and to the entire satisfaction of the Employer. All sheets shall be stacked on firm ground and suitably covered to prevent exposure to weather.

7.7.5.4 **Fixing Accessories**

Fixing accessories shall be of best quality galvanized mild steel from approved manufacturers.

7.7.6 **Steel Doors, Windows And Ventilators**

Steel doors unless specified otherwise shall conform to the requirement of IS:1038 "Steel Doors, Windows and Ventilators" in full regarding all materials, fabrication and dimensions including all fittings or to any other design and standard as approved by the Employer.

7.7.7 **Materials Not Specified**

All materials not herein fully specified and which may be offered for use in the Works shall conform to relevant Indian Standards and shall be subject to the approval of the Employer, without which they shall not be used anywhere in the Permanent Works.

7.8 **WORKMANSHIP**

7.8.1 **General**

7.8.1.1 **Standard**

A high standard of workmanship in all trades will be required. The Contractor shall ensure that only skilled and experienced tradesmen are employed.

7.8.1.2 **Plant**

The Contractor shall be responsible for the supply, use and maintenance of all construction plant and equipment and he shall ensure that it is suitable for the work and is maintained in such a manner as to ensure its efficient working. The Employer may direct that plant which is not efficient and is prejudicial to the quality of the work be removed from the Site and replaced by plant to his satisfaction.

7.8.1.3 **Sub-Contractors**

The Contractor shall be responsible for all Sub-Contractors and he shall ensure that their labour and plant is in keeping with the high standards required.

7.8.1.4 **Supervision**

The Contractor's supervisory staff shall be fully experienced in the types of work being carried out under their supervision and capable of ensuring that it is done well and efficiently.

7.8.1.5 **Temporary Works**

Where required, the Contractor shall furnish such details of his Temporary Works as may be called for by the Employer and the Contractor shall satisfy the Employer as to their safety and efficiency. The Employer may direct that Temporary Work which he considers unsafe or inefficient shall be removed and replaced in a satisfactory manner.

7.8.2 **Structural Steel Works**

7.8.2.1 **Fabrication**

- **Drawings**

The Contractor will be provided fabrication drawings based on the design drawings.

- **Templates**

All fabrication shall be in accordance with IS:800 "Code of Practice for use of Structural Steel in General Building Construction" and IS:1915 "Code of Practice for Steel Bridges". Extensive use of templates shall be made. The templates shall be steel bushed where considered necessary by the Employer. In case actual members are used as templates for drilling similar pieces, it will be at the discretion of the Employer to decide whether such pieces are fit to be incorporated in the finished structure. The Contractor shall arrange for corresponding parts of each unit manufactured from the same drawings to be inter-changeable as far as economic manufacturing conditions permit and shall advise the Employer of the precise arrangements made in this respect.

- **Straightening**

All material shall be straight and if necessary, shall be straightened and/or flattened by pressure, unless required to be of curvilinear form and shall be free from twists. Heating of rolled sections and plates for the purpose of straightening will not be permitted. Limited straightening may, however, be effected by local applications of heat with a gas-torch, only after approval of the Employer.

- **Cutting**

Gas cutting shall preferably be done by pug cutting machine. Gas-cut edges shall be free of gouges; any gouges that remain after cutting shall be removed by grinding. Gas cutting shall, normally, only be permitted for mild steel though gas cutting of high tensile steel may also be permitted, provided special care is taken to leave sufficient metal to be removed by machining so that all metal that has been hardened by flame is removed. Hand flame cutting may only be permitted subject to the approval of the Employer. Rolled sections shall be sawed or flame-cut to length. Small plate pieces like gussets may be sheared or cropped to size. Sawing, shearing and cropping shall be clean and free from any distortion. If necessary, the edges shall be ground afterwards.

- ***Drilling of Holes***

Punching shall not be resorted to unless previously approved by the Employer. Where punching is permitted, the hole shall be punched 3 mm less in diameter than the required size and reamed after assembly to the full size. In any case, the thickness of material punched shall not be greater than 16 mm.

Holes through more than one thickness of material of members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Where two or more pieces are drilled, they shall be separated and the burrs removed, if so directed by the Employer.

Holes for bolts shall not be more than 1.5 mm/2mm larger in diameter than the nominal diameter of the bolt.

Holes for bolts shall not be formed by gas cutting.

- ***Assembly***

Fabricated items may be pre-assembled with bolted or welded joints.

All steel work which is bolted together shall be in perfect contact over the whole surface. Only High Strength Friction Grip (HSFG) bolts shall be used for all structural connections except for temporary connections for erection purposes and for side girts, where use of black bolts may be allowed.

- ***Shop Erection (If Applicable)***

Steel work shall be temporarily shop erected completely or as directed by the Employer, so that the accuracy of fit may be checked before despatch. Due notice shall be given to the Employer in all cases when the work is ready for inspection and the assembly shall not be dismantled until it has been inspected and approval obtained.

The parts shall be assembled with a sufficient number of parallel drifts to bring and keep the components in place. In the case of parts drilled or punched through steel jigs with bushes resulting in similar parts being interchangeable for portions of the steel work, trial assembly shall be carried out to the extent required by IS:1915.

- ***Match-marking (If Applicable)***

All erection marks shall be die-stamped and also distinctly stencilled in paint as per marking diagram prepared by the Contractor.

- ***Despatch of Materials (If Applicable)***

The Contractor shall deliver the fabricated steel work to the site, as far as possible, in the same sequence as that which he wishes to follow for the erection. Despatches should be

scheduled to avoid cluttering up at the site. The bolts required for erection shall be bagged according to size prior to despatch.

7.8.2.2 **Erection**

- **Erection Drawings/Sketches**

The Contractor shall prepare comprehensive erection drawings/ sketches for the structural steel work. The drawings should be made in sufficient details to ensure convenient assembly and speedy and proper erection at site. The drawings should indicate in detail, the sequence of erection that is proposed to be followed and the method being adopted. Three copies of all erection drawings shall be submitted to the Employer / Engineer.

- **Plant and Equipment**

The suitability and capacity of all plant and equipment used for erection shall be to the satisfaction of the Employer / Engineer.

- **Stacking and Handling**

The Contractor shall ensure that steel work is not damaged due to careless or haphazard stacking. The steel work shall be stacked at site in such a manner that it shall be free from dirt. Stacking shall as far as practicable, be done in the sequence of erection but heavy members shall not be stacked on top of light ones.

Arrangements shall always be made at the time of handling, to make sure the damage to steel work is avoided.

In the event of damage due to improper stacking or careless handling, the damaged pieces will be rejected and shall be replaced by the Contractor at his own cost.

- **Method of Erection**

All structural steel work shall be erected in accordance with IS:800 and IS:1915. The steel work shall be erected true to plumb and temporary bracing or staging shall be introduced wherever necessary, to ensure that the structure is not over stressed and to take care of all erection loads. Attachment of such temporary steel work to the permanent steel work shall only be done with the approval of the Employer. Temporary steel work, like bracing and staging shall remain in position until the structure is stable and self-supporting and all the joints and bracing making the structure stable and self-supporting are permanently bolted or welded to the satisfaction of the Employer. After removal of temporary steel work, the permanent structure shall be made good, to the complete satisfaction of the Employer.

No permanent bolting or welding shall be done until proper alignment has been obtained. All site connections shall be of bolted type with HSFG bolts unless otherwise approved by the Employer.

Any errors in the steel work, which prevent the proper assembling and erection of the parts with moderate amount of reaming, chipping or cutting shall be immediately reported to the Employer. The steel work shall be rejected unless corrective action is approved by the Employer.

- ***Erection Tolerances (General)***

Unless otherwise specified the underside of base plates of steel stanchions shall be within plus or minus 3 mm from the elevations shown on the Drawings. The lateral deviations of the base plates shall not exceed 5 mm from the theoretical centre line.

Alignment of individual beams, girders, etc. shall not deviate more than plus or minus 6 mm from the location given on the Drawings. Crane rails shall be installed true and level in parallel straight lines and at the same elevation throughout the entire length of runway, within plus or minus 2 mm from theoretical location, as shown on the Drawings.

- ***Grouting Under Base Plates***

Grouting shall be done after erection of the structural steel, unless otherwise approved by the Employer. The Contractor shall furnish all shims and level all base plates to the proper elevations before grouting.

The pedestal surfaces which are to receive the grout shall be thoroughly cleaned immediately prior to the grouting operation. The grout shall be carefully worked under the base plates and shall completely fill the space between the underside of the base plates and the concrete pedestal including voids around anchor bolts. After the grout has had its initial set, the grout shall be cut back flush with the base plate and the surplus grout shall be removed. Before leaving the site, the Contractor shall retighten the nuts of anchor bolts.

7.8.2.3 ***Welding***

- ***General***

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 Construction in Mild Steel", and the Contractor will be required to submit his proposals in this respect, for certain main welds, for the prior approval of the Employer. The symbols for welding shown on drawings will be in accordance with IS:813 "Scheme of Symbols for Welding". Welding can be replaced only by high strength friction grip bolts.

Electrodes used for hand welding or for automatic welding machine shall conform to IS:814 "Covered Electrodes for Metal Arc Welding of Structural Steel".

- ***Personnel***

The Contractor shall employ only qualified welders capable of maintaining high standards of welding. They shall be trained in the operation of the plant and shall be subject to checking and approval by the Employer. A list of approved welders shall be maintained by the Contractor who shall supply the Employer with a copy of the said list and no other employee shall be permitted to carry out welding for the permanent work. The Employer may call for appropriate tests in accordance with IS:817 "Code of Practice for Training and Testing of Metal Arc Welders" at any time to ascertain that each welder is capable of performing a high standard of welding. Such test welds shall be tested and the Contractor shall provide, without additional charge, all necessary materials, equipment and labour for the same.

Alternately, the Contractor shall produce evidence of welders' previous qualification and for continuity of service in the last six months at least.

- ***Welding Procedure***

The Contractor shall submit the welding procedure for any type of joint for the approval of the Employer if he so requires and shall ensure that copies of the same are, at all times, readily available to the welders employed on the Works. No welding of the joints will be permitted until the Employer has approved the alignment of the members. The use of mechanically guided flame cutting will be permitted for the edge preparation of steel work for welding but steel work shall be machined or ground where the flame cut edges are inferior in appearance to a sawn edge or are not considered sufficiently clean or straight.

- ***Staging for Welders/Workmen***

Proper and sufficient staging shall be provided for welders/workmen whenever and wherever required. All precautions shall be taken to ensure the safety of the welders/workmen at all times.

- ***Gaps for Welded Joints***

The gaps specified on the fabrication drawings shall be accurately set by means of suitable jigs and the steel work shall be held firmly in position by clamps or bolts until the welded joint is sufficiently rigid to be free of clamps without causing strain or distortion. Where contact faces are separated due to rolling or workmanship tolerances the weld sizes shown on the drawings shall be increased by 1 mm for every 1 mm gap upto a maximum of 3 mm. If the gap is greater than 3 mm, it shall be packed with MS shims upto a maximum of 6 mm and the welds shall be increased by the same amount. All welds shall be marked in such a manner that the operator responsible can be identified.

- **Butt Welds**

All main butt welds shall be full penetration butt welds, unless otherwise specified. The ends of the welds shall have full throat thickness. This shall be obtained on all main welds by use of extension pieces adequately secured on either side of the main plates. Additional metal remaining after the removal of the extension pieces shall be removed by machining or by other approved means and the ends and surfaces of the weld shall be smoothly finished.

7.8.2.4 **HSFG Bolts**

When HSFG bolts are used, the contact surfaces of members being connected shall be free of paint or any other applied finish, oil, dirt, loose rust, loose scales, burrs and other defects which would prevent solid seating of the parts or would interfere with the development of friction between them. The bolts shall be finally tightened by "Torque-Control" Method in accordance with IS: 3757 "High Tensile Friction Grip Bolts".

The rotated bolt head or nut shall always be tightened against a surface normal to the bolt axis. This will require the use of an appropriate tapered washer where the surfaces are not parallel. Such a washer shall also be used under the non-rotated component except where the angle between bolt axis and contact surface is within the limits of 90 degree + 3 degree. Tapered washers shall be used for satisfying this requirement and they shall be correctly positioned. All bolts and nuts shall be provided with washers. Bolts shall project beyond nuts by at least one full thread after tightening. Holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely inserted. Driving of bolts is not permitted. Nuts shall be so placed that their identification marks are clearly visible after tightening.

Bolts and nuts shall always be tightened in a staggered pattern and where there are more than four bolts in a joint, from the middle of the joints outwards.

If after final tightening a bolt or nut is slackened off for any reason, the bolt, nut and washer or washers shall be discarded and not reused.

7.8.2.5 **Expansion Bolts/Studs**

Expansion bolts/studs shall be installed in accordance with the following procedure and important points mentioned below shall be noted carefully:

1. Installation hole should be drilled, by means of power drills, perpendicular to the surface of the installation medium.
2. In case of any deviation from the above, the fastener should be inserted and expanded along the axis of the installation hole. Any attempt to straighten the fastener stud by hammering to correct alignment, will reduce its effectiveness.
3. Installation hole should be of the stipulated diameter and depth. An oversized hole can substantially reduce holding power of the fastener. Similarly, it is difficult to insert the fastener stud properly in an undersized hole and causes the expander to foul with the

walls of the hole, without getting full rear end backing required for expansion traverse of the stud over the expander.

4. Installation holes, particularly in walls and floors, should be cleaned / cleared of debris, before inserting the fastener - this can be done with a drinking straw or with a plastic wash bottle.
5. Caulking of the expansion stud over the expander should be carried out by a series of lighter hammer blows, through a caulking tool say with a 2 lb hammer, rather than by direct heavy blows with a heavy hammer. The latter procedure can damage threads, bend the expansion stud and or fracture the medium of installation.
6. Random over-tightening of the holding down nut (particularly for externally threaded expansion fasteners) can cause needless pre-tensioning/jacking up, thereby substantially reducing the effective holding power of the fastening.

7.8.2.6 *Inspection*

- ***General***

The supply, delivery and erection of structural steel work shall be in accordance with the best practice and shall conform in full with the drawings and this specification. The Employer may, if he so wishes, employ Inspectors to supervise the various stages of fabrication, supply, delivery and erection either at site or in the shop or manufacturing plant.

No part of the work shall be treated as approved unless informed by the Employer in writing.

The Inspector shall have free access, at all reasonable times, to those parts of the Contractor's works which are concerned with the fabrication of the steel work and those portions of the site where assembly or erection is being carried out. The Contractor shall cooperate with the Inspector and give all reasonable help required in connection with the inspection and testing of the work. This shall include supply, free of charge, of all labour, gauges, templates and tools required.

- ***Place of Inspection***

Unless specified otherwise, inspection of steel work shall be made at the place of manufacture prior to despatch. The Contractor shall ensure that the Employer is informed of the steel work to be inspected sufficiently in advance so that the inspection can be conducted without delay to erection at Site. Stage inspection, during progress of the works shall be carried out during final assembly and erection at Site.

- ***Acceptance***

The steel work shall be free from all faults. Any work found defective or which is not in accordance with the drawings and this specification may be rejected. No structure or part of

the structure, once rejected, shall be resubmitted for inspection unless the Inspector considers the defects as rectifiable. Defects shall be made good according to the procedure laid down by the Inspector. The Inspector, may at his discretion, check the test results obtained at the Contractor's works by independent tests. The costs of such tests shall be borne by the Contractor and shall be deemed to be included in the rates. No work shall be painted or packed until it has been inspected and passed.

- ***Inspection of Welds***

All welding shall be subject to inspection and approval by the Inspector. The welding shall be tested as specified by the Engineer. The Engineer may require test plates to be prepared in accordance with IS:7310 "Approval Testing of Welders Working to Approval Welding Procedures" or IS:7318 "Approval Tests for Welders When Welding Procedure Approval is Not Required". At main butt welds these may be taken from plates cut from extensions of the main plates and fixed as extensions at the butt joints, so that the direction of rolling is parallel to that of the main plates and the welds continuous with the main welds.

All butt welds shall be tested as under:

- i) 100% ultrasonic test
- ii) 2% radiographic examination for manual welding
- iii) 1% radiographic examination for automatic welding

In case any defects are found during such examination, the Contractor shall make good the defects at his own cost as directed by the Engineer. The Engineer's decision regarding the defects and measures including replacement, if necessary, of welding shall be final.

The cost of testing butt welds, as above, shall be deemed to have been included in the rates.

The Engineer may order selective D.P test (Dye penetration test) or magnetic particle test on fillet welds where defects are observed visually. Cost of such tests shall be borne by the Contractor and shall be deemed to be included in his rates. All remedial measures, as directed by the Engineer, shall be to the Contractor's account.

No painting of welding shall be permitted until it has been inspected and approved.

7.8.3 Steel Doors, Windows & Ventilators

(A) Standard

The requirements regarding the design, fabrication, dimensions and tolerances of steel doors complete with all fittings shall be in accordance with IS:1038 "Steel Doors, Windows and Ventilators" or to any other design and standard as approved by the Employer. The Bidder shall submit along with his tender sketches showing details of the doors he proposes to supply.

(B) Packing and Supply

All doors shall be packed and despatched with the opening parts suitably secured to preserve alignment when fixing and glazing. Fixing lugs, coupling fittings and all hardware shall be despatched separately. Composite windows, etc. shall be despatched uncoupled. (C)

Erection

All doors shall be erected and installed in prepared openings true to plumb and alignment. It is the responsibility of the Contractor to ensure that the openings are prepared true to dimension before installation, allowance being made for expansion between the doors, etc. and the surrounding masonry and finish.

(D) Fixing Rolling Shutters

Brackets shall be fixed on the lintel or under the lintel as specified with rawl plugs and screw bolts etc. The shaft along with the spring shall then be fixed on the brackets. The lath partition (shutter) shall be laid on 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 suspensions 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 girders. These plates and bracket shall be fixed by means of steel screw bolts and rawl plugs drilled in the wall. The plates and screw bolts shall be concealed in plaster to make their location invisible. Fixing shall be done accurately in a workmanlike manner so that the operation of the shutter is easy and smooth.

(E) Fittings

Fittings shall be fixed in proper position as shown in the Drawings or as directed the Employer. These shall be truly vertical or horizontal as the case may be. Screws shall be driven home with screw driver and not hammered in. Recesses shall be cut to the exact size and depth for the countersinking of hinges. In the case of single leaf door where iron socket plate or a brass or aluminium fixing bolt (of sliding door bolt) be drilled in the door frame and an iron or brass plate cut to shape shall be fixed at the face of the hole.

7.8.4 Mortar and Grout

Mortar and grout shall unless otherwise specified be composed of Portland cement and sand and shall be mixed in the proportions called for.

7.8.5 Works Not Specified

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

7.8.6 Civil Engineering Design Criteria

7.8.6.1 *Design Criteria*

- ***General***

This Section establishes the basic requirements for the structural design of steel structures for the bulk material handling facilities. It is intended to be a guide for design of related structures with the objective that they will be built to be functional, serviceable, economical and safe. Engineering judgment should be exercised in applying these guidelines to a particular structure.

- ***Design Codes***

All design shall conform to the relevant Indian Standard Codes of Practice. In case any information is not available in the Indian Codes, the Contractor may adopt equivalent codes issued elsewhere provided the following conditions are satisfied:

- The Contractor notifies the Employer at the time of tendering of his wish to use such standards;
- The Employer / Engineer approves such usage;
- Four copies of authenticated English translations of the codes not originally issued in English are submitted to the Employer / Engineer. In the event, of any discrepancy in translation, the English translations shall be taken as correct.

In all cases, the latest editions of codes available shall apply.

- ***Engineering Drawings and Details***

- Design Basic Report

Separate Design basic report shall be submitted for structural works for the proposed structure. Design shall commence only after the approval of Design basis report.

- Design Drawings

Design Drawings shall include complete load and stress information; pertinent moments, shears and reactions in girders, beams and columns, stresses in trusses and the sizes of all members. If cambering of trusses, beams and girders is required, it shall be indicated. Design Drawings for column bases and anchorages shall indicate all information necessary such as direct loads, locations and eccentricity, moments, shears and uplift for foundation design. Column reactions shall be clearly separated so that they may be combined to cause the most critical loading conditions.

The design drawings shall include sufficient typical details to show the type of connection to be used (i.e. riveted, bolted and welded).

The design drawings, General Arrangement drawings, clearance diagrams and erection procedure drawings shall be submitted to the Employer / Engineer for approval.

- Detail Drawings

The detail drawings including auxiliary material drawings (Design Office Drawing lists etc.) shall be approved by the design office in which the designs are prepared. They shall not be normally subject to Employer / Engineer's approval. If, however, any particular drawing is asked to be submitted, it shall be sent for approval.

7.8.6.2 **Design Analysis**

Design computations should be prepared and forwarded to the Employer / Engineer for approval.

The design calculations shall be in sufficient details to explain the concept and steps of calculations. Final results of analysis in the form of computer print outs alone will not be accepted as design calculations.

7.8.6.3 **Design Data**

- a) Refer design criteria of civil works.
- b) Coefficients of Friction (as applicable)
 - Steel on concrete – 0.5.
 - Concrete on soil – 0.3
 - Concrete on rock – 0.4

7.8.6.4 **Loads and Forces**

(A) General

All structures shall be designed to support all loading which may be applied to the structure. These shall include dead load, live load, equipment loads, impact and special loads, operating forces and loads under normal and temporary conditions, horizontal forces such as crane thrust traction, wind and earthquake.

(B) Dead Loads

The dead load shall consist of the weight of structure and all material permanently fastened thereto or supported thereby.

(C) Live Loads

The live load shall consist of loads not permanently supported by the structure. Some of the basic live loads to be adopted are specified below:

IWAI

a) Galleries

Roof (no allowance for services) : 75 kg/sq.m.

Floor : 500 kg/sq.m

Conveyors - as per the requirement but not less than 500 kg per metre length of conveyor).

b) Drive Houses, Transfer Houses, etc. (Unless Otherwise Specified)

Roof (no allowance for services) : 75 kg/sq.m.

Floors in general equipment : 500 kg/sq.m. +

c) Storage Buildings (if applicable)

Live load on pitched roof to be ignored while evaluating wind suction effect.

Tripper conveyor floor : 500 kg/sq.m.

Tripper conveyor Service area : 1000 kg/sq.m.

(D) Equipment Loads

To the above mentioned live loads will be added all equipment loadings as specified by the mechanical and electrical sections under normal operating conditions including accessories, foundation base, etc.

Under equipment loads, allow for process loads from equipment and load from materials handled in rock boxes, conveyors, feeders, hoppers etc. full of materials upto the normal operating level. Any plug up or serious spillage will be regarded as an extraordinary or temporary load to act at a time on a particular part of the structure and check design of slabs, beams and columns for maximum capacity should be done.

(E) Impact and Special Loads, Operating or Process Loads

Special impact consideration shall be given to such structures as applicable. Floors supporting motors and similar rotating machinery shall be designed to support a vertical impact of 25% of the weight of such machinery.

Supports for the following equipment shall be designed for loads specified below and for the corresponding impact unless impact is reduced by effective dampening devices.

Motors and Similar Balanced Rotating Equipment

Vertical Impact : Twenty five percent (25%) of equipment

(F) Unbalanced Forces

a) Conveyors

Investigate for forces due to tight side and slack side belt tensions.

b) Pipes and Ducts

Anchorage forces shall be considered. Ducts and duct supports carrying dust or other fines shall be checked for accidental full conditions at stresses thirty three percent (33%) greater than usual allowable values.

7.8.6.5 **Materials of Construction**

Members and elements shall meet the following minimum thickness requirements unless indicated otherwise:

Item	Minimum Steel Thickness
Plates, stiffeners and gussets	8 mm (Accessible to cleaning and repainting)
Plates, stiffeners and gussets	10 mm (Not accessible to cleaning and repainting)
Flanges of rolled shapes, stems of tee and legs of angles pipes.	8 mm

Kick plates having minimum height of 100 mm X 6mm thick above floor and shall be provided around all openings on floors and edges.

Stair treads shall be made of gratings.

Back to back angles not to be used else star angles to be used. Minimum thickness of angles shall be 8mm.

Hand rail posts shall be made from minimum 32 NB (M) pipe. The height to the top of the handrail shall be 1,070 mm above finished floor level. Two horizontal rails, shall be provided, one at top 32 NB (M) pipe minimum and the other at 560 mm as 25 NB (M) pipe, above finished floor level. Posts shall be provided to resist 1 kN horizontal load applied at any point along to top rail and spacing of vertical posts at a maximum of 1500 mm.

7.8.6.6 **Performance**

A. Structural Steel

Structural Steel work shall be designed in accordance with IS:800.

All structural steel used in construction shall be as per IS:2062 or higher grade as required.

Structural tubular or hollow sections shall in every case have the ends completely sealed against the ingress of air and moisture. On completion of assembly all such sections shall have every hole of any description permanently plugged and sealed.

No overstress shall be permitted otherwise, except for earthquake and storm wind conditions when the performance of the structure shall satisfy the requirements of IS:1893 and IS:875.

7.9 INSPECTION AND TESTING

7.9.1 Quality Assurance

7.9.1.1 *General*

The Contractor(s) shall ensure manufacturing of the equipment backed up with an effective control of the quality of works, provide test facilities and conduct all tests necessary to demonstrate conformance of the works to the requirement of the contracts. The quality assurance requirements shall apply to all Sub-contractor(s) / Sub-supplier(s) also.

7.9.1.2 *Documentation*

The Contractor(s) shall provide, but not be limited to the following documents to permit audit and surveillance of his quality system including the inspection and test at its & its vendors premises during execution of the contract.

- Quality Plan
- Inspection and Tests Procedures
- Records

The Quality Assurance Plan shall include

The organization structure indicating separately the QA / QC dep't structure.

Identification of specific quality Inspection requirements implemented for the contract;

Outline the procedures for reviewing, updating and controlling the quality inspection plans and the referenced documents;

Details of special processes and procedures;

Details of design verification activities to ensure compliance to design requirements;

Method of control of sub-contracted work;

Method of vendor's qualification and approvals including the product inspection and acceptance procedures.

Details of quality inspection records preparation and maintenance.

The Inspection and Tests Procedures shall include

Identification of Tests/Inspections against specific requirements of the contract;

Hold points and witness points; (Hold point's means the stage in production beyond which work shall not proceed without verification and inspection or written waiver by the Employer. Witness points identify inspection cycles in the production stages with option of witnessing the tests lying with the Employer.

Identification of records to be maintained;

Details of test equipment to be used.

Records

Maintain a system of records with an objective of documentary evidence for conformance of requirements of the contract. The records shall be maintained by the Contractor(s) till the expiry of Defects Liability Period and afterwards hand-over such records to the Employer.

7.9.2 Inspection and Testing

7.9.2.1 *Shop Tests and Inspection*

Contractor(s) shall provide samples of materials for examination or testing as requested by the Employer. Mill test certificates shall be furnished by the Contractor(s).

The Employer or his representative reserves the right to determine by any method whether any of the material including finished items offered or delivered for use in the work are suitable for the purpose. Test(s) will be as per the procedures specified in the relevant standards/codes decided by the Employer. Cost of such tests will be to the account of the Contractor(s). In the event the test reveals that the equipments/material is faulty the Employer may have the option to repeat the test. The cost incurred for such repeat test will also be to the account of the Contractor(s). In case the equipment/material is found to pass the test and if the Employer orders a repeat test on the same equipment/material and in the event the equipment/material is found to pass the test, cost of such repeat test will be reimbursed to the Contractor(s).

Sampling and testing of materials for approval and testing as called for under appropriate Indian Standard or international standard or any other relevant codes / specifications shall be done free of charge well before fabrication and use. Samples provided to the Employer or his representative shall be in labelled boxes suitable for storage. Late submission of samples and test values shall not be accepted as valid reason for delay in completion of the contract. The discretion of sample selection shall be with the Employer or its representative.

At the discretion of the Employer, all materials and workmanship may be subjected to inspection by the Employer or his representative at the place of manufacture or fabrication of the Contractor(s) and/or the Sub-contractor(s) or at the site of the work. The Contractor(s) shall advise Employer sufficiently in advance so that in case of rejection, the rectification work involved does not delay the progress of the contract.

In case of sub-letting to other Contractors or manufacturers or suppliers by the Contractor, the Employer will reserve the right as follows:

- a. that, inspection and/or testing will be carried out at the manufacturer's works.
- b. or that, inspection will be carried out at site by the Employer / Employer's representative;

or that, inspection will be waived subject to the Contractor(s) furnishing a certificate of compliance with specification by a competent authority recognised by national/inter-national institutes.

The Contractor(s) shall notify the Employer of the dates on which manufacture or fabrication of items is to be carried out at the supplier's factory or the dates on which item of standard manufacture will be available for inspection and/ or ready for despatch. In the case of items in the manufacture of which intermediate stages are to be inspected as the work proceeds, the Contractor(s) shall notify the Employer from time to time the dates at which such inspection can be made.

The Contractor(s) shall give at least two weeks' notice for the Employer to make arrangements for inspection or give permission for despatch as the case may be.

Notwithstanding the fact that a material or a piece of equipment has passed the inspection carried out during the stage of manufacture, the Contractor(s) is not relieved from his obligations to conform to the quality, workmanship, guarantee of performance etc. as per the relevant terms of this contract.

Any defective material, equipment or workmanship which may come to the notice of the Employer or his representative after erection and installation shall be liable for rejection, and the Contractor(s) shall have to replace such materials, equipments, etc. or rectify the defects at his own cost.

Welding work, castings and forgings shall be subjected to radiographic or ultrasonic testing or any other test as instructed by the Employer and test certificates shall be furnished. The Employer or his representative reserves the right to examine the radiographic films of welding joints independently. In case of difference of opinion on a radiographic film about the soundness of any welding joint between the Contractor(s) and the Employer, the opinion of any testing laboratory/institute in India approved by Indian Standard Institute shall govern.

Suitable means shall be adopted in identifying each radio graphically tested joint with reference to the radiographic films even after commissioning and the same information shall be furnished to the Board at the time of delivery of the equipment for documentation.

Minimum 300 millimetre for each 1000 millimetre length of welding joints shall be radiographically tested in the following cases:

Wherever design/manufacturing drawings call for testing.

In case of additional welding, joints of the major load carrying members to make up the dimensional lengths, etc.

Employer reserves the right to test radiographically about 3% length of any other welding joints which are not covered by 6.2.1(J) (b).

If any of the tests shows defective welding, further tests shall be carried out. All such tests shall be at Contractor's cost.

All radiographic quality welding joints shall be principally grade 'black'. However, grades 'blue' and 'green' will also be acceptable subject to the approval of the Employer on tension and shear load carrying members respectively provided they are of short lengths.

7.9.3 Shop Assembly

Equipment shall be shop assembled prior to shipment to the extent required to ensure satisfactory field erection. All critical dimensions shall be verified, all motions checked and equipment tested in the shop prior to shipment. All sub-assemblies and parts shall be match-marked and metal tagged with parts numbers to facilitate field assembly. The Bidder shall furnish the list of such components. The components shall be shop assembled for inspection by the Employer before despatch to site.

7.10 COMMISSIONING

7.10.1 General

The Contractor(s) shall prepare erection drawings, programme, list of equipment to be used for erection of each component and shall submit to the Engineer/Employer for review prior to erection. The programme shall include, but not be limited to

- Sequence of erection of each sub-assembly
- Handling and Cranage
- Details of Temporary Bracing and Guying

Erection drawings should show size and location of all members, give complete locations and details for setting anchor bolts, indicating elevations of all bases, extent of bolted or welded connections and all details necessary for erection.

While planning the cranage requirement, site conditions and access roads thereto shall be taken into account. Cranage and spreader beams shall be positioned under load points as necessary. The supplier shall take into account the load carrying capacity of the area. Drawings of yard will be given to the successful Bidder.

Planning of erection procedures including provision of necessary guying / temporary bracing shall be carried out to ensure safety and trueness of the structure under all conditions of wind and erection loads occurring during construction period.

Alignment and fitting of machinery shall be carried out by skilled and experienced machinery fitters.

Driving or hammering in of pins in holes will not be permitted. If at any time during or after the erection it has been established that any machinery was so assembled, it shall be dismantled at Contractor's expenses and suitable modifications made as advised by the Engineer/Employer. Guarantee restriction on time shall not apply in such a case.

It shall be the responsibility of the Contractor(s) to provide crane, steel or other temporary supports during erection.

7.10.2 Improper Fits and Adjustments

Any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting of parts by moderate use of drift pins, moderate reaming cutting shall be reported to the Engineer/Employer immediately and his approval of the method for correction obtained. The correction shall be made in his presence. The Contractor(s) shall be responsible for all damage, errors and replacements.

In all cases of critical specialised adjustments to equipment supplied by Sub-contractors or others the Contractor(s) shall obtain the advice of the relevant equipment supplier and shall advise and obtain the approval of the Engineer/Employer.

All tolerances/adjustments shall conform to any international standards/codes/ practices. Wherever applicable it shall conform to FEM/JIS/DIN Standards.

It shall be the responsibility of the Contractor(s) to provide all lubricants/hydraulic fluids/fuel oil for start-up and upto and the completion of commissioning tests and shall include services for application of such material as and where required.

The sequence of erection of the structure shall be such that no member is stressed beyond what it is designed for.

It shall be the responsibility of this Contractor(s) to co-ordinate with the other Contractors regarding allocation of time, space, erection equipment and other facilities. This shall be done with the approval of the Engineer/Employer.

The Contractor(s) shall strictly adhere to the approved erection schedule. Advancing of the erection schedule may be approved by the Engineer/Employer provided the activities that are inter-related to / dependent on other contractors' work are not strained.

Selection of the type of equipment to be used for erection at the yard shall be based on the consideration of the design live loads of that area / structure to be confirmed by the civil contractor.

If any special methods such as complete shop assembly and transportation to site in assembled condition are thought of, the same shall be supported by details and sketches and shall be submitted along with the bid. Also, the type of trial runs to be conducted prior to despatch shall be brought-out.

7.10.3 Field Tests

7.10.3.1 Tests

The tests shall comprise the following:

- (a) Equipment / Unit assembly test.
- (b) Adjustments, alignments and settings.
- (c) Satisfactory completion of No Load Tests for each equipment in the system.
- (d) Final operational tests such as commissioning, reliability and performance guarantee tests
- (e) For carrying out tests, readiness of works supplied by other contractor(s) interfaced with the equipment to be tested, will be essential.

Before any electrical system is put to use, the contractor shall carry out the tests, as detailed in Section 5.0, to the satisfaction of the Employer.

7.10.3.2 General

- a) Contractor(s) shall be responsible for testing individual components / equipment, commissioning of the conveying system as a whole.
- b) For the period of adjustments and setting, the Contractor(s) shall provide services of adequate number of teams of personnel which shall include, but not be limited to, Engineer, foremen, fitters, welders, electricians, etc., who apart from their technical experience are well acquainted with all the machinery and equipment.
- c) All tests shall be carried out in the presence of the Employer and any corrections found necessary shall be approved by the Employer and the Contractor(s) shall be responsible for producing all necessary work sketches and drawings for the approval of the Employer. The Contractor(s) shall be responsible for obtaining the services of sub-contractors (as and when necessary).
- d) Final operational tests by the Contractor(s) with the cargo will depend on the availability of material and interfacing equipment/system falling under the scope of other

contractors. The Employer will set the date for operational tests after receipt of the notice(s) from the Contractor(s) and the Contractor(s) will be informed of this date in advance. The Contractor(s) shall be responsible for any adjustments or corrections found necessary during these tests.

- e) Employer will ensure that interfacing equipment/system (by others), are ready to work in conjunction with the conveyor system falling under the scope of the Contractor(s).
- f) The Contractor(s) shall be responsible to coordinate/exchange of technical inputs, as may be found necessary during load trials with the other Contractors.
- g) Interruption/delay due to malfunctioning/adjustments in the system by other Contractor(s) during commissioning may occur. The Contractor(s) shall account for such interruptions/delay during the tests (except the Performance Tests).
- h) The Contractor(s) shall during the period of Field Tests instruct the Employer's staff in the operation of the conveyor system and acquaint them with the adjustments that are made. The Client's staff shall be given reasonable opportunity to become conversant with the operating features of the equipment.

7.10.3.3 **Adjustments**

- a) Contractor(s) shall be responsible for all necessary alignment and adjustment of machinery and equipment to obtain efficient operation.
- b) All critical and specialized adjustments shall be carried out in the presence of the Employer. Procedures and necessary precautions in regard to such adjustments shall be conveyed to the Client/Consultant in writing.
- c) Special attention shall be given to final adjustment of:
 - Load sharing by individual drives if multiple drives are used
 - Brakes, Back-stops (if any), couplings
 - Lubrication System (As Applicable)
 - Various interlocks and safety devices
 - Proper tensioning of take-up arrangement
 - Belt training
 - Adjustment of dust suppression system

7.10.3.4 **No Load Tests**

- a) Employer shall provide electricity for conducting the no-load tests.

- b) After completion of the erection the works under this contract shall be tested. The facility shall be run without load and all necessary adjustments shall then be completed. The no load tests are intended to demonstrate that all components will function successfully, separately and as components of an integrated facility in accordance with the requirements of the contract documents.
- c) After completion of erection, the Pipe Conveyor shall be tested individually and with related equipment by the respective Contractor(s) (in case of more than one Contractor). The system shall be operated ensuring that individual equipment supplied under the contract are functional while operating in conjunction with equipment.

7.10.3.5 **Load Tests**

Load Tests shall be undertaken in two phases:

Phase A

System testing of all components shall be conducted as a dry run. Each system or component shall first be run individually under manual control, then in automatic mode to check interlocks and the associated schematics.

At this stage each equipment shall be completed in all respects excluding minor items like painting, etc.

Phase B

When Phase 'A' is completed to the satisfaction of the Employer, the Client on being intimated by the Contractor and subject to all statutory clearances obtained by the Contractor(s), shall furnish cargo and the equipment with the conveyor system for carrying out the following tests :

- Commissioning
- Performance Test

Wherever possible, each equipment shall be tested independently / simultaneously.

7.10.3.6 **Commissioning**

Employer shall supply the cargo for loading the System. If the Employer's obligations under the above sub-clause are fulfilled, Contractor(s) shall commence commissioning under the supervision of the Employer. The Contractor will be responsible for co-ordination with all Contractors concerned.

Commissioning tests by the Contractor(s) shall include but not necessarily be limited to the following:

- Check that all system is complete, clean and clear of obstructions and ready to test.

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- Limit switches checked for location and that they operate satisfactorily adjust as necessary.
- Conveyor belts to be run and tracking of belt checked and corrected where necessary.
- All centralized controls, monitoring devices, safety devices, visual and audible indications, etc., to be tested for successful operations (by others).

However this contractor shall provide all possible assistance for testing of controls.

Records shall be kept of the tests carried out, faults/defects noticed and corrections made, and four copies of such records shall be submitted to the Client/Consultant by the Contractor.

Notes:-

- The Contractor shall put his best effort to ensure least stoppage of Port operation during carrying out all the tests.
- Generally minor shortcomings shall be those which, according to the Employer shall not affect safe operation and achieving peak output. Items which could be considered 'minor' would depend on the nature of malfunctioning and such decisions shall be taken solely by the Employer after completion of the Performance Tests.
- The Contractor shall arrange for responsible representatives and competent engineers to be present throughout the tests.
- In case, in the assessment of the Employer, the tests are unreasonably delayed or prolonged once a testing facilities has been provided for testing, the Employer may discontinue the tests to release the facilities and instruct the Contractor to reschedule fresh tests.

7.10.3.7 **Performance Test**

Performance Test shall be conducted after commissioning tests.

Notes:-

- a) The Contractor shall put his best effort to ensure least stoppage of Port operation during carrying out all the tests. Cumulative breakdown time shall not be more than 30 min per shift of 8 hrs while operating the conveyors.
- b) Generally minor shortcomings shall be those which, according to the Employer shall not affect safe operation and achieving peak output. Items which could be considered 'minor' would depend on the nature of malfunctioning and such decisions shall be taken solely by the Employer after completion of the Performance Tests.
- c) While conducting the tests mentioned in this section/specification and/or any other test(s) mutually agreed upon prior to the beginning of such test, the performance of

other systems like, field devices, etc., shall also be tested both in manual control and in central-control modes, as long as the connected system will be in operation.

- d) The Contractor shall arrange for responsible representatives and competent engineers to be present throughout the tests.
- e) The Contractor shall have the option to carry out the tests/trials/handling of cargo during non-tests/trial period upto taking-over mentioned herein either entirely with his own personnel or assisted by the Employer's personnel. In either case Employer shall be informed in advance.
- f) All materials and equipment which fail the tests during various tests shall be replaced by the Contractor without any extra cost to the Client and the tests shall be repeated on the new equipment/item unless it is agreed otherwise by the Employer. All instruments and tools required for tests shall be supplied by the Contractor at no extra cost to the Employer.
- g) Belt Scale installed on the equipment shall be used for weighment record unless agreed otherwise by the Employer. The Belt Scale will be calibrated prior to commencement of the Performance Test. The Employer at their discretion may get the Belt Scale recalibrated by the Contractor/Supplier either during the Test or at the end of the Test. The Employer at their discretion may take note of the corrective factor for calculating the capacity of the respective equipment during Performance Guarantee Test.
- h) In case, in the assessment of the Employer, the tests are unreasonably delayed or prolonged after commencement of testing, the Employer may discontinue the tests and instruct the Contractor to reschedule fresh tests.

7.11 SURFACE TREATMENT AND PROTECTIVE COATINGS

7.11.1 General

The recommended painting system for general service requirement of steel structures covering surface preparation, application of primer coat, intermediate coat and final coat to develop the required minimum dry film thickness on steel surface as indicated below:-

7.11.2 Technical Specification

Before fabrication all steel that is subsequently over coated shall be shot blasted to SA ½ quality standard and primed immediately after blasting with one coat of approved shop primer. Therefore the skin plate, tank, frame, fitting, shall be coated with anticorrosive and antifouling paint system to achieve minimum guarantee life to first maintenance of 15 years based on ISO 12944. Contractor shall select a proven painting schedule from reputed paint manufacture's to ensure guarantee life.

Colour scheme of final painting shall be as approved by the Employer.

7.12 TRAINING

The Contractor(s) shall train the Employer's staff (Operators, Technicians, etc.) in operation and maintenance of the equipment.

7.12.1 Training in Different Disciplines

The scheme shall cover the disciplines of mechanical, electrical, electronics and communication engineering encountered in the various equipment to be installed under this contract.

The Contractor(s) shall make available experienced and competent instructor for the formal training of operating and maintenance personnel, who can communicate with the trainees in English language.

The training shall be sufficiently comprehensive to enable the nominated person to operate and maintain the equipment in a safe, efficient and workmanlike manner. Training in the maintenance of equipment shall include routine maintenance level, breakdown maintenance level and other levels as required.

The instructors shall be fully qualified and conversant with the installations and with the details contained within the approved Operating and Maintenance Instructions.

All training methods shall have content consistent with the Operating and Maintenance Instructions provided by the Contractor(s).

All necessary training aids, such as videos, models, etc., shall be provided and retained by the Owner (Purchaser) for future training.

The Contractor(s) shall involve the Owner (Purchaser)'s operations and maintenance staff to become familiar with the machine and the installed equipment during their erection and commission time.

The Contractor(s) shall allow for a minimum training period of 12 weeks for operating and maintenance personnel for the equipment during the erection and commissioning. The Bidder may suggest increase or decrease in the duration in his offer. Date of commencement of training under the contractor's scheme shall be decided in consultation with Employer.

The training programme shall include but not be limited to:

- Class-room training,
- Familiarization during erection,
- Hands-on training with the help of similar equipment operating elsewhere (preferably supplied by the same Contractor),

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- During Field Tests

During the Contractor(s)' training scheme to the Owner (Purchaser) documentation, but not be limited to the following, shall be made available as part of the training scheme:

- Course material for class room / site instructions to trainees – all disciplines.
- Charts, formats, reporting system, paper work models for maintenance, data logging, management information, etc.
- Audio-visual aids used for illustrations.
- Write-ups, notes on equipment / components of critical nature.
- Typical case histories / studies of the machines in other installations exemplified during training.
- Safety emphasis.

All these documentation shall be distributed to the trainees as applicable and three (3) copies of all the paper documentation shall be supplied to the Employer for use and library record.

7.12.2 Price

The Contractor(s) shall quote for the above scheme, indicating the details by a write-up supported by data sheets with a separate price under the head "Training". However, the Contractor(s) is also required to quote unit rate for the training personnel / experts beyond the fixed sum quoted for the purposes of continuation, if necessary of such expertise, over and above the training scheme envisaged.

The Contractor(s) in his proposal shall recommend the required number of persons category-wise to be trained for the Employer's assessment and recruitment action.

All travelling and living expenses for the engineering/operation personnel of the Employer to be trained during the total period of training will be borne by the Employer. The above personnel while undergoing training shall be responsible to the Contractor abiding by the regulations in respect of discipline.

7.13 SPECIAL APPLICATION

7.13.1 Temporary Works

The Contractor shall furnish such details of his Temporary Works as may be called for by the Employer and the Contractor shall satisfy the Employer as to their safety and efficiency. The Employer may direct that Temporary Works which he considers unsafe or inefficient shall be removed and replaced in a satisfactory manner.

The contractor may be, at his own expense, and subject to the approval of the Employer and statutory authorities, construct offices, stores, workshop and accommodation for staff and labour in the area allocated to him and remove the same as per the orders of the Employer on completion of the Contract.

7.13.2 Design and Drawings

7.13.2.1 General

The drawing listed herewith is issued only for information and guidance on general system requirements and specifications. Contractor shall make all arrangement and design drawings to suit his equipment and submit the same for approval to the Employer. Detailed Engineering shall be done by the Contractor.

The Contractor shall submit for the Employer approval from the date of receipt of the letter of acceptance three copies of the following:

- General layout, Conveyor Assignment and profile drawings - within 30 days.
- Cross sections and other details showing important particulars such as overall dimensions, clearances, etc. – within 45 days.
- Power Requirement (installed and peak demand loads) – within 45 days.

7.13.2.2 Design Drawings

The Contractor shall submit progressively for Employer's approval three (3) copies each of the following documents at least two months prior to the starting of manufacture / placement of order of these items. The scope of these drawings etc. shall include but not be limited to the following:

- Calculations pertaining to selection of components and power requirement for all drive units.
- General arrangement of each conveyor / assemblies.
- Specification/catalogues of all standard bought-out items.
- Drawings other than shop fabrication/ manufacturing drawings. These will include, but not be limited to assembly, sub-assembly, key components, typical arrangement of technological structure.
- Single line diagram and schematic drawings.
- Single line diagrams, Wiring drawings, cable routes, equipment inter-connection and terminal diagrams.

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- Write-up on List of Field Devices and interlocks considering sequential starting and stopping, emergency stopping during regular operation and 'maintenance mode'.
- Write-up on Control System taking into account of interfaces with Silo and Pipe Conveyor.
- I/O Chart and Control schematics.
- General arrangement of lighting and lightning protection and earthing systems.
- Calculations in support of Selection of the following items:
 - i) Switch gears
 - ii) Size of the power cable, current, voltage drop & cable schedule.
 - iii) Number of cores of control cables and size & cable schedule.
- Calculations in support of input and output requirements of the system and selection of microprocessor to meet the requirement.

7.13.2.3 ***Design Calculations***

The design calculations shall be written in English language, computer print outs of only the results of analysis will not be accepted in lieu of written design calculations.

7.13.2.4 ***Manuals and Technical Data***

- ***Manuals***

The Contractor shall supply six copies of erection or 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, breakdown maintenance and over haul shall be brought out in the inspection and maintenance manuals.

- ***Technical Data***

On completion of the works and before handing over possession to Employer, the Contractor shall supply one hard and soft copy of the following:

- Shop drawings of all wearing parts and also major assemblies and minor assemblies which require unit replacement;
- Complete technical data and dimensional drawings of all bought out product items such as bearings, seals, couplings, gear reducers, brakes, valves, limit switches, switchgear, PLCs and controllers, field safety level sensors, etc., and such other items in the machine;
- List of recommended spare parts.

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

7.13.2.5 ***Tools and Maintenance Equipment***

- A complete set of tools and instruments required for satisfactory maintenance of the machines shall be provided with each machine.
- A set of hydraulic jacks / jacks shall be provided where the design of the machine dictates that the jacks are required for maintenance.

8 BELT WEIGHER

Belt weighers shall be provided in the system at appropriate locations for measurement of cargo handled.

The belt scale shall be load cell type and shall be continuous operating. Accuracy shall be 0.25%.

Provisions for local and remote measurement of instantaneous throughput and to falling shall be made. Signals for remote indication and overload alarm shall be provided. Local control panel including rate indicator and totalizer shall be provided.

The load cells shall be completely sealed, water and dust proof, and maintenance free.

9 DUST EXTRACTION SYSTEM

- a) Dust control and abatement systems shall be provided to contain escape of dust into atmosphere while the facilities at the terminal are in operation. The systems shall be designed to conform to the permissible limit of dust emission by the concerned statutory pollution control authorities.
- b) However, the concentration of RSPM-10 shall be limited to an average 5 mg/normal cum over and above the ambient dust concentration measured at a circumferential distance of 5 m from the dust generation source.
- c) The filtering efficiency shall not be less than 95%.
- d) The material handling scheme of the facility is shown in the Layout Drawing number I-525/HT/1001.
- e) The Bidder may also (if required) quote an alternative to meet the system requirements mentioned above.
- f) Dust Extraction System shall be designed in accordance with ACGIH & APPCB norms.

9.1 SYSTEM REQUIREMENT

The following Dust Control System shall be provided

S. No	Facilities	Dust Control System
1.	At Transfer Towers	Insertible Pulse Jet compact bag filter
	At Towers	
	At Barge loader	

9.2 DESIGN REQUIREMENTS FOR DUST EXTRACTION SYSTEM

Dust control at discharge and receipt points in the transfer towers shall comprise of reverse pulse jet compact bagfilters with independent fan. However, the reverse air jet shall be provided through a common air compressor for all the dust extraction units.

The Dust Extraction System shall consist of, but not limited to:

- i) Compact reverse pulse jet unit with Insertiblebag filters suitable for working at the ambient conditions.
- ii) The filter media shall be of standard dimension using surface filtration technique so as to reduce the need of formation of primary cake for better reverse air jet cleaning process. The fabric shall be abrasion and static charge resistant, non-woven needle felt made from polyester or polypropylene. The bagfilters shall be suitably supported from within with steel cages.

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- iii) The Air to Cloth ration shall be suitable maintained for the efficient working of filter
- iv) Filterbags under cleaning cycle shall be 25 – 30% depending upon the system design.
- v) Centrifugal air fans with backward curved blades. The capacities of the fans shall be as required at each potential dust generation point. The indicative particulars of transfer towers are given hereunder:
- vi) A common Air Compressor shall be provided for the supply of reverse air jet to each dust extraction unit in the dust control system. The air compressor shall be able to deliver air at the required pressure at the inlet to pulse jet valve but shall not be less than 7 Kg/Cm² g. He may arrive at the capacities and operating pressure based on his system design. However, other parameters specified shall be adhered to.

10 BARGE LOADER

The Scope of Work is for the engineering, design, manufacture, delivery to site, erection, testing and commissioning upto handing over of the following equipment.

- a) Barge loader ...2 Nos.

All equipment described and specified herein shall be fixed type for handling bulk materials as specified.

All equipment shall be complete and shall include everything necessary to provide fully commissioned and operational machines that will perform as specified. Overall dimensions (boundary dimensions) and functional requirements as shown on the drawing(s) and/or specified shall be adhered to as far as possible unless in the opinion of the Bidder it is necessary to change the dimension(s) to meet the operational requirement.

In any case the performance of the equipment delivered shall be guaranteed in every detail by the contractor.

All works incidental to the above including additions, substitutions and modifications, if any are deemed to be included in the scope.

10.1 SCOPE OF WORK

- A. Supply, erection and delivery of all temporary structures, tools, rigging, erection, machinery, temporary power for erection, testing, adequate site lighting, temporary water supplies, transport logistics, etc.
- B. Supply of all engineer and labour for design, manufacture, delivery, erection, testing and commissioning of equipment, including transportation as required, housing, security, temporary sanitation and safety requirements, up to handing-over of equipment.
- C. All consumable materials including filters, lubricants, electrical fuses, temporary loads; up to equipment handing-over.
- D. Cleanup at site of all debris and temporary structures on a daily basis and final cleanup at handing-over.
- E. All electrical safety requirements during erection, testing and commissioning, including adequate earthing of erection equipment and machines.
- F. Proper safe storage of all equipment and materials delivered at site, in areas designated by the Consultant/Client in line with customs regulations if applicable.
- G. Labour tools and materials for connection of equipment to permanent power and controls.
- H. Supply of spare parts as required upto Performance Guarantee Test and Taking-over and

- I. Interfacing with overall systems controls etc.

10.2 DESIGN FEATURES FOR MAINTENANCE

- A. Safe and direct access shall be provided to all drives, auxiliaries, electrical equipment, including limit switches and junction boxes, lubricating points and all other areas of the structure where switches, indicators or pivots of any type are installed. Ready access shall also be available between parts of the machine which move to one another.
- B. All walkway and stairways shall be minimum 750mm clear width unless otherwise specified.

Platform, walkways, stairs, ladders and handrails shall comply with code requirements.

- C. All structural steel surfaces intended for access shall be treated with proprietary approved non-slip surface. All other surfaces intended for pedestrian access shall consist of hot dip galvanized welded flat bar grating unless otherwise specified. Angular pattern floor plate shall not be used except in front of electrical cubicles or over structural members where spillage can be trapped by grating.
- D. Hand railing shall preferably be of proprietary tubular with all joints seal welded.
- E. Equipment and other mechanical components shall be designed throughout with special attention to accessibility permitting inspection, maintenance and renewal of parts with minimum of delay. Pulley assemblies, etc. shall be readily removable. Wherever possible, each gear, pinion, shaft, coupling, bearing, shall be readily removable without disturbing other parts. Lubrication and hydraulic fittings shall be readily accessible. Walkways, stairs, ladders, if approved by the Consultant, shall be provided for personnel carrying out inspection and maintenance. All replaceable components shall be accessible to mobile cranes from ground level.

Means shall be provided to facilitate the replacement of pivot, etc. and carrying out other maintenance operations.

10.3 EQUIPMENT DESCRIPTION

10.3.1 General

In general, the machines shall operate within the constraints and infrastructures as described herein and in the attached drawings. This shall include climatic conditions, materials handled, stability, performance expected, interfaces described and for future installations, as noted on the drawings.

The mandatory clearances and interface limitations, and machine and human safety, requirements shall be respected in all modes of operation.

10.4 CONFIGURATION OF BARGE LOADER

10.4.1 General

The Barge loader shall be fixed type machine conforming to the general arrangement and geometry shown on the drawings. It shall be suitable for loading barges up to 1500 DWT at all load/ballast and tide conditions.

Barge loader shall comprise a main portal gantry supporting a Conveyor with a telescopic spout.

Equipment shall receive material from the conveyor BC-5 & 6.

10.4.2 Superstructure

- A. The Superstructure shall be of robust design and provide access for inspection, adjustment and maintenance of all mechanical equipment including idlers, etc.
- B. The conveyor may be designed as a built in dust proof enclosure and shall include walkways on both sides. The conveyor return idlers shall be located above the walkway and be accessible for replacement from the walkway.
- C. The conveyor shall discharge through a telescopic spout which shall be capable of being expandable in the vertical direction (refer enclosed drawing). The telescopic chute shall be provided with insertable bag filter to control the dust emission while loading into the barges.

The telescopic chute shall be electric power driven with suitable gear box, input/ output couplings.

The speed of telescopic chute shall be limited to maximum 5 m/min.

The Bidder shall quote alternatively with/ without insertable bags in telescopic chute.

The spout shall be lined with durable and replaceable Hardox-400 Liners. Liner plate thickness shall not be less than 12 mm.

10.4.3 Technical Parameter

The following parameters shall be adhered to in the bid. Berth layout, travel rail span, Barge sizes and dimensions, clearances, berth conveyor details, etc., are given in the attached drawing. Those listed but not given here shall be supplied with the bid:

Cargo	Fly Ash
Barge loading Capacity	
Rated	400 TPH
Design	500 TPH

Barge Size	Up to 1,500 DWT
Conveyor Outreach	11 m (approx.)

10.4.4 Barge loading Operation

Barge loader shall be manually operated from the local Push Button Station have following interfaces:

- Conveyor shall start before the berth conveyor,
- The belt scale on the conveyor BC-5 & 6 shall be pre-set from the discharge of the required tonnage. The belt-scale shall be re-set to a fresh tonnage once the earlier target has been reached.

10.5 MECHANICAL CRITERIA AND DESIGN REQUIREMENTS

10.5.1 Design Criteria

The design of the equipment shall be such that Barges up to 1500 DWT can be berthed and de-berthed without any interference.

The equipment shall be capable of performing all unloading operations 25 m / sec wind velocity.

All components shall be designed and constructed to operate outdoors continuously at peak loads and under climatic and ambient conditions outlined in relevant sections. Barge shall be fully loaded by moving the Barge in position till completely loaded.

Internals of all chutes shall be designed to eliminate ledges, steps or any other surfaces where material can collect.

Equipment shall be designed for 45°C site temperature.

10.5.2 Conveyor

- The conveyor shall have a sturdy, welded, structural steel frame and supports for mounting all the machinery. Frame shall be designed suitably for the belt tension, clearances etc. Frame shall be fabricated from steel conforming to IS: 2062. Antifriction bearings with double labyrinth dust seals and easily accessible pressure gun lubrication fittings shall be provided.
- It shall be possible to operate the telescopic movement of the spout, within the operating range while the machine is operating at its full capacity.
- All bearings shall be lubricated and sealed for life.

10.5.3 Belting

The belting for conveyor shall be of suitable EP belt for heavy duty application and shall have adequate number of plies to withstand the tension and support load, adequately; top and bottom cover thickness shall not be less than 8 mm and 3 mm respectively.

The rated maximum allowable tension shall be 140 per cent of the normal working tension.

The ratio of breaking strength to rated allowable working tension shall be minimum 9.

Belt shall be pre stretched and cut edge type construction.

Belts supplied shall not blister or separate in the plies or at seams or stretch more than two and half per cent of their original length within one year of installation and normal operation. Belt construction shall be such that in the case of edge damage, ply separation and ingress of moisture shall not take place.

(A) Belting shall conform to latest revision of IS: 1891 (Part I), IS: 11592-2000 and other relevant Indian Standards.

(B) Belts shall have hot vulcanized joints after erection.

10.5.4 Idlers

All carrying idlers for shuttle conveyors carrying material in bulk shall be single roll flat type and shall be fitted on fixed type supports on the Shuttle conveyor stringer frame.

Carrying Idlers shall be suitable for required belt widths. All carrying Idlers shall be spaced at 550 mm centres.

Outside diameters of normal carrying and impact rolls shall be 139.7 mm respectively.

Idler rolls shall be made of electric resistance welded (ERW) tube and minimum wall thickness shall be 4.85 mm. Mechanical properties of the idler tubes shall be equivalent or better than YSt 210 grade as per IS: 9295.

Return idlers shall be Flat type. Diameter of each return roll shall be 127 mm. Return idlers shall be placed at 3.3 m centres. The return idlers shall be fitted on fixed type supports on the Shuttle conveyors.

Brackets for the idlers shall be of fabricated steel and shall have ample strength and rigidity to operate under all conditions without vibration or chatter. Use of Cast Iron support brackets are not acceptable. The bases shall be provided with slotted holes with two bolts of min 16 mm on each end.

Bearing housing shall be made of min 3 mm cold deep drawn rolled carbon (CDDRC) pressed steel.

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Idler shaft material shall be EN8 or better steel.

Idlers shall be easily removable type and designed for continuous duty.

All idler bearings shall be 'Sealed, lubricated for life' type. Deep groove ball bearings shall be used. The bearings shall be chosen for life L-10 equal to 50,000 hours minimum. All bearings shall be protected by double labyrinth seals. The bearing seals shall have minimum resistance to rotation. Lubrication fittings for the labyrinth seals shall be provided in the case of idlers provided at loading points, for the purpose of occasional greasing to keep the dirt and dust out. Felt seals will not be accepted.

All idlers and assemblies shall conform to latest edition of IS: 8598 or equivalent.

Internal rolling friction resistance of idler rolls shall not exceed 0.011 while testing.

10.5.5 Pulleys

Pulleys shall be made of welded steel and stress relieved in the furnace before machining. All hubs shall be of forged steel and end discs shall be accurately machined for concentricity.

Pulley shall be straight faced. Drive and discharge pulleys shall be of same diameter provided with 16 mm thick diamond type grooved rubber lagging. The rubber hardness shall be IRHD 60.

All pulleys shall be statically balanced. The balance weight shall not exceed 0.25% of the total weight of the pulley.

The pulleys shall have minimum rim and disc thickness of 12 mm. The face width of pulleys shall be as per relevant IS Standards suitable for belt. The face run-out on diameter shall not be more than 0.5 mm.

The run-out tolerance after lagging shall not be greater than 0.5 mm on diameter.

Bearings for all pulleys shall be antifriction double row, self-aligning, spherical roller bearings mounted on adapter sleeves. All Plummer blocks housings shall be of cast steel construction with double / triple labyrinth seals.

All pulley bearings shall have life of 50,000 hours.

10.5.6 Belt Cleaners

Multiple blade spring operated belt scraper of proven design shall be provided at the discharge end of belt conveyors for effective cleaning of the belt and ensure no spillage of the material from return belt. The discharge from the belt scraper shall fall within the transfer chute. A V type Plough Scraper shall be provided on return belt at the discharge end.

10.5.7 Safety & Control Devices

All conveyors, unless mentioned otherwise, to be equipped, but not limited to the following:

One no. Belt side travel switches to stop drive units for protecting belt from rubbing the structural parts.

Motion (under speed) switches to stop the motor when the speed of the equipment drops below a specified value or if normal speed is not reached within a specified time, and to signal starting and stopping of preceding conveyor/equipment.

10.5.8 Drive Unit

Drive shall be through reversible Geared Motor/Motor & shaft mounted Gear box, flexible couplings and brake etc. Gear type shall be Bevel Helical of reputed make.

10.6 ELECTRICAL SYSTEM

10.6.1 General

The specifications and standards cited herein are, unless otherwise stated, equally applicable to all of the machine included in the Scope of Work. A single power point shall be provided near by the machine for electrical supply by others.

10.6.2 Power Supplies

The interface for all machine power shall be through cable connection to the yard supply at 415 V, 50 Hz. A single power point shall be provided near by the machine for electrical supply by others. Power supply tolerance at this point of connection will generally be as follows:

- AC Motors : 415 V+5%, 3 Ph , 50+3% Hz
- AC fractional HP motors : 240 V, 1 Ph, 50Hz
- Lighting : 240 V, 1 Ph, 50Hz
- Controls : 240 V, AC, 1 Ph, 50 Hz and 24 V, DC

System Fault Level Current shall be taken to be 50 kA @ 415 V bus

Voltage drops between 415 V switchgear and end devices such as motors shall not exceed 2%.

10.6.3 Codes and Standards

The established standards may be used for the design & manufacture and testing of machine mounted electrical equipment. Other standards that will result in an equal or higher quality product than the standards listed below may also be accepted at the discretion of the Engineer.

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In addition to Codes and standards, the installation works shall also confirm to the requirement of following

- a) Indian Electricity Act & Rules.
- b) Fire Insurance Regulations.
- c) Regulation laid down by Chief Electrical Inspector of Gujarat.
- d) Regulation laid down by the Factory Inspector of Gujarat & Gujarat Electricity Board.
- e) Regulations for the electrical equipment of Tariff Advisory Committee.
- f) Any other regulations laid down by the Authority.

10.6.4 Enclosure Ratings and Designs

Ambient temperature for the design and manufacture of enclosures and equipment shall be taken as 45°C.

The switchboard and control equipment housings which shall be located within on-board protected enclosures such as switch rooms and operator's cabins shall be manufactured to IP54. All electrical equipment located outdoors shall have an enclosure rating of IP55.

10.6.5 Lighting

The lighting system on the machine shall consist of the following:

Minimum levels shall be as given below:

Area	Lux Level	At	Type of Luminaire
Platforms, Stairs and Walkways	150	1 M above Floor level	Metal Halide
Working areas for machine	200	1 M above Floor level	Fluorescent
under the boom area of barge loader	30	-	HPS

All luminaries on stack – barge loader shall be suitable for industrial duty and provided with IP55 housings for outdoor enclosures and IP54 for indoor enclosures.

Lamp life rating shall be a minimum of 10,000 hours for fluorescent and 18,000 hours for HID lamps (HPS).

10.6.6 Emergency Lighting

Emergency lighting luminaries shall be supplied to ensure a safe exit in the case of power failure.

10.6.7 AC Motors

- Type

The motors shall be squirrel cage induction type.

- Motor Control/Starting

The motors shall be capable of starting at minimum 80% of nominal voltage rating with connected load throughout the whole starting period at rated frequency.

The motor characteristics shall be such that it shall be suitable for continuous running with full load at 75% of voltage for 5 mins. Motors shall not stall due to voltage dip with system causing momentary drop in voltage to 70% of the rated value.

- Duty, Output and Characteristics

The motor shall have a pull out torque of more than 250% of full load torque.

The starting torque of motor shall be coordinated with the requirement of the driven equipment on the basis of minimum voltage of 80% rated voltage at motor terminals. There shall be sufficient margin of motor torque over the torque requirement to obtain proper accelerating torque so that the starting time is minimized.

The motors shall be designed to withstand 120% of rated speed for 2 minutes without mechanical damage.

- Enclosure Protection

Motors shall have totally enclosed fan cooled enclosures for operation in humid and dusty atmosphere. Motors shall have degree of enclosure protection IP: 54 for indoor and IP: 55 for outdoor use as per IS: 4691.

- Class of Insulation

Motors shall have class 'B' insulation with permissible temperature rise max. 75°C over 45°C by resistance.

- Winding Protection

Motors rated 75 kW and above shall be fitted with thermistors for winding protection.

- Cooling and Cooling Fans

The motor shall be in general fan cooled type having the fans as integral parts of the motors themselves.

The cooling fans for each motor shall be of such design that the motors can turn in any direction without/with minor modification at site.

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- Painting

All ferrous surfaces shall be subjected to the following pre-treatment before final painting:

- a) Degreasing
- b) Pickling for complete rust removal
- c) Phosphating
- d) Corrosion resistant primer painting.

The paint shall be epoxy based and shall be suitable for withstanding specified site conditions.

- Specified Tests

- a) All motor shall be routine tested as per latest relevant IS.
- b) The type test certificate of tests conducted on identical motors shall be furnished.

10.6.8 L.T. & Control Cables

L.T. Power Cable: 1.1 KV grade, 70 Deg. C rating heavy duty aluminium conductor, XLPE insulation, PVC inner sheath, galvanized single round steel wire/flat armoured, PVC outer sheath conforming to IS: 1554 Part I.

Control Cable: 1.1 KV grade, 70 deg. C rating, PVC control cable h with annealed copper conductor, PVC inner sheath, galvanized flat/wire armoured, overall PVC sheath conforming to IS: 1554 Part I.

10.6.9 Local Control Panel

10.6.9.1 *Construction*

Sheet steel clad, fabricated out of 2.5 mm thickness CRCA sheet steel. The panels shall have (Lift Off Type) hinged doors, capable of being opened through 180 deg. A packet shall be provided on panel door for cable termination charts which are also in the purchaser's scope. All doors shall be supplied with built-in locking facility. All doors, removable covers and plates shall be gasketed all around with neoprene gaskets.

In case of floor-mounted type, panels shall be supplied complete with foundation and lifting eyebolts along with panel base frames for foundation.

10.6.9.2 *Enclosure Protection*

Dust and vermin proof, IP: 54 for indoor & IP: 55 for outdoor.

10.6.9.3 ***Push Buttons/Control Switches***

Push buttons shall be shrouded and spring return type. "STOP" push button shall be mushroom-headed stay-put type lockable in pressed condition.

Local push button station on the berth shall possess IP: 65 degree of protection.

10.6.10 **Safety Switches**

10.6.10.1 ***Pull Cord Emergency Switches***

Heavy duty enclosed epoxy painted dust and vermin proof Pull Cord Switches with IP-65 degree of protection shall be provided on both sides of conveyor at intervals of about 50 meters.

10.6.10.2 ***Belt Side Travel Switches (BSTS)***

Heavy duty long vertical roller lever type belt side travel switches in epoxy painted IP 65 protected enclosure, shall be provided on both sides of Belt Conveyors at transition point near head end and tail end respectively.

10.6.10.3 ***Zero Speed Switches***

A non-contact electronic type Zero Speed Switch shall be provided on a tail end pulley of each Belt Conveyor.

11 MOBILE HARBOUR CRANE

11.1 OPERATING CONDITIONS

Mobile Harbour Crane shall be of rubber-tyred, self-contained construction and shall be equipped with a diesel engine as a prime mover for crane operation and travelling. The crane shall be of four-rope construction and shall be designed and equipped for multi-purpose operation like general cargo handling, bagged cargos, heavy lift operation as well as containers with automatic Spreader and bulk handling with suitable four rope grab. Crane will cater to barge up to 3000 DWT size with the dimension of 95 x 15 x 2.5.

Being a new terminal and to have edge in the industry market, equipment should have maximum efficiency to perform highest in its class.

11.2 MAIN TECHNICAL REQUIREMENTS

The following minimum operating characteristics are required:

11.2.1 Load Capacities

11.2.1.1 *General Cargo Handling*

The crane shall have a lifting capacity of minimum 40T on hook up to a radius of 20 m from crane centerline.

11.2.1.2 *Four Rope Grab Operation*

The crane shall have a lifting capacity of minimum 20T in grab mode up to a radius of 20 m from crane centerline.

11.2.1.3 *For Container Handling*

The crane shall have a lifting capacity of minimum 30T under spreader up to a radius of 20 m from crane centerline. Spreader weight is about 7.6 t.

Total weight of the loaded container considered as 30 T.

11.2.2 Classification of Crane and Machinery

The crane and its machinery shall be classified according to the FEM 1.001 (Rules for the Design of Hoisting Appliances) and shall have the following minimum classifications:

11.2.2.1 *Crane Classification*

Heavy lift operation 50 T on hook	– A4
Grab Operation	– A8
Container Operation	– A7

11.2.3 Operating Speeds

The following speeds shall be provided as a minimum:

Hoisting/ Lowering	0-50 m/min
Slewing	0-1.2 rpm
Luffing	0-40 m/min
Travelling	0-60 m/min

11.2.4 Main Dimensions:

Minimum outreach of the boom from crane centerline	20 m
Height of boom pivot point above ground	minimum 8 m
Height of eye level in tower cab	minimum 13 m
Maximum hoisting height on hook above ground	minimum 33.5 m
Minimum hoisting height on hook below ground	10 m

11.2.5 Quay Load Arrangements

Uniformly distributed load under pad	1.5 T/m ²
Max. Load per tyre	5 T

11.2.6 Environmental Conditions

The crane shall be designed to work safely and reliably under the following environmental conditions:

Temperature range	±25°C
Maximum operating wind speed	24 m/s
Maximum wind speed for travelling	24 m/s
Maximum wind speed out of operation with boom in steepest position	46 m/s

11.2.7 Detail Technical Requirements

11.2.7.1 Chassis

The chassis of the crane shall be constructed as a welded steel structure in a stiff box design to carry the forces and moments occurring in crane and travel operation.

The steel structure of the chassis shall be fitted with two head beams for accommodation of the stabiliser beams, which are extended and retracted by means of hydraulic cylinders inside the head beams. By means of hydraulic cylinders the stabiliser pads shall be lowered, to prop the crane, and raised. The stabilisers should be operated in automatic or manual modes.

Access from quay to chassis shall be provided by stairways at the end of the chassis. The superstructure shall be accessible from the chassis in every position of the superstructure to allow safe exit in case of an emergency.

The stabiliser pads shall be pivotably mounted on the jack cylinders and shall be easily removable.

The filler neck for filling the fuel tank shall be located at the chassis at ground level in order to enable refilling of the fuel tank during crane operation.

The axles and axle suspensions shall be of robust low-maintenance mechanical design and shall be equipped with tyres of large diameter in order to allow safe travelling also in case of uneven ground. The axle suspension system shall compensate height differences of ± 250 mm in order to cross obstacles (> 100 mm) such as rails and dips without difficulty. The number of individual components of the travelling gear and the suspension system shall be kept to a minimum in order to avoid frequent failures of components.

The steering system shall allow conventional travelling and steering motions as well as crab steering to facilitate slight sideward movements of the crane. All steering manoeuvres shall be safe also at maximum permissible wind speed.

The chassis shall be equipped with a weather proof cab at the front side near ground level, equipped with a detachable control panel which can be used wirelessly as well. The chassis cab shall be equipped as a minimum with an adjustable driver seat, safety glass, a heater system, a ventilation system, wiper and washer system.

In the steel structure of the chassis four fixed lifting points for lifting the fully mounted crane shall be incorporated in order to allow transport of the crane in fully rigged condition.

11.2.7.2 Superstructure

The superstructure shall be a stiff welded steel load-bearing structure designed to carry all the forces and moments occurring in crane operation. The superstructure shall accommodate the diesel-generator system, the hoist, the slewing gear, the pressure oil unit as well as a fully enclosed electrics room.

The access route to the tower cab shall be via walkways and stairways at the outside of the machinery house in order to keep crane operators out of the machinery room due to safety considerations.

11.2.7.3 **Main Drive System**

The crane shall have a diesel-electric drive system in order to provide maximum efficiency and lowest operating costs.

An adequately dimensioned diesel generator set shall be located in a separate room of the superstructure. The diesel engine shall be running at constant speed and shall be connected to a three-phase generator. Diesel engine and generator shall be installed in a common containerized room in order to facilitate exchange of the entire set in case of a failure.

The crane shall be prepared for running on electrical shore power supply as well. An electrical cabinet at the chassis shall be provided with terminals to feed the crane for full crane operation from a shore power supply in case of a diesel engine failure. This also shall act as a preparation for retrofitting a full electrical shore power supply (incl. cable reel and trailing cable) in the future without the need of further internal installations (cabling, slip ring, motors etc.). In case of full electric operation regenerated energy shall be fed back to the shore grid when braking or lowering the load to minimize energy consumption.

11.2.7.4 **Hoist**

The crane shall be equipped with a hoist system comprising one rope drum, one completely enclosed spur gear reduction unit, spring-loaded disc brake and an electric motor. The hoist ropes shall be coiled in one layer on the milled rope drum in order to keep the wear low. A nearly horizontal load path during luffing is required. The number of individual components of the hoisting gear shall be kept to a minimum in order to avoid frequent failures of components.

11.2.7.5 **Slewing Gear**

The superstructure shall be 360 degrees rotatable. The slewing gear shall consist of an electric motor, a disc brake, a three-row roller bearing slew ring with internal toothing and a fully enclosed planetary reduction gear unit.

11.2.7.6 **Luffing Gear**

The boom shall be luffed in and out by means of a hydraulic luffing cylinder that holds the boom in position. The luffing cylinder shall be mounted below the boom in order to avoid the boom falling down in case of a rupture.

The valve block shall be located directly at the bottom of the cylinder and shall be equipped with safety valves which hold the oil pressure inside the cylinder even in case of hose damage. The valve block shall be accessible from a platform without the need of using personal protective equipment.

11.2.7.7 **Tower**

The crane shall have a tower with a high boom pivot point, a suspension for the tower cab, support for the rope pulleys as well as means of access to the tower cab inside the tower construction. This access shall be designed in a spacious way having a stair angle of maximum 50 degree from horizontal. Spiral staircases shall be avoided to facilitate access.

Sufficient maintenance platforms for boom pivot point and for the rope pulleys are to be provided.

11.2.7.8 **Boom**

The boom shall be of a welded tubular-lattice design having three chords. The connecting chords and cross-members of the boom shall be welded by special castings in order to improve the notch effect and to decrease the possibility of cracking.

A motorized cable reel at the boom head shall be provided to coil and uncoil the electrical cable for hook rotator, automatic spreaders, electro-hydraulic grabs, magnetic lifting devices etc.

11.2.7.9 **Tower Cab**

The crane operator shall be able to operate and control all functions of the crane from a spacious, ergonomically designed tower cab having large windows and a cab position high on the tower.

The tower cab shall be made of steel plates and sections which are protected against corrosion in a salt-laden, marine environment by a tried-and-tested paint finish. The cab shall be fitted with safety glass windows. The non-glazed surfaces shall be panelled with a heat and sound insulating material having a dark colour scheme to minimise reflections from the windscreen.

As a minimum the cab shall have the following features: adjustable upholstered operator seat, a front window with variable opening, all controls and indicators for crane operation and travelling, air outlets, air conditioner, electric heaters, wiper and washer system, lighting, communication system, CD radio.

The crane shall be equipped with a crane management system, displaying all the crane functions in an easy-to-understand form on a colour screen near the crane operator seat. The majority of the functions shall be selected with function keys on the screen, minimizing the number of individual hardware function keys next to the operator's seat.

11.2.7.10 **Hook Rotator**

A motorized electro-hydraulic hook rotator with ramshorn hook shall be provided.

11.2.7.11 **Lubrication System**

An automated motorized lubrication system for boom pivot point, luffing cylinder pivot points, slew bearing and slew pinion shall be installed.

11.2.7.12 **Safety Equipment**

The crane shall provide the following safety equipment as a minimum:

- Safe load indicator
- Mechanical interlock of chassis and superstructure during travelling
- Stabiliser monitoring
- State-of-the-art electronic limit switching system
- Safety valves at hydraulic cylinders
- Anemometer
- Emergency stop buttons at various locations of the crane
- Video camera at the boom tip
- Appropriate lighting system for night-time operation
- Crane management system (optional)

11.2.7.13 **Electrics Room**

A totally enclosed and lockable electrics room shall be provided for accommodation of the crane control system as well as the electric control equipment. The electrics room shall be completely separated from the machinery room(s) and shall have a separate entrance door.

The electrics room shall be dust-proof. Sufficient split-type air conditioners and heating measures shall be provided.

11.2.7.14 **Electrical Control System / Central Control Computer**

All crane functions shall be controlled and monitored by a programmable logic controller (PLC). The PLC hardware and software system shall be of an international well-known brand, preferably Siemens, to facilitate maintenance and troubleshooting by local engineers without the need of prior extensive special training on the manufacturer's own system.

As an option the bidder shall include a web based remote monitoring system displaying main crane operation figures, crane maintenance issues and crane faults in real-time via a 3G mobile network connection. The monitoring capability shall be accessible via any web-linked computer via a standard web browser client.

The crane must not have any proprietary electric or electronic control components that prevent the port from acquiring parts or services from local or third parties. Electronic control

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components of the crane shall be available from third parties within India and not only through the crane manufacturer. In addition, purchase should have an option to source the parts locally through respective OEMs.

12 GANTRY TYPE GRAB CRANE

12.1 SYSTEM DESCRIPTION

2 nos. Gantry Type Grab Crane are proposed for transshipping coal from 6000 T barge to 3000 T barge as shown in drawing number I-525/HT/1018.

12.2 MATERIAL HANDLED & BARGE SIZE

Physical Properties of coal to be handled are furnished below:-

Sl. No.	Description	Specification
a)	Material handled	Coal
b)	Bulk Density	0.8 t/m ³ {for volumetric calculation}
		1.2 t/m ³ {for structural design}
c)	Angle of Repose	37 Degree
d)	Angle of Surcharge	20 Degree
e)	Abrasiveness	Moderately Abrasive
g)	Lump size	-75 mm

Barge Size

Sl. No.	Barge Capacity (DWT)	Dimension (m)
a)	6000	120 x 17 x 6
b)	3000	95 x 15 x 2.5

12.3 DESIGN REQUIREMENT

- Capacity of each Gantry Type Grab Crane shall be such so that both cranes will be able to unload 2 numbers of 6000 T barge and simultaneously load 4 numbers of 3000 T barge within 20 hrs.
- The design of the equipment shall be such that both 6000 T & 3000 T barge can be berthed and de-berthed without any interference.
- Gantry Type Grab Crane shall be designed and built to operate under outdoor conditions at guaranteed operating / design capacity furnished in this specification considering continuous duty of 24hr/day, ambient temperature and under climatic and ambient conditions at site.
- The cranes and its machinery shall be designed as per FEM1.001 (rules for the design of hoisting application).

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- e) The equipment shall be suitable for handling damp and sticky coal during monsoon season with moisture content of 31% and fines (-1 mm) up to 40%.
- f) The equipment shall be capable of performing unloading/loading operations for wind velocity upto 25m/sec.
- g) The boom of crane shall have adequate length which will be able to cover both the barges for loading/unloading coal at berth as shown in Drawing no I-525/HT/1018.
- h) The equipment structure shall be stable, free on wheels during wind pressures corresponding to wind velocity of upto basic wind speed of 50 m/sec as per IS 875 (Part III) during non-operating condition. However, anchoring device and suitable anchor points on the equipment are to be provided, as stand-by for holding the equipment during storm condition.
- i) Equipment shall be stable under all operating conditions including when some portion of the machine touches the ground or the barge.
- j) Suitable crane or monorail with electric hoist shall be provided to handle items requiring maintenance/replacement on the machine.
- k) Common/ Composite Cable reeling drum for Control and Power Supply shall be provided and shall be mounted on the equipment structure.
- l) End Buffers shall be installed at the end of each long travel track. The buffers shall be rubber/ spring operated. The same shall be designed in such a way that the collision forces are distributed / absorbed without transferring that to the berth. Buffers installed on the crane structure shall be hydraulically dampened.
- m) Required information and drawings showing static and dynamic loads shall be supplied to the client to design and construct necessary foundation work falling under scope of others.
- n) Hand Appliances for fire protection shall be provided on board of the machine as per IS: 2190.
- o) Operator's cabin with all controls shall be provided at a suitable location to have an unhindered view of the handling operation. Bidder to provide the suitable location of Operator's Cabin in their drawing in the tendering stage for satisfactory operations.
- p) The crane shall be capable of unloading/loading the coal without moving the barge. Equipment shall be anchored and the locations shall be shown by the Bidder.

12.4 TECHNICAL SPECIFICATION

12.4.1 General

All crane described herein is electric powered, rail-mounted type for handling bulk materials as specified.

All equipment supplied shall be complete in all aspects as the machines will perform as specified.

Bidder based on International sources shall have due consideration for maximizing components, which have service / support in India. Bidder shall list out the availability of such facilities and the details of arrangement the Bidder could arrange in the event of award.

In general, the machines shall operate within the constraints and infrastructures as described. This shall include climatic conditions, materials handled, stability, performance expected, interfaces described and for future installations.

The mandatory clearances and interface limitations, machine and human safety requirements shall be respected in all modes of operation.

Stability of all machines shall be unconditional for all operating and non-operating loads, including but not limited to: portal and boom collisions; operating and non-operating wind; grab overloads. All possible loading combinations shall be examined in this regard. All machines shall be stable (from over-tipping) free on rails under all conditions.

The grab trolley shall be rope operated and shall carry out barge unloading/loading operations with a rope operated grab.

12.4.2 Crane Components

12.4.2.1 *Gantry Structure*

The Gantry structure shall be a rigid and robust support to minimize structural distortion and to distribute the loads to ensure well distributed corner loading. The gantry shall be a four point; four corner fully equalized support system. The gantry structure shall incorporate the long travel drive assemblies.

12.4.2.2 *Trolley and Boom*

The horizontal boom shall support the rope or motor driven (main trolley) trolley and shall have adequate length which will be able to cover both the barges and berth to comfortably allow grab operation.

12.4.2.3 *Long Travel Drives*

- a) Long travel drives for all machines shall achieve specified speeds in all combinations of operating weather, loading conditions, and track tolerances, specified herein.

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- b) Drives shall be electric motor driven mechanical type with gear reducers shaft mounted on the driven wheels. Torque reaction shall be via flexible mounting on bogie. Reducer shall not be self-locking.
- c) Brakes shall be separate assemblies mounted on motor or reducer high speed shaft. Brakes shall be mainly used as holding brakes. Capacity of each brake shall not be less than 150% of the full load motor torque.
- d) At least half the wheels shall be driven.
- e) Drive speed shall be infinitely variable in both travel directions, from 0-100% of nominal speed. This shall be accomplished with inverter duty, AC 415 V, 3 phase motors, variable frequency drives (VFD) / hydraulic drive, controlled machine acceleration and deceleration shall be field adjustable. VFD shall operate in all modes necessary to accomplish dynamic braking under all wind and load operating conditions. Load sharing between multiple drive shall be done electronically.
- f) Sustained constant speed travel shall be available and possible from 10% to 100% of nominal speed, for continuous operation.
- g) All drive components shall be capable of withstanding loads safely from overdriven or reversing loads due to wind loads, power failures or braking.
- h) The un-loader assembly shall be fully equalized to ensure all wheels share the load equally.
- i) Hydraulic buffers shall be provided at each corner of the carriage. End buffers shall have sufficient capacity to stop the equipment travelling at maximum speed.
- j) Rail cleaners shall be provided at the outer end of each bogie to clear the rails of any obstruction. The rail cleaners shall be adjusted vertically.
- k) Provisions shall be made at each corner of the under carriage for jacking to permit the removal of travelling wheels/bogies. The jacks required for replacement shall be the part of supply.
- l) All wheels shall be mounted on shaft with self-aligning bearings.

12.4.2.4 *Trolley Travel*

- a) The trolley with double-flanged wheels/rollers shall be mounted on rails fitted on boom structure. Elastic pads of suitable thickness shall be provided underneath the trolley rail to reduce vibration and shock load transferred on to the machine structure. Rails shall be installed in a manner that permits easy replacement.
- b) The trolley shall be rope driven / motor driven and shall have built-in safeguard against differential tension in the ropes.
- c) Maximum trolley travel shall be restricted by end buffers. Buffers shall have sufficient capacity to stop the trolley when it travels at its maximum speed with full load.
- d) Trolley design shall be in such a way that in case of breakdown of wheel/axle and during derailment, the trolley does not fall.

12.4.2.5 **Grab Hoisting & Lowering Mechanism**

- a) In case of grabbing operation, system used shall ensure an equal division of the hoisted load between the closing and holding ropes.
- b) Both closing and holding ropes shall be designed for the factor of safety 6 when the grab is fully loaded during cream digging.
- c) Ropes shall be laid in opposite direction for holding and closing the bucket for improved bucket stability. Ropes with ordinary lay shall be used.
- d) Over-winding and slack-winding detectors shall be built in each drum.

12.4.2.6 **Wire Ropes**

All wire ropes shall conform to IS: 2266. The tensile strength of the wire shall be 175-190 Kg/sq.mm.

All wire ropes shall be pre-formed or IWRC, ordinary lay construction, unless otherwise specified.

The fleet of the rope shall not exceed 1 in 12 for any relative position of the sheave/drum assemblies.

All wire rope terminations shall be made with solid forged thimbles and splices shall be mechanical splices made with aluminium or copper ferrules.

Unless otherwise specified, factor of safety for wire ropes shall not be less than 6, based on the nominal breaking strength and the working tension of the rope.

12.4.2.7 **Wire Ropes Sheaves**

Wire rope sheaves shall be made of cast steel or fabricated with groove surfaces hardened to 320 BHN minimum. The sheaves shall have machined grooves of uniform diameter accurately turned and finished smooth. The groove depth, contour, angle and radius shall be as per recommendations in IS: 3177.

The diameter of the sheaves measured at the bottom of the groove shall be as per recommendation in IS: 3177.

12.4.2.8 **Wire Rope Drums**

Drums shall be made of cast steel or fabricated from structural steel conforming to the relevant materials specification. The size, length, diameters, grooving, anchorage and strength of the grooved drums shall be as specified and as recommended in IS: 3177. Grooved drums shall not have more than one layer of rope on the drum when the rope is in its fully wound position.

12.4.2.9 Shafts and Axles

All shafts less than 50 mm dia. shall be made of cold drawn wrought steel. All shafts over 50 dia. shall be of forged steel. Shafts shall be machined all over and the finish under the bearings shall be to the degree and tolerance required by the bearing manufacturer.

Generous fillets or long taper shall be provided at each end of the swell.

Truck axles shall be of forged steel.

In the case of design of shafts and axles based on strength, the computed bending and torsional moments in the shaft or axle shall be multiplied by the load service factors K_m and K_t respectively.

Nature of Load	Load Service Factors	K_m	K_t
Stationary Shafts	Gradually Applied Loads	1.0	1.0
Axles	Suddenly Applied Loads	1.5 to 2.0	1.5 to 2.0
Rotating Shafts & Axles	Gradually Applied & Steady Loads	1.5	1.0
	Suddenly Applied & Minor Loads	1.5 to 2.0	1.5 to 2.0
	Suddenly Applied & Heavy Shock Loads	2.0 to 3.0	1.5 to 3.0

Shafts and axles shall be checked for deflection and slope as specified below.

- The deflection of shafts and axles shall not exceed $1/1500$ of the distance between bearing centres.
- Shafts carrying toothed gearing shall be sized so that the relative slope of the two shafts shall be limited to 0.0005 mm of face, at the mesh.

12.4.2.10 Pins

All pins except those used for rotation or oscillating duty shall be of wrought steel (cold drawn) and machined all over. All pins subjected to wear due to rotation or oscillation shall be case hardened, ground and polished. Surface hardness shall be 80 to 85 Shore and the depth of case hardening 1 mm minimum. The maximum permissible stresses in the design of pins shall be as follows:

Stress Mode Permissible Stress

Stress Mode	Permissible Stress
Bending Stress	33% of Yield Stress
Shear Stress	22.5% of Yield Stress
Bearing Stress	40% of Yield Stress

12.4.2.11 Fasteners and Keys

All gears, pinions, wheels, couplings, etc. subjected to torsion shall be keyed to the shafts using parallel keys and keyways in accordance with IS: 2048. Idlers may be press fitted on the shafts. Fits and tolerances shall be in accordance with IS: 919, IS: 210 and IS: 2709.

Set screws shall not be used for transmitting torsion but may be used for holding keys or light parts in place.

Unless otherwise specified all holding down bolts and machinery bolts shall conform to IS: 1363 for bolts of 6 to 39 mm dia and to IS:3138 for all bolts larger than 39 mm. Friction grip bolts shall conform to IS:3757.

Plain washers conforming to IS:2016 shall be used under bolt heads and nuts, whenever the material is softer than the bolts themselves. Spring or lock washers shall be used throughout for assembly of all machinery subject to vibration loads. All bolts, nuts and washers shall be galvanized.

12.4.2.12 Castings

All castings shall be sound and free from pin holes or imperfections. Outside surface shall be well sand blasted and smooth. Critical castings shall be checked for internal flaws by x-ray and/or ultrasonic methods.

All castings shall have well-rounded corners and generous fillets to avoid stress concentrations.

All boss facings under bolt heads shall be machined.

Steel castings shall be stress relieved by suitable heat treatment.

12.4.2.13 Holes

All holes for fitting bolts and pins shall be drilled / reamed. Flame cut or punched holes will not be accepted.

Unless otherwise specified, clearance holes for metric bolts shall be as per IS: 1821 (medium).

12.4.2.14 Base Plates

Each base plate shall be single-piece of welded steel construction.

They shall be designed with sufficient depth and stiffness to ensure rigidity of drive assembly.

All machinery mounting surfaces shall be machined. Base plates shall be provided with lockable adjustment screws to facilitate alignment of speed reducers, motors and brakes.

12.4.2.15 ***Bearings, Bearing Seals & Pillow Blocks***

Wherever practicable, bearings shall be of the antifriction type, (ball, roller, taper roller) with a minimum life expectancy compatible with the class of the mechanism with which they are used, unless specified otherwise. Plain bearings shall not be used, unless approved by the Employer/ Employer's Representative.

On shafts supported by two bearings one bearing shall be a fixed type and the other a floating type to allow for thermal expansion of the shaft.

All bearing housings and pillow blocks shall be fitted with labyrinth-type seals, suitable for operation in an atmosphere containing very fine and abrasive dust and saline water spray.

All spherical roller bearings in pillow blocks shall have taper bores and adapter sleeves for locating on shafts.

Pillow blocks shall be of cast steel construction.

Base plates for pillow blocks shall be provided with lockable adjusting screws for accurate bearing alignment.

Plain bearings (if used) shall have bronze bushings. The bearing pressure on plain bearings shall not exceed the manufacturers' recommended ratings for the material used and the application. The plain bearing shall have grease grooves and labyrinth type seals to prevent entrance of dust into bearing.

12.4.2.16 ***Gear Reducers***

All equipment supplied shall be of approved manufacture, unless otherwise specified. The equipment shall be the Supplier's normal design suitable for the duty specified. Replacement gears, bearings and seals shall be readily available in India. Reducers shall be of the helical, bevel helical or planetary gear type. Reducers shall be capable of being driven in either direction at the rated capacity without reduction of the specified design life. Hollow shaft drives may be avoided.

All components of speed reducers shall be designed for continuous duty at maximum demand power with capacity to stop and start under fully loaded conditions. The speed reducer shall also be designed to allow back driving through the reducer to the motor.

The thermal rating for reducer operation shall be based on the lubricating oil bulk (or sump) temperature not exceeding 80°C for maximum ambient temperature and shall not be less than the installed motor power. The use of mineral oils is preferred. The use of synthetic oils shall be subject to specific approval by the Employer/ Employer's Representative.

Reducer's durability service factor and strength factor shall be 1.5 and 2.5 respectively based on motor power.

All gearing shall be capable of safely withstanding not less than the full peak torque of the drive motor applied twice in direct succession. The reducer shall be capable of not less than 10 full load starts per hour. When the braking torque is applied to the high speed shaft and the braking torque exceeds the starting torque, then the braking torque shall be considered in the selection of the speed reducer.

Overhung loads generated by flywheels and / or brakes and / or fluid couplings shall not exceed the speed reducer manufacturer's recommendation. If excessive overhung load can be induced, these items shall be mounted between pedestal bearings with flexible coupling used between both the motor shaft and the reducer input shaft.

The reducer casings shall be steel fabricated. The welding shall be oil-tight and the housing stress relieved after welding, and prior to any machining. Reducer casings shall be provided with easily removable inspection covers to allow the reducer internals to be viewed without disturbing the drive. Reducer casings shall be provided with lifting lugs, oil filling cap, a visible oil level indicator, a side located oil drain, an air-breather and a permanent magnet plug.

Provision shall be made in the casing design for horizontal alignment of the reducer in longitudinal and transverse direction, as well as vertical adjustment. Mounting areas for attachment of vibration monitoring transducers shall be provided adjacent to all bearings. The vibration transducers may be either fixed or temporary magnet mounted type.

A drilled and tapped connection shall be provided for installation of a temperature transducer.

The connection shall be such that transducer oil well is covered with oil. The hole shall be plugged.

Adequate means of lubrication for all gears and bearings shall be maintained at all operating positions of the reducers. Splash lubrication using mineral oil is preferred. Where pumped lubrication is unavoidable, the pump suction shall remain submerged in the lubricant for all operating positions of the reducer. A pressure gauge and an adjustable oil flow switch shall be fitted to the delivery line from the pump. The reducer identification plate shall specify the required oil type and quantity. Oil sampling points shall be fitted in a suitable location to allow sampling when operating.

Bearings shall be of standard type and size readily available in India. Bearing selection and life shall be in accordance with specifications herein.

All reducer shaft seals shall be of the "labyrinth and double lip neoprene" type with provision to purge with grease. TACONITE type seals or modified TACONITE type with non-contact lip seals are preferred or approved equivalents.

It is preferred that reducers be rated with sufficient thermal capacity so that fan cooling will not be required. If fan cooling is used, then the fan impeller shall be of the split type to facilitate replacement without removal of the couplings and/or disturbing the alignment of

any component in the drive. External oil coolers shall not be used, unless approved by Employer/ Employer's Representative.

The following applies to a holdback integral with the speed reducer (where ever applicable):

- The holdback shall be rated to a minimum of 3 x maximum hold back torque transmitted to the speed reducer or equal to the locked rotor torque of the motor whichever is the greater.
- The holdback shall be fitted externally to the speed reducer on an extension of an intermediate speed shaft of the reducer is on the side away from the driven machine.
- Holdbacks shall be lubricated independently with the same grade oil as that of the reducer.
- The holdback shall be suitably covered and sealed but the holdback shall be readily accessible for removal, disconnection or reversal of direction of rotation without dismantling the reducer, opening the reducer casing, removing the high speed coupling or disturbing the alignment of any components in the drive.
- The holdback shall be designed to allow controlled release under full load.
- Direction of rotation shall be clearly stamped outside of the holdback cover.

Un-machined external surfaces of the speed reducer shall be painted in accordance with specifications herein. Machined surfaces shall be suitably protected from rusting during transport and storage with an easily removable coating. Threads on casing locating dowels shall be covered with a thread anti-seize solution (Kopr-Kote or equivalent) prior to installing the nut.

12.4.2.17 **Mechanical Brakes**

Brakes shall be fail-safe and applied upon loss of electrical power. Brakes shall be spring or counterweight applied. Caliper type brakes (disc brake) for 'Hold', 'Close' and 'Trolley' (Grab Un-loader), etc., shall be provided.

Electric braking system, wherever it can be justified, shall always be supplemented by mechanical braking system.

Brakes shall be equally effective in both directions of shaft rotation.

Brakes shall generally be mounted outside either on motor shaft or on high speed shaft of reducer. Integrated brakes, for instance with motor or reducer are not acceptable (Exception: cable reeling drums and electric wire rope hoist).

The braking torque shall not be less than 1.5 x motor full load torque.

The brakes shall be capable of dissipating, without external cooling, energy released by stopping the machine or machine assembly twice in immediate succession plus the required

number of equally spaced stops per hour as would be applicable to the duty. For conveyors this shall be not less than 8 stops per hour.

Braking equipment located outdoors shall be designed to operate in a highly abrasive dust laden atmosphere, and shall be high pressure hose proof.

12.4.2.18 **Lubrication**

Lubrication shall be provided for each rotating part or sliding ways that operate continuously when equipment is in operation. As far as possible centralized grease system with hand operated pumping units with reservoir having sufficient storage capacity, unless otherwise specified, shall be provided. Hand operated pumping unit as stand-by arrangement shall be quoted with each motorized unit.

Panel type centralized grease lubrication system shall include but not be limited to the following groups of machinery.

- All truck axles and drive shaft bearings of all equipment;
- Closing, holding and traversing rope machinery of grab un-loader.

Each of the systems shall be designed to ensure positive lubrication at every point and to supply a measured quantity of lubricant to each lubrication point whenever the pump is operated.

Each system shall be equipped with one motor operated high pressure pump (wherever the system is motorized) and all necessary components, including relief valves, vent valves, filters, pressure indicators, manifold or distributor block, etc.

All lubrication fittings, bushings, brackets, support clips, piping, etc. shall be provided for the efficient installation of each system. All fittings shall be standardized to IS 4009.

Extra strong wrought steel pipes shall be used for main header lines and bundy tubing for branch lines to individual greasing points. All pipes shall withstand 100% higher pressure than maximum applied by the pump.

Visual indicators shall register any single line blockage.

Extension of lines from header shall be maximum of 10 m.

If lubrication is required at a moving point, coupled wire braid reinforced lubricant hose shall be used.

12.4.2.19 **Hydraulic Systems**

Hydraulic Systems shall be designed to operate in a highly abrasive dust-laden atmosphere. All equipment shall be suitable for high-pressure wash down. The equipment shall be of standard design selected to meet the specified operating conditions with special emphasis on safety,

efficiency, reliability and maintainability. Components (eg. Pumps, valves, pipe fittings, instrumentation, bearings and the like) shall be manufactured or readily available in India.

Hydraulic components shall be arranged so they can be serviced with safety. In order to ensure long life of equipment, it would be preferred to keep the working pressure below 15 MPa. Working pressures of 20 MPa shall not be exceeded. Backpressure in drain lines shall not exceed 70 kPa. The design of hydraulic systems shall provide for smooth movement of hydraulic activators (pumps, motors, cylinders), free from sudden stop and start effects and be capable of either continuous or stop / start operation. The circuit shall be designed to prevent uncontrolled movement of hydraulic actuators at any time.

Maximum use of hydraulic manifolds with sub plate-mounted valves shall be made to minimize the use of hydraulic pipe / hose runs. Hydraulic manifolds and connections between the individual items of equipment within a unit shall be shop assembled.

Air bleeds shall be provided at all points where the system shall need to be bled. Hydraulic circuits shall be designed and manufactured to minimize surge pressures. The components shall be designed to withstand such surge pressures. Hydraulic circuits containing accumulators shall be designed for safe operation and maintenance. The design shall make provision for isolation of the accumulators and release of stored energy. Careful attention shall be given to circuit design to the possibility of pressure intensification across hydraulic cylinders. Where this is considered a possibility, means shall be provided to prevent this occurring, during operation or maintenance.

Equipment shall be air cooled unless otherwise approved by Employer/ Employer's Representative. Fluid temperature shall not exceed 60°C at the pump inlet or 70°C elsewhere in the circuit. The system capacity shall be sufficient to maintain hydraulic oil temperature within the hydraulic oil manufacturer's recommended range at continuous full load while operating at maximum ambient temperature.

Hydraulic system shall include the following but not limited to the mentioned list for the effective operation.

- a) Hydraulic variable displacement pumps of the axial piston type and fixed displacement pumps of the gear type.
- b) Hydraulic drive motors either of the axial piston or rotary vane type.
- c) Hydraulic cylinders of heavy-duty repairable construction with progressive cushions at both ends.
- d) Hydraulic system valves suitable for heavy-duty service.
- e) Hydraulic system valve panels to ensure good access to oil control and pipe connections.
- f) Hydraulic system power packs designed as a self contained pack for continuous 24 hour per day operation.
- g) Hydraulic system oil tanks including, but not limited to, Internal baffles, Low oil level float switch, Oil temperature gauge, High oil temperature switch, Magnetic drain plug or

suspended magnet, Oil level sight gauge showing maximum and minimum levels, Drain fitted with ball valve and hose adaptor minimum 25 mm diameter, Fill point with quick connect coupling and filter and Oil sampling test points.

- h) Hydraulic system accumulators of nitrogen charged diaphragm type sized to have a volume of 50% in excess of the theoretical design working volume.
- i) Hydraulic system filters with renewable cartridge type filter element.
- j) Hydraulic system pressure gauges to indicate system pressure in the main pressure lines and the boost pressure lines.
- k) Hydraulic system oil coolers provided to keep the oil temperature within the ambient temperature.
- l) Hydraulic system piping of stainless steel seamless tube.
- m) Hydraulic system flexible hoses provided between piping and hydraulic motors, and cylinders.

12.4.2.20 **Operator's Control Cabin**

- a) The Control Cabin shall be of ergonomic, modern design with sufficient glassed area for optimum visibility of the working area. The Contractor(s) shall demonstrate the visibility range from the Operator's Cabin under all operating conditions by means of 3D CAD modeling or demonstration of existing similar cabin concept.
- b) The cabins shall be manufactured from steel framing clad with painted steel sheeting inside and out. Provide heat and noise insulation and dust seals for all doors and windows. It shall also be fitted with a cable access within the floor. Textured SS cladding shall be used in all high mean areas within cabin.
- c) The minimum clear height within the cabin to be 2200 mm. sufficient room shall be provided for a seated operator to swivel 360 deg on the seat.
- d) The windows shall be of approved tinted safety glass. The front and floor windows shall provided for a seated operator to swivel 360 deg on the seat. cleanable and replaceable from inside the cabin.
- e) Safe and easy access to the control cabin shall be provided over the full range of machine operation. The cabin door shall be a hinged type self-closing door with adjustable hydraulic closer and fitted with an approved type of security lock. The cabin is to be designed to maintain comfortable conditions for the Operator under all climatic operating conditions. A window type air-conditioner shall be provided to maintain required temperature inside.
- f) Noise level inside the cabin shall be limited to 60 dB when cabin door and other windows are closed and ventilation system is operating. Vibration inside the cabin shall be limited to such level as to ensure unhampered functioning and safety of all sensitive equipment and also as to ensure operator's comfort for continuous working. Equipment installed inside the operators cabin shall include, but not be limited to the following:
 - Swiveling, height and back adjustable operators chair incorporating joysticks, switches, and push buttons.

- Light fittings with dimmers.
- A minimum of 2 x 240 V, 5 A, 1 Ph, and 2 x 240 V, 15 A, 1 Phase General Purpose Outlets (GPO).
- Telephone – 1 No.
- Fold down jump seat on the back wall to allow for an instructor
- Operators console and monitoring interface as specified.
- Battery operated mains charged Emergency Lighting to provide minimum 15 lux level in cabin and outside of cabin.
- Fire Extinguisher CO2 – 2 Nos. (1 inside & 1 outside)
- Smoke and fire detection system shall be provided including alarm in operator's cabin.
- Handset station for Public Address – 1 No.
- Equipment installed outside the cabin shall include:
- Electrically amplified weatherproof loud hailer.
- Emergency lighting head(s), powered by inside located power pack.
- Window washers and wipers.

It shall be possible for the operator to safely escape the cabin to a convenient walkway from any location along its travel path.

12.4.2.21 **Cable Reeling Drums**

Cable reel with common cable for power and control shall be mounted outdoors on the equipment structure generally as shown on the attached drawings. The Bidder shall provide sufficient length of continuous un-spliced cables ensuring that entire travel length is fully covered and include 4 dead turns and extra length for required terminations.

Trailing cable shall be connected to the payout point with suitable anchoring, turning devices and junction boxes. Payout point may be considered in the centre of long travel. However, exact payout point will be provided only after contract award.

Cable Reel shall be drum wound, electric stall torque motor driven, designed for taking up and paying out the composite trailing cable at an adequate controlled tension regardless of the position of equipment or the Travelling speed of equipment. The reel shall be furnished with collector rings, stall torque, slip ring type motor having IPW 65 degree of protection. The motor shall be suitable for 415V, 3 Ph, 50 Hz operation and shall be equipped with a brake.

It shall be possible to adjust tension of cable by adjusting motor resistance in the field.

The collector ring assembly shall be enclosed in an IPW 65 rated outdoor steel enclosure.

The reel shall possess the following features:

- Epoxy encapsulated watertight collector ring enclosure for moisture protection.

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- Extra space in the collector ring enclosure for stress coning.
- Heavy-duty ball bearing, self-contained collector ring and brush assembly.
- Heavy-duty 100% stall copper bar rotor torque motor totally enclosed non-ventilated with brake.
- Limit switches for cable protection.
- Heavy-duty construction with dry galvanise primer, epoxy enamel finish, and stainless steel fasteners.
- Sheet metal enclosure fabricated with minimum of 10 gauge metal.

12.4.2.22 **Grabs**

Size and capacity of grab shall be determined from the number of operating cycles of the grab to achieve the specified rated free digging capacity.

Clamp shell / Scissor type grab shall be provided for unloading/loading duty of the material and type of barges to be unloaded/loaded.

The grab shall have digging ability to penetrate a crust cover whenever formed on the top of the material due to ingress of moisture inside the barge hatch.

The bucket tips shall be made of abrasion and corrosion resistant steel. The tips shall be easily repairable and replaceable.

Bucket shall be suitable for handling sticky and slushy material as well, in case the material becomes sticky and slushy during ocean voyage, etc.

Design of the bucket shall be such that dust generation and spillage shall be reduced to minimal.

Grab bucket shall be rope operated. Mechanical items, like reeving ropes, shall not come in direct contact of material when scooping.

The bucket attachment block shall be designed to allow for rapid change of the bucket without reeving of the ropes through hoisting drums. The Bidder shall describe in the tender the arrangement proposed, supported with drawing(s). Bidder shall also indicate (and demonstrate in the field in case of award) the time of change over from one grab to another.

The bucket shall be of low headroom type and shall be stable when lowered on inclined surface of material heap inside the hatch.

12.4.2.23 **Machine House**

- i) An all steel construction and weather proof enclosed space shall be provided on the equipment to house the HT Load break switch panel, motor control centre, programmable logic controller, thyristor panels, lighting distribution board, etc.
- ii) The structure shall be lined with anti-condensation and fireproof material.

- iii) It shall be provided with propeller type Vent fan (suitable for minimum 15 air changes / hr) designed to maintain a positive pressure with reference to atmospheric pressure in order to maintain dust free conditions in the interior. Dust tight seals shall be provided for all doors, windows and electric cable entry points.
- iv) The room shall be of adequate size to meet the requirements of Indian Electricity Rules/Tariff Advisory Committee and to provide good access to all equipments for maintenance or disassembly.
- v) Rubber insulating carpet in front of Electrical Panels shall be provided. All cable entries to electrical room shall be sealed with fire resistant compound.
- vi) Smoke and fire detection system shall be provided including alarm in operator's cabin.
- vii) A maintenance electric hoist for lifting components from ground level shall be provided. The hoist shall have sufficient capacity to lift the heaviest single piece of equipment in the machinery house. All equipment shall be accessible by the hoist. Hoisting speed in fully loaded condition shall not be less than 4 m/min.
- viii) Door shall be provided with heavy-duty latches, hinges, door stop and pad lock.
- ix) A chemical toilet complete with perennial hose and spray nozzles shall be installed inside the room complete with wash basin, water tank, piping and pump to bring water from ground level to water tank. The disposal tank of toilet shall be located at suitable level so that it will be accessible for replacing a filled tank with an empty one from the truck bed at berth.
- x) The following accessories shall be provided in the room:
 - Fire extinguishers CO2 - 2 Nos.
 - Telephone - 1 No.
 - Handset station for PA System - 1 No.
 - Battery operated emergency light - 2 Nos.

12.4.2.24 **Diesel Generator Set (Genset)**

A Diesel Generator Set (Genset) to be provided, where indicated, for emergency power, in case of main power failure; for each crane.

Genset shall be rated for 415 V, 3 Ph, intermittent duty with +5% voltage variation, +3% frequency variation, suitable for following functions at 415 V, 3 Ph.

Genset shall serve but not be limited to the following manual operation:

- Travel of Operator's Cab to parking anchorage.
- Long travel of un-loader to berth anchorage.
- Emergency Lighting, if required.

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- Provide adequate power dissipation resistor banks, if required, for emergency motions that operate in power generating quadrants. Ensure that Gensets power system will be stable for all conditions.
- Provide controls and interlocks to allow operator to use generator power to perform the intended operations without overloading the Genset.
- Gensets shall be equipped with a critical engine silencer and exhaust shall be routed away from operating areas.

The emission concentration shall comply with the parameters specified below:

Parameter	Emission Rate (g/s)	Highest Concentration (µg/m ³)	Distance from Source (m)
SPM	1.25	2.21	500 m downwind
CO	14.6	25.9	500 m downwind
HC	5.42	9.61	500 m downwind
Nox	38.3	67.9	500 m downwind

12.4.2.25 *Safety & Control Devices*

Limit switches, position indicators, level indicators, actuating cams and other safety and control devices shall be included but not be limited to the following operations:

Travel

- a. Limit switches for each rail mounted machine unless mentioned otherwise at both ends of travel including two over travel limit switches.
- b. Horn or whistle to sound continuously when machines are travelling, activated 10 seconds prior to start up.
- c. All monorail hoists and cranes having motorised traverse.
- d. Interlock between long travel of equipment and boom.
- e. Interlock of long travel drive of equipment with anti-skewing / anti-crabbing devices.
- f. Encoders shall be provided to indicate the position of the un-loader in the operator's cabin & central control room.

Interlock for anchorage with long travel of outdoor duty equipment.

Wind anemometer at the top of each crane. It shall continuously monitor wind velocity and shall be provided with contacts to permit interlocking with equipment controls and annunciators so that operations shall cease when steady wind velocity exceeds an adjustable limit.

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Anti-collision device on each crane to sense the approach of the other equipment and to energize the travel shut-down (stop) controls and sound alarm.

Interlock between brake / hydraulic coupling and motor wherever drive units have brakes / hydraulic couplings.

Interlock between rail clamps and travel drives.

Interlock between hydraulic power pack and oil level indicator.

Interlock between centralised automatic lubrication system.

Limit switches for the protection of cable in cable reeling drum and festoon cables.

Vibration measurement devices at the machine structures (at least at the tip of boom, Operator's Cabin) shall cut off the supply voltage if abnormal situation continues over a predetermined time.

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13 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.

13.1 SCOPE OF WORK

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 inbuilt 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.

ENVIRONMENT MANAGEMENT PLAN : HALDIATERMINAL

INTRODUCTION

Inland waterways Authority of India (IWAI) has proposed to augment the navigation capacity of waterway NW-1 (Haldia to Allahabad) and continue to maintain the entire stretch. Under this project, IWAI has proposed to develop the infrastructure facility like Multimodal terminals, Navigation aids for day & night navigation, River information system with all hardware and software, Ro-Ro jetties, Bank & slope protection, River training works, Equipment like tow barges, inland vessels, survey vessels including rescue boats & survey equipment and Dredging of the navigation channel, to augment the navigation capacity of the waterway.

An inland water terminal at Haldia is proposed to be developed within Haldia Dock Complex at River Hooghly (NW-1) under this project to enhance the navigation facility of the NW-1. The project is also requirement of Haldia Dock Complex for its economy, better serviceability to end customer and to improve the primary / secondary logistic cost. Location map of the project is given in **Figure 1** below.



Figure 1: Location Map

PROJECT BRIEF

Project involves development of an inland water terminal at River Hooghly (NW-1) proposed to be located at Haldia industrial area, near Durgachawk, Haldia, District Purbi Medinipur, West Bengal. Geographical coordinates of the centre of site are 22°03'38.34"N & 88°08'29.49"E. River Hooghly flows in South direction of the terminal site. Terminal site is well connected by the roads. Site is connected to NH-41 through 7 m paved road (Haldia-Macheda) in North direction. Durgachak Railway Station is about 0.6 km away from the site towards North direction and Haldia railway station is about 12 km away towards west direction. Nearest Airport is at Kolkata which is about

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135 km away from the site in north direction. River Hooghly in this stretch is navigable and local ferries are currently operating in the river for transportation of men and material. Internal roads of width 17 m & 10 m will be developed at project site.

Total area of terminal site is 61.0 acres. The identified land belongs to Haldia Dock Complex. Site is low lying area with elevation ranging from 4-9 m amsl. It is required to fill the site to achieve finished level of 7 m, i.e. 2.54 m above HFL. Soil required for filling is 3.3 lakh cum.

Terminal facility is designed to handle 2.28 MTPA of cargo. Out of 2.28 MTPA of cargo, 1.85 MTPA of cargo comprises of fly ash, 0.11 MTPA of fertilizer, 0.16 MTPA of stone aggregate, 0.16 MTPA of edible oil & POL. These materials will be stored, loaded, unloaded and transported from the terminal site.

Facilities to be developed at terminal site include both onshore and off-shore facilities. Onshore facilities includes 16 nos. of silos for fly ash storage, stockyards for stone aggregates, fertilizers & edible oil/POL, internal roads, administration building, worker's amenity building, lighting tower, power supply system, fire-fighting system, sewerage system, storm water management system, waste management system and green belt (3 acres).

Off-shore facilities include 5 nos. of berths & approach trestles and water approach channel. One of the proposed berths is proposed to be dedicated for imported coal transshipment purpose.

The proposed terminal project will be developed in phases, i.e. phase 1A & 1 B. Phase 1 A will comprises of all the proposed developments except berth proposed for transshipment of coal, 8 nos of fly ash storage silos and its conveyors out of proposed 16 nos. of silos and stockyard development area (future storage).

ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

Effective measures are required to be proposed and implemented during design, preconstruction and construction stage to eliminate or minimize the impact of the project development. **Table 1** provides details of mitigation measures with implementation and supervision responsibility. Indicative costs are also given for few environmental measures, however, these costs has to be assessed by contractor.

Since project is likely to have impact on various components of environment, the monitoring requirement covering soil erosion, tree plantation, air quality, water quality noise, river sedimentation has been defined and included under respective head at **Table 2**.

It will be essential for contractor to comply with applicable regulations and World Bank safeguard requirements. Contractor will also have to comply with applicable standards with respect to Water, air, Noise, Dredge Material, soil and biodiversity as applicable to this project. Environmental management budget including the cost of environmental monitoring during the design, construction and operation phase of the project is given in **Table 3**.

ENVIRONMENT HEALTH AND SAFETY CELL

It is essential to establish environment health and safety cell for the project by contractor to ensure the health & safety of workers and environmental management of study area through effective implementation of EMP. Highly qualified and experienced persons in the field of Environmental Management of Similar projects shall be considered to man the cell who shall ensure the effective implementation of the environment management plan.

REPORTING REQUIREMENTS:

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It is required that contractor will submit quarterly compliance report to Project Management Consultants (PMC) as well as to PMU (Project Management Unit) of IWAI. PMC will analyze the report and notify the corrective action if any required to contractor under intimation to IWAI.

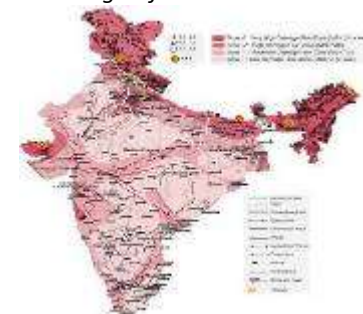
TABLE 1: ENVIRONMENT MANAGEMENT PLAN HALDIA TERMINAL DURING CONSTRUCTION PHASE

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
DESIGN AND CONSTRUCTION PHASE						
1. Climate						
❖ Project is unlikely to cause negative effect on climate. However, project can contribute positively for climate	<ul style="list-style-type: none">Dense green belt in 3 acre area shall be developed along the project premises.Tree species high in organic content like Neem, gulmohar, shisham, pongamia, siris Mango etc should be planted.Provision of alternative energy options like solar energyAdoption of best practices to cut down resources and energy requirement	Kyoto Protocol, National Water Policy, 2012, Forest Conservation Rules & National Forest Policy	Construction site	During Design, and construction stage	Contractor,	IWAI/PMU/PMC ¹

¹ It is proposed to set up Project Unit (PMU) in IWAI to manage social and environmental aspect of NW1 augmentation. PMC (Project Management Consultants) anticipated to be appointed for project management and quality check.

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
2. Natural & Man-made Hazard						
❖ Earthquake- Seismic Zone – III damage risk zone ²	<ul style="list-style-type: none"> Relevant IS code for structures shall be adopted for designing the civil structures to sustain the earthquake of high to very high intensity 	NBC, 2005, local	Construction	During Design	Contractor	IWAI/PM

²IS:1893 (Part 1): 2002 Indian Standard Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions and Buildings Fifth Revision divides the



Indian subcontinent into five seismic zones (I to V) depending on the magnitude and damage intensity of seismic activity.

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Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
<ul style="list-style-type: none"> ❖ Risk of flood & Cyclones ❖ Risks due to occupational hazards and fire 	<ul style="list-style-type: none"> • All facilities developed shall be above HFL of River Hooghly • Regular maintenance and strengthening of the embankments to prevent the erosion and flooding • Emergency preparedness plan should be prepared for situations of cyclone, flood, earthquake and fire and should be available at the site all the time. This plan should be inline with and integrated with the off-site emergency plan prepared for the area. • Employee shall be given training to handle the emergency situation • Site should be vacated in case of cyclone alerts • Location of nearest cyclone shelters shall be located in the map and shall be displayed at the site. Coordination should be done with IMD to receive the cyclone threat and in case of cyclone threats the site should be vacated. • Mock drills to handle the emergency 	building bye laws, state factory rules, Petroleum Rules and MSIHC Rules, 1989	n site & Navigation Channel	n and construction stage.		U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>situation shall be conducted for workers</p> <ul style="list-style-type: none"> Emergency collection area should be provided at the site near the exit gate of the site and all workers should be aware about this collection point and shortest route to reach this place Availability of the first aid boxes and necessary medicine as per State Factory Rules Compulsion for workers to wear PPE while working to prevent injury due to accidents while working Only skilled/trained person should be allowed to do the tasks involving the risk of accidents with due permission of site supervisor/safety officers Separate work procedures and safety procedures should be prepared, if any night time working is involved 					
3. Site Preparation: Levelling Terminal Site, Construction Camp, Construction Works						
❖ Leveling of terminal site & Removal of vegetation	<ul style="list-style-type: none"> Excavation and filling operations should be carried out in parallel so as to minimize the soil erosion Compaction of soil shall be undertaken by sprinkling the water to minimize the erosion Water sprinkling to be carried out for dust suppression Top soil (15 cm) should be stripped and preserved under covered conditions for landscaping purpose in later stage. This should be stored in the form of the heap with the slide slopes covered with grass. Excavated soil should be used within the site for leveling purpose (1.5 lakh cum to be 	<p>Municipal Solid Wastes (Management and Handling) Rules, 2015</p> <p>Hazardous Waste (Management, Handling &</p>	Construction site	Durimg design and Construction Stage	Contractor.	IWAI/PMU/PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>used for leveling). However most of the soil will be used for leveling within the site if remains any it should be used for realignment (diversion) of the existing road.</p> <ul style="list-style-type: none"> • Dredge soil should be either utilized for construction activity or disposed off along with excavated soil to the identified debris disposal site • Green belt (area of 3 acres) should be developed at the site and as per the Green Belt management Plan (Annexure -1) • Survival rate of tree should be regularly monitored. It should be minimum 70%. • Work timings should be restricted from 6:00 AM to 10:00 PM. Adequate illumination should be provided at site during evening hours • Rest area should be provided for workers at site and sleeping/lying down at site should be strictly prohibited to prevent accidents • Develop and obtain approval from IWAI for occupational health & safety management. The plan should follow safety guidelines as given at Annexure -2 and other tools such as OSHAS 18001 • Movement of construction vehicles shall be restricted to the designated haulage roads only to prevent compaction of soil in other areas • The earth stockpiles to be provided with gentle slopes to prevent soil erosion. • Sedimentation tanks shall be provided with storm water drain to arrest the sediments and these sediments shall be removed and stored with remaining excavated soil • Existing river bank protection is sufficient for 	<p>Transboundary) Rules, 2008</p> <p>Forest (Conservation) Act</p> <p>Social Impact Assessment requirements</p>				

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>shore protection.</p> <ul style="list-style-type: none"> Wash-off from concrete mixing tanks and wash from washing area shall not be allowed to enter the soil. This wash shall be collected through drains into tanks and concrete shall be settled, collected, dried and re-used in the site again <p>Solid Waste Management:</p> <ul style="list-style-type: none"> Arrangement should be made for segregation of waste into recyclable and non-recyclable waste Non-recyclable waste generated should be disposed regularly through authorized agency. Recyclable waste should be sold to authorized vendors. Construction waste generated should be segregated at site into recyclable, reusable & rejected fraction. Recyclable should be sold to authorized vendor, reusable waste should be stored at site for usage and rejected fraction and debris should be disposed at waste disposal site of Haldia Development Authority. (Annexure-3) Any waste oil generated from construction machinery that should be stored on concrete platform and disposed off to authorized recyclers. 					
❖ Setting of Construction site/Labor Camps: contamination of land and water resources from	<p>Location of Camp:</p> <ul style="list-style-type: none"> Construction camp sitting, establishment, location and management should be as per proposed Construction & Labour Camp Management Plan (Annexure-4) Labour camps should be located within the construction sites to the extent possible 	The Building and Other Construction workers (Regulation)	Labour Camp Locations	During design and Construction	Contractor.	IW AI/ PM U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
municipal waste from Camps, worker's health, Pressure on natural resources due to establishment of labour camps	Sanitation and Worker's Health & Safety: <ul style="list-style-type: none"> Hygiene in the camps should be maintained by providing good sanitation and cleaning facilities. Soak Pits can be provided only if labour camp is located away from river. Camp should be well ventilated. It should have adequate provision for illumination, kitchen and safe drinking water facility. Proper drainage to be maintained around the sites to avoid water logging leading to disease Proper sanitation facility like toilet and bathing facility should be provided at site and labour camps. Wastewater generated from these facilities should be disposed off through septic tanks and soak pit Preventive medical care to be provided to workers Segregated, collection and disposal of solid waste on regular basis at municipal solid waste disposal location of Haldia development Authority. Provision should be made essential material supply like cooking fuel (gas) Provision should be made for day crèche for children First aid facilities, first aid room, first aid trained personnel and ambulance should be provided at the site 24 X 7. Also tie-ups with local hospital should be done to handle emergency case, if any Rest area should be provided at the site where labour can rest after lunch and should not lie on site anywhere Working hours of labour should not exceed 	n of Employment and Conditions of Service) Act 1996 and Cess Act of 1996 and The Water (Prevention & Control of Pollution) Act, 1974 and amendments thereof. Municipal Solid Wastes (Management and Handling) Rules, 2000		n Stage		

Environmental Issue/Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>than standard norms as per state factory law</p> <ul style="list-style-type: none"> Wastewater from construction site should not be allowed to accumulate at site as standing water may lead to breeding of mosquitoes. Septic tanks/soak pits should be provided for its disposal Temporary storm water drainage system should also be provided at camp site and construction site so as to drain the storm water and prevent accumulation of storm water at site and thus breeding of mosquitoes/flies 					
❖ Setting up construction camp, Concert Mix Plant, Hot Mix Plant, Mechanical Workshop, Fuel storages, Lubricant storages	<ul style="list-style-type: none"> All these facilities shall be installed at proposed terminal site itself. All maintenance facilities, hot mix plant and concrete mixing plant shall be established with prior consent to establish to be obtained from WBSPCB. All such equipment/plant shall be fitted with air pollution control system and shall comply with condition of consent to establish. Periodic monitoring shall be carried as per consent conditions. 	Air (Prevention and Control of Water Pollution) Act, 1981 and Water (Prevention and Control of Water Pollution) Act, 1974	Site construction Camp	During design and construction Stage	Contractor	IW AI/ PM U/P MC
4. Site Preparation : Power supply, Water Supply, and Drainage, disposal of piling muck and debris						
❖ Power supply and Energy Conservation: Air Pollution , energy loss	<ul style="list-style-type: none"> Power shall be sourced from State electricity board during construction stage as well as operation stage. DG sets shall be used only in case of power failure. DG sets shall be enclosed in acoustic enclosures and shall be provided with stacks as per CPCB norms to discharge exhaust gases Solar energy shall be used in common 	Air (Prevention and Control of Water Pollution) Act, 1981 & ECBC	Construction Site and Lab	During design and construction stage	Contractor.	IW AI/ PM U/P MC

IWAI

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	lighting area on 1:2 basis. <ul style="list-style-type: none"> Energy Conservation Building Code shall be used as applicable to various office and other structures. 	Norms, 2007	our Camp Locations			
❖ Water Supply, Drainage and effluent discharge	<ul style="list-style-type: none"> Construction water requirement shall be sourced from municipal supply and necessary permission should be taken from concerned authority. No ground water or river water should be used because the CGWB has already classified the Haldia as Notified area. Caution signage shall be placed at site for optimal use of water Garland storm water temporary drains shall be provided around the excavated or activity area so as to divert rainfall run-off away from these location. These pits shall be covered during rainy season to the extent possible. Excavation shall be avoided during monsoon season. Storm water drains shall be connected to sedimentation tank for arresting the sediments before discharging into the river All washing and maintenance effluent from the workshop area of vehicle maintenance area should Darin to separate collection areas fitted with oil and grease trap and de-siltation chamber. The treated water shall be used for dust separation and green belt development. This water shall not be discharged in to river at all. Vehicle washing and maintenance 	Central Ground Water Board , Water (Prevention and Control of Water Pollution) Act, 1974	Construction Sites and Labour Camp Locations	During design and construction stage	Contractor.	IWAI/PMU/PMC

Environmental Issue/Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	workshops shall be located away from river <ul style="list-style-type: none"> Rain water should be collected into rain water harvesting ponds which should be used for various construction activities and dust suppression. 					
❖ Disposal of piling earth, muck and debris: uncontrolled disposal may lead to increased sedimentation of the river.	<ul style="list-style-type: none"> Top soil (15 cm) should be stripped and preserved under covered conditions. This should be stored in the form of the heap with the slide slopes covered with grass. Excavated soil should be used within the site for leveling purpose (3.3 lakh cum to be used for leveling). All the soil will be used for leveling within the site. Provision shall be made for collection and draining of water for the piling earth. Possibility should be explored for using it for filling land. If not feasible it should be disposed off to TSDF. Piling earth or dredged soil shall not be disposed off on the River bank as they are critical habitats especially during the breeding and spawning season. Provision shall be made for geo Synthetic Screen or turbidity traps for arresting silt flowing down stream. 	Solid Waste (Management & Handling) Rules, 2015	River Bank along the terminal site	Pre-Construction and construction Stage	Contractor.	IW AI/ PM U/P MC
5. Embankment Design and Construction, Drainage Pattern						
❖ River Bank Erosion Protection: Construction of Embankment and construction of berths may lead to accumulation of	<ul style="list-style-type: none"> The existing river bank protection work is adequate to prevent river bank erosion. Erosion monitoring shall be carried out periodically downstream as well. River Bed material/dredged soil shall be tested for toxicity before its use or disposal for land fill site. If any level of heavy metal contamination or toxicity is found than it shall be disposed off in a secure manner to TSDF location of Haldia Dock complex. 	Water (Prevention and Control of Water Pollution) Act, 1974	River banks along the terminal	During design, Pre-Construction and const	Contractor.	IW AI/ PM U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
sediments on the updrift side and erosion of the downdrift side .			site	construction Stage		
❖ Dredging activities :Impacts on fishes, and benthic organisms	<ul style="list-style-type: none"> As part of the detailed engineering design and when dredging is required, the Contractor shall prepare a Dredging plan that will ensure no adverse impacts shall occur on the local biodiversity. The Dredging Plan shall comply with the following: Roles and Responsibilities. Define roles and responsibilities for implementing and adhering to the commitments made within this Dredge Management Plan. Legislative Requirements and Guidelines. All dredging and disposal of dredge material will be undertaken in compliance with relevant national and state legislation. In case no standards exist, best international practice will apply. Studies on the existing Environment: Contractor shall carry out supplementary EIA study including Key Environmental Sensitivities, Physical Freshwater Environment: Riverbed morphology and geology, Bathymetry, Hydrodynamics, Sediment quality. Fresh Water Quality: Physiochemical, Chemical, Sediment plume modeling. Biological freshwater Environment: Benthic Primary Producer Habitat, Freshwater Fauna. Dredging Environmental Impact Assessment And Management: The Contractor shall prepare a supplementary 	Part of EMP/Wild Life Protection Act, 1972	In river stretch along the terminal	During design and construction stage	Contractor.	IW AI/ PM U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>EIA to establish potential impacts and its effective management in terms key performance indicators, mitigation and monitoring measures on the: freshwater quality, benthic primary producer habitat (BPPH), tidal, riverbank including bank, freshwater fauna, dredge materials disposal and spoil ground management</p> <ul style="list-style-type: none"> • The Dredging Plan shall highlight the following: • Location of dredging sites must avoid key habitat areas such as breeding and feeding grounds etc. of key biodiversity species found in the project area. • The schedule or time of dredging must avoid breeding season of fishes etc. • Decisions on method of dredging and type of technology and equipment to be used must consider the noise and vibration levels and extent of siltation being generated. Noise and vibration levels must be far below levels that can cause injury to aquatic animals and other wildlife. The dredging space must include measures to contain silt or suspended solids to a minimum area within the river as excess siltation can hamper wildlife activities. • Appropriate protocols and procedures must be prepared for sighting of endangered wildlife species (migratory birds, reptiles etc.) within the vicinity of the dredging site. The objective of the protocols and procedures must be aimed at having no or minimal impacts on the respective wildlife species. • Dredged soil shall be tested for contamination and toxicity and accordingly 					

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	shall be disposed <ul style="list-style-type: none"> Dredged soil shall not be piled on the River banks 					
❖ Drainage Pattern	<ul style="list-style-type: none"> Natural Drainage pattern of area around shall be maintained. Storm water management drains shall be provided at site for management of storm water management 		Construction Sites and Labour Camp Locations	During construction stage	Contractor.	IW AI/ PM U/P MC
6. Construction Material Sourcing						
❖ Borrow areas for sourcing earth for filling as required (erosion, loss of productive land, land degradation, air pollution)	<ul style="list-style-type: none"> Earth will be required only for filling of land to achieve finished level of 7 m amsl. Sand may be required to be brought from borrow areas. Borrow areas should be established as per the borrow area management plans attached as Annexure-5. Following guidelines should be followed for establishment and closure of borrow areas Non-productive lands, barren lands, raised lands; wastelands shall be used for borrowing earth with the necessary permissions/consents. Agricultural areas not to be used as borrow areas unless requested by the landowner for lowering the land for making it cultivable. 	IRC Guidelines on borrow areas and for quarries. EIA Notification 2006(under Environmental Protection	All Identified Borrow sites	During design and construction stage	Contractor	IW AI/ PM U/P MC

IWAI

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<ul style="list-style-type: none"> Environmental Clearance from State Environmental Impact Assessment Authority under EIA Notification, 2006 and required permission from District Magistrate shall be obtained prior to excavation. Copy of this permission shall be submitted to IWAI before start of excavation. Record of location, area, accessibility to the location and photograph of borrow area should be maintained prior to excavation Site selected for borrow area should be approved by PMC/PMU & IWAI expert prior to excavation Ridges of not less than 8m width will be left at intervals not exceeding 300m. Small drains will be cut through the ridges, if necessary, to facilitate drainage. The slope of the edges will be maintained not steeper than 1:4 (vertical: Horizontal). Topsoil to be stockpiled and protected for use at the rehabilitation stage. Rehabilitation shall be satisfactorily undertaken immediately after the use has ceased and at least three weeks prior to monsoon. Unpaved surfaces used for the haulage of borrow materials to be maintained. Transportation of earth materials shall be through covered vehicles. Borrowing should be carried out within 20 kms area of the project site so as to minimize the emission due to earth transportation. Dredged soil and debris resulting from realignment of road should be used for the site filling to the extent 	Act and Rules, 1986;)				

Environmental Issue/Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	possible.					
❖ Quarries for sourcing stone and aggregates (loss of productive land, land degradation, air pollution. Any illegal quarrying may lead to land use change, unstable rock formation)	<ul style="list-style-type: none"> Aggregates required for construction of terminal shall be sourced from nearby quarries It shall be ensures that selected quarries are having requisite environment clearance, and comply with Air Pollution Control and Noise level requirements as per the law. Material shall be transported in covered vehicles only. Each Quarry shall be visited prior to its selection to ensure its compliance with lease conditions, EC and consent conditions. 	EIA Notification 2006(under Environmental Protection Act and Rules, 1986;)	Quarry Site	During design and construction stage	Contractor	IWAI/PMU/PMC
7. Protection of Flora and Fauna						
❖ Protection of terrestrial flora & fauna	<ul style="list-style-type: none"> No significant flora is present at the site except some shrubs and herbs. Some trees are existing along the road to be diverted which will be retained as part of green belt. Project layout design shall be in a way to minimize tree cutting along the road. At present no tree cutting is envisaged No terrestrial fauna is present in site except common avifauna. Permission shall be obtained from forest department if tree cutting is required. Thick green belt (3 acres) shall be developed as per the CPCB guideline at the periphery and along the roads on the project site which will prevent spread of dust and reduce noise propagation. Areas reserved for future development at site shall also be made green by growing grass and shrubs and herbs 					

IWA

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<ul style="list-style-type: none"> Provision shall be made for strict penalty for hunting/harming any animal Construction activities shall be restricted to 6:00 Am-10:00 Pm especially noise generating activities. Workers should not use any timber or firewood as fuel for any purpose. LPG should be made available to workers in construction camp. No hazardous material or waste shall be disposed off in the other land or nearby area as it may harm the animals, if consumed accidentally. Speed limit will be regulated to prevent any leakage of oil so as to prevent pollution of the soil and impact on fauna and flora dependant on soil. Regular Water Sprinkling shall be carried out to minimize dust generation and settling the dust on surface of flora. Construction activities and vehicle washing should not be undertaken at the river or any other water body or close to the water body Site should be barricaded to prevent entry of the animal in the site Hunting, poaching and harming any animal (wild or domestic) by any worker or project related person should be strictly prohibited and monitored Illumination at the night time should be reduced during the night time (if no activity is going on) as it may disturb the nocturnal animals Noise generating activity should not be undertaken during night time to minimize 					

IWAI

Environmental Issue/Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>disturbance to animals. Noise levels should be maintained within the prescribed CPCBs limits to the extent possible during the day time.</p> <ul style="list-style-type: none"> Workers should not use any timber or firewood as fuel for any purpose 					
❖ Protection of Aquatic Fauna from high sound generation during piling	<ul style="list-style-type: none"> The area in which the construction of the Berth (jetty) is planned, advisable to carefully determine drop sites before anchor placement to ensure that fish and other aquatic faunal communities that could locally still be present in the area are not unnecessarily damaged. Before starting piling allow some time to aquatic fauna to displace from the piling area. Bubble curtains can be provided at the time of piling so as to displace the aquatic fauna prior start of construction activities The piling activities must be carried out in shortest possible timeframe as possible All the debris shall dispose away from river course as per debris management plan of the project. Decisions on method of construction and type of technology and equipment to be used must consider the noise and vibration levels and extent of siltation being generated. Noise and vibration levels must be far below levels that can cause injury to aquatic life. Noise reducing devices like mufflers, enclosures shall be fitted with the equipments as much as feasible. Erecting barriers shall also be installed Fish exclusion devises shall be installed in 	Wild Life (Protection) Act, 1972	Around Pilling Area	During design and construction stage	PMU through DFO	IWAI/PMU/PMC

IWAI

Environmental Issue/Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>water column around the pile driving area to prevent fish access</p> <ul style="list-style-type: none"> Geo Textile synthetic sheet curtain & turbidity traps shall be placed around piling and construction area to prevent movement of sediments and construction waste 					
❖ Protection of Aquatic Fauna from increased sedimentation in water body during piling & dredging and other construction activities	<ul style="list-style-type: none"> To avoid the construction debris wash or blown into the water the area shall be surrounded by silt screens, which must be placed in the water before the work starts. Geo-Textile synthetic sheet curtain can act silt screen which should be placed around piling and construction area to prevent movement of sediments and construction waste. The screens should also be placed around storage areas, to prevent waste from blowing away and to prevent sediment run-off into the river. The storm water drain shall be connected to temporary sedimentation pit and collected water shall be used for dust suppression. Run-off from site should also pass through oil/grease traps and flow down to the same sedimentation tank before its reuse In addition to silt screens, building guidelines of the Bonaire National Marine Park require that storage areas for sand and soil, and all work areas, must be at least 20 meters away from the high water mark and construction equipment must not be cleaned or washed within 50 meters of the high water mark. Piling and dredging activities should be carried out rapidly. Piling should not be carried out during breeding and spawning season means during rainy season. It 	Wild Life (Protection) Act, 1972	Around Pilling Area	During design and construction stage	PMU through DFO	IW AI/ PM U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>should be carried out in low water season, i.e. pre-monsoon</p> <ul style="list-style-type: none"> Equipments shall be maintained in good condition to prevent leaks or spills of potentially hazardous materials like hydraulic fluid, diesel, gasoline and other petroleum products Excavation and filling activities onshore should not be undertaken during monsoon season so as to minimize sediment load of run-off Workers should be trained to handle the equipment and material at site so as to minimize the spillage of materials and contamination of water All workers should be made aware of not throwing any waste in the river or any drain No construction debris/ already accumulated solid waste at site or waste generated from labour camp should be thrown in river or any drain Sewage generated from labour camp should not be directed into river but should be disposed off through septic tank/soak pit Aquatic ecology monitoring should be carried out prior start of construction and after completion of construction so as to assess the impact of construction activities on aquatic life. All construction and operation equipment shall be maintained in good condition shall be checked for oil & grease leakage Dredged soil shall not be disposed off in river or its banks especially during breeding spawning seasons of aquatic 					

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	organisms					
8. Air Quality						
❖ Fugitive Dust Generation due to construction activities and Exhaust gas emissions from machinery and vehicular traffic	<ul style="list-style-type: none"> Barricading the site to prevent dust dispersion to nearby areas Excavation and filling to be carried out in parallel and in phases. Water spraying on earthworks, unpaved haulage roads, other dust prone areas and construction yard. Flow of water sprinklers shall be maintained to avoid water accumulation. Proper servicing and maintenance of excavators/levelers/loaders and other machinery to minimize the emission generation Top soil stripping before excavating the soil and storage under covered conditions for usage in landscaping at later stages Storage of surplus excavated soil in covered conditions for its use for construction of roads and railways or for filling the depressions areas. Plantation to be undertaken as per Green belt development plan Transport of loose and fine materials in covered conditions only Loading and unloading of construction materials in covered area. Make Provision of PPEs like face masks to workers. Raw materials like cement, sand and construction debris should be stored under covered conditions Development of green belt should be started in the construction stage only within the identified 3 acres of area. 	<p>Environmental Protection Act, 1986 and amendments thereof;</p> <p>The Air (Prevention and Control of Pollution) Act, 1981 and amendments thereof</p>	Construction sites, Loading areas, storage areas,	During the Construction phase	Contractor	IWAI/PMU/PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<ul style="list-style-type: none"> LPG should be used as fuel source in construction camps instead of wood. Tree cutting shall not be allowed for fuel wood. Mixing Plant, crushers and batching plant shall be located on downwind direction of the site fitted with adequate stack height to ensure enough dispersion of exit gases. with appropriate pollution control measures Loading and unloading of construction materials shall be made at designated locations in project area with provisions of water fogging around these locations Low sulphur diesel should be used for operating DG sets and construction equipment. Regular maintenance shall be carried out of machinery and equipment. Diesel Generating (DG) sets shall be fitted with stack of adequate height as per regulations (Height of stack = height of the building + 0.2 $\sqrt{\text{KVA}}$.) Monitoring of air quality for PM₁₀, PM_{2.5}, SO₂, NO_x, and CO shall be carried out quarterly at construction site Efforts shall be made to move construction material early morning and late evening period. Transportation vehicle shall strictly adhere to the designated routes and timings and shall avoid the peak traffic hours Parking space for dumpers shall be provided within the site so as to prevent parking of vehicles on road and other area and thus preventing traffic jams. 					
❖ Emissions at access road :	<ul style="list-style-type: none"> Efforts shall be made to move construction material early morning and late evening 	Environmental	Existing	During the	Contractor	IWAI/

Environmental Issue/Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
avoidance of traffic Jams	period. <ul style="list-style-type: none"> No construction, material, equipment or vehicle shall be stored or parked at any road or the non project area Transportation vehicle shall strictly adhere to the designated routes and timings and shall avoid the peak traffic hours Parking space for dumpers shall be provided within the site so as to prevent parking of vehicles on road and other area and thus preventing traffic jams 	Protection Act, 1986 and amendments thereof; The Air (Prevention and Control of Pollution) Act, 1981 and amendments thereof	roads	Construction phase		PM U/P MC
9. Noise and Vibration						
❖ Noise from construction vehicle, equipment and machinery.	<ul style="list-style-type: none"> Barricading (Temporary noise barrier) the construction site to minimize the noise level outside the site boundary Restriction on Honking at the project site Hearing test for the workers prior to deployment at site and high noise areas followed by periodic testing every six months. Job rotations systems for workers, working in high noise level areas Restriction of high noise generating activity between 6:00 AM to 10:00 PM. Periodic monitoring (monthly level) of noise levels to check the level of pollutants and effectiveness of proposed EMP Protection devices (earplugs or earmuffs) shall be provided to the workers operating near high noise generating machines. Construction equipment and machinery shall be fitted with silencers and maintained 	Noise Pollution (Regulation and Control) Rules, 2000 and amendments thereof	Terminal site	During the Construction stage	Contractor	IW AI/ PM U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility		
					Implementation	Supervision	
	<p>properly. Noise measurements should be carried out to ensure the effectiveness of mitigation measures and develop a mechanism to record and respond to complaints on noise.</p> <ul style="list-style-type: none"> All equipment shall be fitted with silencers/noise mufflers and will be properly maintained to minimize its operational noise. Noise level will be one of the considerations in equipment selection, which will favour lower sound power levels 						
10. Land-use and Landscape							
❖ Loss of agricultural land and productive top soil	<ul style="list-style-type: none"> No agriculture land will be lost for terminal construction. The land is industrial land. However, 15 cm of top soil layer shall be stripped off prior to excavation and shall be stored separately in covered condition and used for landscaping purpose within the site Agriculture land should be avoided for establishing borrow areas and waste land preferably be considered for borrowing earth required for filling the terminal site 	Design requirement	Around project site area	During construction Stage		Contractor	IWAI/PMU/PMC
❖ Soil erosion due to construction activities, earthwork	<ul style="list-style-type: none"> The earth stockpiles to be provided with gentle slopes to prevent soil erosion. Sedimentation tanks shall be provided with storm water drain to arrest the sediments and these sediments shall be removed and stored with remaining excavated soil Provision of cross drainage structure like culverts shall be made in the access road if required to maintain the natural drainage pattern and prevent soil erosion. Provision of side drain shall be made in access road if required to prevent water logging. 	Municipal Waste Rules, 2015, Hazardous Waste Rules, 2008	Terminal site and river bank	During construction Stage	Contractor		IWAI/PMU/PMC

Iwai

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<ul style="list-style-type: none"> The existing bank protection work is adequate for shore protection. 					
<ul style="list-style-type: none"> Compaction and contamination of soil due to movement of vehicles and equipment 	<ul style="list-style-type: none"> Excavation, filling and leveling work should be carried out in parallel so as to minimize the soil erosion. Unusable debris material should be suitably disposed off at pre designated disposal locations, with approval of the concerned authority. Leveling activity shall not be carried out during monsoon season. Leveled areas shall be compacted. Compaction of soil shall be undertaken by sprinkling the water to minimize the surface runoff and erosion. Excavated soil shall be used for leveling purpose and left if any shall be stored in covered conditions for use in existing road diversion. Dredge soil shall also be either utilised for construction activity or disposed off. Fuel shall be stored in HDPE containers on paved surfaces with provision of catchment pit to prevent soil contamination from oil spillages. Municipal waste likely to be generated at site shall be collected in segregated manner with the use of two bin system at site. It shall be segregated into biodegradable and non-biodegradable waste. Provision of bio composter shall be made at site. The biodegradable material shall be decomposed for production of compost for use at site. The non-biodegradable waste shall be disposed off to predefined land fill site of Haldia Development Authority. Septic tank or mobile toilets fitted with 	Municipal Waste Rules, 2015, Hazardous Waste Rules, 2008	Terminal site	During Design & Construction stage	Contractor	IW AI/ PM U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>anaerobic treatment facility shall be provided at construction camp.</p> <ul style="list-style-type: none"> Aggregates will be sourced from existing licensed quarries. Copies of consent/ approval / rehabilitation plan for a new quarry or use of existing source will be obtained by contractor and submitted to IWAI. Hazardous waste like used oil from DG sets shall be stored in HDPE containers and shall be stored on paved surfaces in isolated location to prevent its spillage and contamination of soil. Used oil shall be disposed off through authorized vendors only. Movement of construction vehicles shall be restricted to the designated haulage roads only. Wash-off from concrete mixing tanks and wash from washing area shall not be allowed to enter the soil. This wash shall be collected through drains into tanks and concrete shall be settled, collected, dried and re-used in the site again. 					
11. Water Resources						
❖ Depletion of Ground water resources due to unregulated abstraction for construction purpose	<ul style="list-style-type: none"> No ground water should be used for construction purpose. However the rain water shall be stored in rain water harvesting pond and shall be utilized for dust suppression and watering the greenbelt No waste water should be stored on the site in unlined ponds 	Water Act, 1972		During Construction stage	Contractor,	IWAI/PMU/PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
❖ Increase in water Siltation levels due to construction of terminal and contamination due to disposal of domestic waste	<ul style="list-style-type: none"> Washing of vehicle and equipment shall not be carried out at river, green belt canal or any water body. Washing area should be provided with the storm water drains fitted with oil & grease trap. Piling of the raw materials & debris shall be avoided at the site. Storage of debris and raw material shall be carried out in paved and covered areas. This will minimize interface of run-off with raw material and debris. Site should be cleaned regularly Septic tank/soak pit shall be provided at site for disposal of sewage from the toilets at site and from the labour camps. Adequate toilets & bathrooms shall be provided to prevent open defecation. Wherever septic tanks are not provided mobile toilets with anaerobic digestion facility shall be provided and no domestic waste shall be discharged in to river. Water use shall be minimized by using RMC, practicing curing by water sprinkling, maintaining flow of sprinklers, covering the water storage tanks to minimize water evaporation, creating awareness for water conservation and regular inspections at site to monitor the leakages in water storage area Temporary rain water storage structures should be provided at the site to store rain water and this water should be used for sprinkling and construction activities In case RMC is not used then concrete transit mixer should be washed and cleaned daily. Wash from these mixers shall be 	Water Act, 1972	Terminal Site	During Construction stage	Contractor	IWAI/PMU/PMC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>collected in block work tanks which will allow settling of concrete, removal of aggregates and allowing the waste to wastewater drain. This collected waste concrete can be dried and used for various purposes at site like construction of temporary roads at site.</p> <ul style="list-style-type: none"> Wastewater generated from the washing/cleaning area after passing through oil & grease trap & curing area shall be re-used for water sprinkling and wheel washing Fuel shall be stored in leak proof containers and containers shall be placed on paved surface. The piling work in river shall be undertaken during low flow period. Drains along with turbidity traps/curtains should be provide or Geo-Textile synthetic sheet curtain shall be placed around piling and construction area to prevent movement of sediments and construction waste. Sedimentation tanks shall be provided at the site so as run-off from site shall enter the sedimentation tanks before discharging into the river. Sedimentation tanks will trap the sediments in the run-off Provision shall be made for geo Synthetic Screen for arresting silt flowing down stream. Proper collection, management and disposal of construction and municipal waste from site shall be made to prevent mixing of the waste in run-off and entering the water bodies Natural Drainage pattern of area around shall be maintained Dredged soil shall be tested for toxicity & 					

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	contamination, if toxic/contaminated shall not be disposed off back in water and should be send for disposal to TSDF <ul style="list-style-type: none"> Monitoring of surface water quality shall be carried out on monthly basis to check the level of pollutants and effectiveness of proposed EMP 					
12. Socio-economy, Accident and Safety Risks						
❖ Impact on Social life	<ul style="list-style-type: none"> Separate SIA is being carried out to anticipate the impact on socio-economy of the area which can be referred to understand the impact on socio-economy on the project in detail. Skill training and assistance should be given to local people so as they can preferably be employed at the site Local labour should preferably be employed for construction purpose Site should be barricaded and should have entry guarded by security guard. Register should be maintained for entry of outsiders. No unauthorized person should be allowed to enter the site. A board should be displayed at entrance of site displaying name of project, area and hazards associated with the site on entrance and activities prohibited within and near site area in local language. Fishermen should be consulted prior restricting fishing activity in the activity area Necessary permits should be obtained from concerned authorities in case any quarry site, batching plant, hot mix plant, WMM plant etc. is set up. 	Labour Laws	Construction sites and labour camps	During construction period	Contractor	IW AI/ PM U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<ul style="list-style-type: none"> Management, rehabilitation and closure of these sites should be as per the Management plans proposed for these sites. Implementation of EMP adequately so as to prevent environmental pollution and its impact on socio-economy due to project development 					
❖ Accident risk from construction activities and health & safety of workers	<ul style="list-style-type: none"> Adequate illumination should be provided at site during evening and night time till the work is being carried out. Rest area should be provided at site in which workers can rest after the lunch hours Workers should wear the personal protective equipment like helmet, gum boots, safety shoes, safety jackets, ear plugs, gloves etc while working. Noise level in the work zone should be maintained and followed as per OSHAS norms Contractors should adopt and maintain safe working practices. SOPs should be prepared for each and every activity and all activities should be undertaken as per SOPs under supervision of site engineer. Training should be given to workers to handle the heavy equipment so as to prevent accidents Training should be given to workers to handle emergency situation like fire, earthquake, cyclone and flood. Emergency preparedness plan should be available at the site all the time and mock drills for workers should be conducted from time to time Complete medical check-up should be done for workers prior to joining and after six 	<p>Central Motor and Vehicle Act 1988</p> <p>EP Act 1986</p> <p>Noise Rules 2002</p>	Construction sites	Construction period	Contractor	IW AI/ PM U/P MC

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>months of joining.</p> <ul style="list-style-type: none"> First aid facilities, first aid room, first aid trained personnel and ambulance should be provided at the site 24 X 7. Also tie-ups with local hospital should be done to handle emergency case, if any List of emergency nos., hospital contacts, ambulance contacts and doctors contacts should be displayed in first aid room, rest area and at all required location Working hours of labour should not exceed than standard norms as per state factory law Labour camps should be located at neat and clean location with no water logging issues and should be well ventilated with adequate illumination, kitchen and safe drinking water facility Construction labour camps and site should be properly cleaned and hygiene should be maintained Proper sanitation facility like toilet and bathing facility should be provided at site and labour camps. Wastewater generated from these facilities should be disposed off through septic tanks and soak pit LPG should be provided as fuel for cooking to workers and open burning of fuel should not be allowed Temporary storm water drainage system should also be provided at camp site and construction site so as to drain the storm water and prevent accumulation of storm water at site and thus breeding of mosquitoes/flies Safety officers should be appointed at site so as to ensure all safety measures are 					

Environmental Issue/ Component	Remedial Measure	Reference to laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
					Implementation	Supervision
	<p>taken at the site</p> <ul style="list-style-type: none"> • Activity like smoking and consuming liquor should be prohibited at the site • Awareness on AIDS should be spread among the workers • Traffic manager should be present at the site all the time to manage incoming and outgoing traffic to prevent accidents • Crèche facility should be provided for kids if female workers are employed • Speed limit of vehicles should be restricted at site to prevent any accidents and fines should be imposed on vehicles if same is not maintained. All construction vehicles should follow the designated routes & timings only. • Dustbins should be provided at labour camps for collection of waste and waste should be regularly disposed off through the concerned agency • Arrangement of fire-fighting should be made at site and workers should be trained to use the system in case of fire • Sprinkling of water should be carried out in haul road to minimize dust generation due to movement of construction vehicles. 					

TABLE 2: ENVIRONMENT MONITORING PLAN OF HALDIA TERMINAL FOR CONSTRUCTION PHASE

	Aspect	Parameters to be monitored	No of sampling locations &	Standard methods for sampling and analysis	Role & Responsibility	
					Implem	Supervis

			frequency		entation	ion
Construction Period						
1.	Air Quality (Ambient & Stack)	PM ₁₀ , PM _{2.5} , SO ₂ , NO _x , CO	Three Locations up wind and downwind direction including project site. once in two months	<ul style="list-style-type: none"> • Fine Particulate Samplers for PM_{2.5} • Respirable Dust Sampler for PM₁₀ fitted with Gaseous sampling arrangements for SO₂ and NO_x, • CO analyzer; 	Contractor	IWAI & PMC
2.	Surface Water Quality	Physical, chemical and biological	Hooghly river u/s and d/s of terminal Once a month	Grab sampling and analysis by using standard methods	Contractor	IWAI & PMC
3.	Drinking water Quality	Physical, chemical and biological	Drinking water for labour camps Once a month	Grab sampling and analysis by using standard methods	Contractor	IWAI & PMC
4.	Noise Level	Day time and night time noise level (max, min & Leq levels)	Construction labour camp, construction site and nearest habitation Once a month	Noise meter	Contractor	IWAI & PMC
5.	Soil	Soil texture,	Construction	Collection and	Contractor	IWAI &

IWAI

	Quality	type, Electrical conductivity, pH, infiltration, porosity, etc.,	site, labour camps and debris disposal site Once in 6 months	analysis of samples as per IS 2720	tor	PMC
6.	River Bed Sediment	Texture, type, Electrical conductivity, pH, infiltration, porosity, etc., and biological compounds	River bed near site Once in 6 months	Collection and analysis of samples as per IS 2720	Contractor	IWAI & PMC
7.	Green Belt	Plantation survival rate	All along the premises of Terminal site Once in year	Survey, counting, recording & reporting	Contractor	IWAI & PMC
8.	Soil Erosion	---	Upstream & downstream of project site near river bank-- Once a month	Survey & observation; Extent and degree of erosion; Structures for controlling soil erosion	Contractor	IWAI & PMC
9.	Aquatic ecology	Phytoplankton , Zooplankton and species diversity index	River Hooghly (u/s and d/s of the site) Six monthly	Plankton net of diameter of 0.35 m, No.25 mesh size 63 and analysis by using standard methods.	Contractor	IWAI & PMC
10.	Integrity of embankment	---	Upstream & downstream	Survey & observation; Extent	Contractor	IWAI & PMC

IWAI

	ent		of terminal site along River Banks- Once a month	and degree of erosion; Structures for controlling soil erosion		
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1.0 Introduction

Green belt acts as bio filter for the air pollutants and play a major role in safeguarding the environment and controlling the increasing level of air and noise pollution. It can serve as buffer and shock absorber against transient and accidental release of pollutants from industrial activity.

The green belt has been recommended as one of the major components of the EMP which will further enhance the environmental quality by:

1. Mitigation of air pollution
2. Attenuation of noise level
3. Maintaining the bio diversity of the area and improve aesthetics.

1.1 Size of Green belt

Dense greenbelt should be developed all along the boundary of the terminal premises. The width of the greenbelt will be 10 m. About 3 acre (1.21 ha) land has been kept for green belt development and 1200 trees along with herbs and shrub shall be planted. 3 x 3 m spacing will be kept between trees. A standard horticultural practice involving planting of saplings in pits of substantial dimensions i.e., 1m x 1m x 1m for big trees and along half of these dimensions for smaller trees and shrubs. The pits are then filled with earth, sand, silt and manure in pre-determined proportions. Saplings planted in such pits are watered liberally during dry months.

1.2 Selection of Tree Species

The Project construction involve movement of vehicle for transportation of material. Thus emissions like particulate matter, SO₂, NO_x & CO shall be generated at site. Plants possess a large surface area and their leaves exhibit an efficient pollutant trapping mechanism. The effectiveness of plants to control pollution depends upon the physiological, morphological traits such as leaf epidermis, size, leaf orientation, internal enzyme system, etc. Systematic screening of plants for their ability to tolerate pollutant need be undertaken. For pollution abatement purposes tree species would be fast growing native species, wind firm, unpalatable to animals, hardy and dust and pollutants tolerant/resistant.

1.3 Time of Plantation

Plantation would be done two weeks after the rain starts. It is advised to avoid planting during the dry season, as this will require watering. It is advantageous to plant trees on cloudy days.

1.4 Recommended Plant species

Based on nature of pollutants following tree species are recommended to be planted

S. No.	Plant Species	Common Name	Habit
1.	<i>Azadirachta indica</i>	Neem	Tree
2.	<i>Delonix regia</i>	Gulmohar	Tree
3.	<i>Albizia lebbek</i>	Siris	Tree
4.	<i>Cassia fistula</i>	Golden shower	Tree

5.	<i>Pongamia pinnata</i>	Indian beech	Tree
6.	<i>Hibiscus rosa sinensi</i>	Hibiscus	Shrub
7.	<i>Delbergia sisoo</i>	Shisham	Tree
8.	<i>Cocus nucifera</i>	Nariyal	Tree
9.	<i>Bougainvillea glavra</i>	Bougainvillea	Shrub
10.	<i>Narium indicum</i>	Kaner	Shrub
11.	<i>Thespesia populnea</i>	saru	Tree
12.	Grasses and hedges	--	Herbs

1.5 Protection of Tree saplings

Circular tree guard should be placed after the plantation of the saplings for the protection of these young plants from the ravages of cattle, sheep and goat and other animals. If tree saplings died or damage occur after placing the circular tree guard, timely replacements of damaged plant and thereafter care is important.

1.6 After Care & Monitoring

The growing plants are cared at least for the first two years under favorable conditions of climate and irrigation. Nutrients in pits are supplemented and the juveniles provided protection.

Thinning shall start after the stand is 3-4 years old and repeated every 4 years until the stand is 15 years old. Between 15-25 years old, thinning should be conducted every 5 years and after 25 years old, thinning shall be done after every 10 years. When the canopy closes, at about 6 years, 30-40% of the stems shall be thinned to selectively remove suppressed, diseased and badly formed trees.

Periodic assessment shall be carried for survivability of the trees. Minimum 70% survival rate shall be achieved.

1.7 Records Keeping & Reporting

The following records shall be maintained:

1. Record of Tree plantation
2. Record of Survivability rate

■ Inspection shall be carried out at site to know the survival rate of the plantation. The tree plantation and survivability report shall be prepared every six monthly.

Appendix 2: Guidelines for On Site and Off Site Emergency Management

1.0 INTRODUCTION

Many emergencies can occur on any construction site and need to be effectively handled. The environmental and occupational health and safety aspects and related emergency can include incidence such as Collapse / subsidence of soil / Fire / Explosion / Gas Leak, Collapse of Building / Equipment and other Occupational Accidents. On site and off site emergency management plan shall be developed to effectively handle them.

Thus every contractor shall have an approved on-site emergency plan. The contractor should submit a copy of this plan to PIU and Supervision consultant before the start of the work. Contractor shall develop the onsite emergency plan considering the potential environmental, occupational health and safety emergency situation at site and activities involved. This plan shall include a list of these potential emergency situations in the onsite emergency preparedness & response plan. Contractor shall get the plan approved from IWAI/PMC

1.1 ANTICIPATED EMERGENCIES AT CONSTRUCTION SITE

The potential emergency situations have been defined below for guidance purposes. The contractors can follow these for developing site specific on site emergency preparedness plan.

Emergency conditions / situations	Sources
Collapse / subsidence of soil	<ul style="list-style-type: none"> ▪ Civil structures
Bulk spillage	<ul style="list-style-type: none"> ▪ Hazardous substance / inflammable liquid storage ▪ Vehicular movement on highway
Fire and explosion	<ul style="list-style-type: none"> ▪ Inflammable Storage Areas ▪ Gas Cylinder Storage Areas ▪ Electrical Circuits ▪ Isolated Gas Cylinders (LPG / DA) ▪ Welding / Gas Cutting Activity
Electrical Shock	<ul style="list-style-type: none"> ▪ HT line ▪ LT distribution ▪ Electrically Operated Machines / Equipment / Hand Tools / Electrical Cables
Gaseous Leakage	<ul style="list-style-type: none"> ▪ Gas Cylinder Storage Areas ▪ Gas Cylinder used in Gas Cutting / Welding Purposes
Accidents due to Vehicles	<ul style="list-style-type: none"> ▪ Heavy Earth Moving Machinery ▪ Cranes ▪ Fork Lifts ▪ Trucks ▪ Workman Transport Vehicles (cars / scooters / motor cycles / cycles) ▪ Collapse, toppling or collision of transport equipment
Slips & Falls (Man & Material)	<ul style="list-style-type: none"> ▪ Work at Height (Roof Work, Steel Erection, Scaffold, Repair & Maintenance, Erection of equipment, Excavation etc.) ▪ Slips (Watery surfaces due to rain) ▪ Lifting tools & Tackles (Electric Hoist & Forklifts)

Collision with stationary/ moving objects	<ul style="list-style-type: none"> ▪ Vehicular movement
Other Hazards	<ul style="list-style-type: none"> ▪ Cuts & Wounds ▪ Confined Space (under & inside machinery etc.) ▪ Hot Burns ▪ Pressure Impacts (Plant contains several Pressure Vessels & pipefitting containing CO₂, air, water, product & steam, which can cause accidents & injuries to person around.)

1.2 DESIGN OF 'ON-SITE EMERGENCY PLAN'

The 'On-site emergency plan' to be prepared by contractor and shall include minimum the following information:

- Name & Address of Contractor
- Updation sheet
- Project Location
- Name, Designation & Contact Numbers of the organization, nearby hospitals, fire agencies etc. and key personnel including their assigned responsibilities in case of an emergency.
- The roles and responsibilities of executing personnel
- Site Layout Diagram showing location of fire extinguishers, emergency collection area and fire alarm
- Identification of Potential Emergencies Situations/ preventive measures / control & response measures
- Location of Emergency Control Centre (or designated area for emergency control / coordination) with requisite facilities.
- Medical services / first aid
- List of emergency equipment including fire extinguishers, fire suits etc.

1.3 EMERGENCY CONTROL CENTRE

The emergency control centre shall be equipped with following facilities

- Copy of current on-site emergency plan
- Display of the name of site emergency controller
- Two numbers of artificial respiratory sets
- Two numbers of Stretchers
- Vehicle for 24 hours (for large construction sites)
- Inter personnel/section telephone (2 numbers)
- Site layout diagram with entry and exit routes / Assembly points
- Directory of internal / external emergency phone Numbers
- A set of fire extinguishers (DCP type / Foam Type / CO₂)
- List of fire extinguishers installed in the construction site including maintenance record
- A set of personal protective equipment (PPE)
- Two numbers of first-aid boxes with prescribed first-aid medicines
- List of competent first-aiders
- List of fire trained personnel
- Two numbers of blankets
- Drinking water
- Two numbers of rescue ropes
- Two numbers of high beam torches
- Two numbers of gas leak detectors
- Life boat & jackets (if working in or near water course)

1.4 RECORDS

The following records shall be maintained:

1. Record of emergency preparedness plan with emergency contact numbers
2. Mock drill/emergency preparedness exercise records
3. Corrective preventive action record after emergency is occurred

1.5 REPORTING

The accident and incident records and emergency preparedness drill reports shall form part of quarterly report to EA

1.6 RESPONSIBILITY

Contractor shall be responsible to handle emergency condition and shall be liable to compensate the damage against accident, if any occurs at site.

Appendix 3: Guidelines for Debris and Solid Waste Management

1.0 INTRODUCTION

Waste will be generated from the construction site and labour camps during the construction phase. Type of the waste to be generated during construction phase is given below.

Excavated Soil

Site is undulating and thus will require cut & fill for levelling. Finished level of the soil will be 37 m. Top excavated soil of 15 cm shall be stripped and shall be stored separately under covered sheds. This soil shall be used for green belt plantation.

Lower layers of excavated soil shall be re-used within the site for filling purpose, construction of approach & internal roads & railway link. If any extra soil is remained, then that should be disposed of to the approved debris disposal site or for mines rehabilitation located in the nearby areas.

Dredged Material

Dredging shall be carried out in the river for construction of off-shore structures like jetty & berths (pilling) and navigation channels. Dredged soil shall not be disposed off along the river bank as they are sensitive habitat for various aquatic species and provide as the spawning and breeding grounds also. Dredged material shall be tested for its quality. If non-toxic then should be disposed off at disposal site but if toxic & contains heavy metals, then it should be disposed off to TSDF site.

Construction Waste

Construction waste will comprise of broken bricks, dry cement, discarded timber, metal piece, cement bag, dry asphalt/bitumen, glass, paint/varnishes box etc. These wastes should be segregated into recyclable and non-recyclable waste. Recyclable waste shall be stored in the covered area and shall be sold to authorized vendors regularly. Non-recyclable waste shall be disposed off at approved debris site in covered vehicles.

Municipal Waste

Municipal waste will be generated from labour camp. Dustbins for recyclable and non-recyclable waste shall be provided in labour camp area. Recyclable waste shall be sold to authorized vendors and non-recyclable shall be disposed off through authorized agency in area responsible for waste collection and management.

Waste generated requires proper management so as to minimize the negative impacts on environment. Concept of reduce, re-use and recycle shall be followed at site. The rejected waste should be disposed off in a secured manner. Thus a site should be identified for disposal of the rejected waste.

1.1 SELECTION OF DISPOSAL SITES:

The locations of Disposal sites have to be selected such that:

- Disposal sites are located at least 1000 m away from sensitive locations like settlements, water body, notified forest areas, wildlife/bird/dolphin sanctuaries or any other sensitive locations.
- Disposal sites shall not contaminate any water sources, rivers etc so the site should be located away from water body and disposal site should be lined properly to prevent infiltration of water.
- Public perception about the location of debris disposal site has to be obtained before finalizing the location.
- Permission from the village/local community is to be obtained for the Disposal site selected.
- Environment Engineer of PMC and Executive Engineer of Contract Management Unit must approve the Plan before commencement of work.

1.2 PRECAUTIONS TO BE ADOPTED DURING DISPOSAL OF DEBRIS / WASTE MATERIAL

The Contractor shall take the following precautions while disposing off the waste material.

- During the site clearance and disposal of debris, the Contractor will take full care to ensure that public or private properties are not affected, there is no dwellings around the dumpsite and that the traffic is not interrupted.
- The Contractor will dispose off debris only to the identified places or at other places only with prior permission of Engineer-in-Charge of works.
- In the event of any spoil or debris from the sites being deposited on any adjacent land, the Contractor will immediately remove all such spoil debris and restore the affected area to its original state to the satisfaction of the Engineer-in-Charge of works.
- The Contractor will at all times ensure that the entire existing canal and drains within and adjacent to the site are kept safe and free from any debris.
- Contractor will utilize effective water sprays during the delivery and handling of materials when dust is likely to be created and to dampen stored materials during dry and windy weather.
- Materials having the potential to produce dust will not be loaded to a level higher than the side and tail boards and will be covered with a tarpaulin in good condition.
- Any diversion required for traffic during disposal of debris shall be provided with traffic control signals and barriers after the discussion with local people and with the permission of Engineer-in-Charge of works.
- During the debris disposal, Contractor will take care of surrounding features and avoid any damage to it. The debris should not be disposed along the bridges & culverts and near the water bodies.
- While disposing debris / waste material, the Contractor will take into account the wind direction and location of settlements to ensure against any dust problems.
- Contractor should display the board at disposal site stating the name of project, usage of the site and type of debris being disposed.
- A guard shall be kept at disposal site to prevent any unauthorized disposal of waste at the debris disposal site
- Material should be disposed off through covered vehicles only
- No contaminated/hazardous/e-waste shall be disposed off at the debris disposal site

1.3 RECORD KEEPING

Site approved by site engineer only can be used as disposal site. Record of all such site should be maintained along with the area of disposal site, type & quantity of material disposed off daily and capacity of disposal site.



1.4 GUIDELINES FOR REHABILITATION OF DISPOSAL SITES

The dumpsites filled only up to the ground level could be rehabilitated as per guidelines below and to be decided by the Engineer and the supervision consultant.

- The dumpsites have to be suitably rehabilitated by planting local species of shrubs and other plants. Local species of trees has also to be planted so that the landscape is coherent and is in harmony with its various components.
- In cases where a dumpsite is near to the local village community settlements, it could be converted into a play field by spreading the dump material evenly on the ground. Such playground could be made coherent with the landscape by planting trees all along the periphery of the playground.
- Closure of the disposal site should be upto the satisfactory level of site engineer

1.5 PENALTIES

Stringent action & penalties should be imposed off on contractor for dumping of materials in locations other than the pre-identified locations. Grievance Redressal mechanism should be in place for taking note and action on such complaints.

Annexure 4: Selection and Management of Construction/Labour Campsite

1.0 Selection and layout of construction camp

Labour camps, plant sites and debris disposal site shall not be located close to habitations, schools, hospitals, religious places and other community places. A minimum distance of 500 m shall be maintained for setting up such facilities.

2.0 Facilities at workers camps

During the construction stage of the project, the construction contractor will construct and maintain necessary (temporary) living accommodation, rest area and ancillary facilities for labour. Facilities required are listed and elaborated below.

- Site barricading
- Clean Water Facility
- Clean kitchen area with provision of clean fuel like LPG
- Sanitation Facilities
- Waste Management Facilities
- Rest area for workers at construction site
- Adequate Illumination & ventilation
- Safe access road is required at camps
- Health Care Facilities
- Crèche Facility & Play School
- Fire-fighting Facility
- Emergency Response Area

2.1 Site Barricading

Site should be completely barricaded from all the sides to prevent entry of outsiders and animals into the site. Entry gate should be provided at the site and labour camp which should be guarded by security guard. All workers should be issued ID cards and entry of outsiders shall be maintained in the register at the gate. Board should be displayed at the site and the labour camp, the name of project, capacity of project, authority carrying out projects, restriction of entry without authorization, no smoking zone and associated risks. Plant operation shall be restricted to 6:00 Am to 10:00 PM

2.2 Clean Water Facility

Potable water shall be provided for construction labour for drinking & cooking purpose. Clean water shall be provided for bathing, cleaning and washing purpose. Water quality testing for water shall be carried out on monthly basis.

2.3 Clean Kitchen Area

Provision of clean kitchen area for cooking and storage of eatables shall be provided. Clean fuels like LPG shall be provided for cooking purpose. Burning of firewood, garbage, paper and any other material for cooking or any other purpose shall strictly be prohibited at the site.

2.4 Sanitation Facilities

Construction camps shall be provided with sanitary latrines and urinals. Toilets provided should have running water availability all the time. Bathing, washing & cleaning areas shall be provided at the site for construction labour. Washing and bathing places shall be kept in clean and drained condition. Workers shall be hired especially for cleaning of the toilets and bathing area. Septic tanks and soak pits shall be provided at site for disposal of the sewage generated.

2.5 Waste Management Facilities

Waste generated should be segregated at the site by providing the different color bins for recyclable and non-recyclable waste. Recyclable waste shall be sold to authorized vendors and non-recyclable shall be handed over to authority responsible in area for waste management. Waste management for construction site shall be as per waste management plan proposed in EMP.

2.6 Rest Area For Workers at Site

A rest area/shelter shall be provided at the site for construction workers where they can rest after lunch time and shall not lay down at site anywhere. The height of shelter shall not less than 3m from floor level to lowest part of the roof. Sheds shall be kept clean and the space provided shall be on the basis of at least 1.0 Sq.m per head.

2.7 Adequate Illumination & Ventilation

Construction worker camps shall be electrified and adequately illuminated. Illumination level shall be maintained after 5.30 Pm at the site to minimum 200 lux. Labour camps shall be adequately ventilated. Fans shall be provided for ventilation purpose.

2.8 Safe Access Road for Labour Camps

Temporary paved surface shall be constructed to approach the labour camp from the site. Movement shall not be hampered during monsoon season due to water logging and muddiness.

2.9 Health care Facilities:

First aid box, first aid room and personnel trained in first aid shall be available at labour camp and site all the time (24X7). Equipment in first-aid box shall be maintained as per State Factory's Law. Ambulance/ 4 wheeler motorized vehicle shall be available at the site for carrying injured to the nearby hospital. Tie-ups should be made with nearby hospital to handle emergency, if any. Nos. of ambulance, doctors and nearby hospital shall be displayed in first-aid room, site office & labour camps. Workers shall be made aware about the causes, symptoms and prevention from HIV/AIDS through posters and awareness programs

2.10 Crèche Facility & Play School

Crèche facility and play school should be constructed at the site temporarily so as children of construction labour can be kept there. Care takers should be hired for taking care of children. Attendance records of children shall be maintained. Children should not be allowed to enter active work areas.

2.11 Fire-Fighting facilities

■ Fire-fighting facility such as sand filled buckets and potable fire-extinguishers shall be provided at labour camps and at site. Fire-extinguishers shall be provided as per NBC norms.



2.12 Emergency Collection Area

■ Area shall be demarcated as emergency collection area near the gate where all the workers shall be guided to collect in case of any emergency like fire, flood and earthquake.



3.0 Activities prohibited at site

■ Activities which should be strictly prohibited at site shall include



- Open burning of wood, garbage and any other material at site for cooking or any other purpose
- Disturbance to the local community.
- Operation of the plant and machinery between 10 pm to 6 am unless approved by team leader
- No animal (wild or domestic or bird) shall be harmed by any construction worker in any condition at site and nearby areas
- Cutting of tree without permission of team leader/authorized person
- No indigenous population shall be hurt or teased

4.0 Guidelines for night time working at the site.

■ No activity generating noise shall be carried out at the site after 10:00 PM. Night working protocol should be followed (if required) as per guidelines prepared by IWAI. Site should be well illuminated to maintain minimum illumination level of 200 lux. Personnel working shall obtain permit to work from the team leader prior carrying out any work in night time and the record of such working shall be maintained in register. Any accidents, if occurs at site during night time working shall be immediately reported and recorded. Penalty shall be imposed on the contractor for the accident. Analysis shall be carried out to find the reason for such accidents for future learning.



5.0 Record keeping & Maintenance

■ Record of entry/exit of the people in the construction site and labour camp area shall be maintained in register at gate. Record of material coming in and going out from site also shall be maintained.



6.0 Auditing & Inspection

■ Conditions of labour camp and site shall be inspected and audit report shall be submitted to IWAI on monthly basis.



7.0 Closure of the Construction Site and Construction labour Camps

■ Construction site and labour camps shall be restored back to the original site conditions. Following measures are required to be taken during closure

IWAI

1. Septic tanks/soak pits should be dismantled
2. Any temporary/permanent structure constructed shall be dismantled
3. Construction/demolition waste, hazardous waste and municipal waste at site and labour camp site shall be disposed off as per waste management plan in EMP
4. The site shall be cleaned properly
5. Tree plantation to be carried out, if any required for stabilizing the area
6. Any pit excavated shall be filled back
7. Closure of the site and labour camp shall be approved by authorized person.

Annexure 5: Borrow Area Establishment, Management & Closure Plan

1.0 Introduction

■ Borrow areas will be finalized as identified by Contractor as agreed by the PMC and IWAI as per the requirements of the contract. Environment clearance under EIA Notification, 2006 from competent authority and NOC from state pollution control board under Air Act, 1981 as applicable shall be obtained by contractor prior excavation. Consent from land owners and DC of the area shall also be taken prior undertaking any excavation. The Contractor in addition to the established practices, rules and regulation will also consider following criteria before finalizing the locations. Contractor should submit borrow area establishment plan along with the locations marked in map and the environmental settings of the planned area to PMC/IWAI for approval of the “Engineer” through RFI.

- 1) The borrow area should not be located in agriculture field unless unavoidable i.e. barren land is not available.
- 2) The borrow pits should not be located along the roads, close to project site
- 3) The loss of productive and agricultural land should be minimum.
- 4) The loss of vegetation is almost nil or minimum.
- 5) Sufficient quality of soil is available.
- 6) The Contractor will ensure the availability of suitable earth.

■ The Contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme as approved by the concerned Engineer. It shall be ensured that the fill material compacted to the required density. The Contractor shall submit the following information to the Engineer for approval at least 7 working days before commencement of compaction.

- The values of maximum dry density and optimum moisture content obtained in accordance with ARE: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.
- A graph of density plotted against content from which, each of the values in (i) above of maximum dry density and optimum moisture content are determined.

■ After identification of borrow areas based on guidelines and full filling the following requirements are to be fulfilled

- Quantification of Earth
- Land Agreement
- Clearance from local authorities
- Environmental Clearances from SEIAA should be obtained. All EC conditions are to be followed by contractor and contractor should submit EC to IWAI/PMC/PMU

■ After receiving the approval Contractor will begin operations keeping in mind following:

- Haulage of material to the areas of fill shall proceed only when sufficient spreading and compaction plants are operating at the place of deposition.
- No excavated acceptable material other than surplus to requirements of the Contract shall be removed from the site. Contractor should be permitted to remove acceptable material from the site to suit his operational procedure, then he shall make good any consequent deficit of material arising there from.
- Where the excavation reveals a combination of acceptable and un-acceptable materials, the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the

permanent works without contamination by the un-acceptable materials. The acceptable material shall be stockpiled separately.

- The Contractor shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

1.1 Borrow Area Management

■ Borrow areas located in different land will require different management. Management measures to be taken in different land types are given below.



1.1.1 Borrow Areas located in Agricultural Lands

- The preservation of topsoil will be carried out in stockpile.
- A 15 cm topsoil will be stripped off from the borrow pit and this will be stored in stockpiles in a designated area for height not exceeding 2m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- Borrowing of earth will be carried out up to a depth of 1.5m from the existing ground level.
- Borrowing of earth will not be done continuously throughout the stretch.
- Ridges of not less than 8m widths will be left at intervals not exceeding 300m.
- Small drains will be cut through the ridges, if necessary, to facilitate drainage.
- The slope of the edges will be maintained not steeper than 1:4 (Vertical: Horizontal).



1.1.2 Borrow Areas located in Agriculture Land in un-avoidable Circumstances:

- The preservation of topsoil will be carried out in stockpile.
- A 15 cm topsoil will be stripped off from the borrow pit and this will be stored in stockpiles in a designated area for height not exceeding 2m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- The depth of borrow pits will not be more than 30 cm after stripping the 15 cm topsoil aside.

1.1.3 Borrow Areas located on Elevated Lands

- The preservation of topsoil will be carried out in stockpile
- A 15 cm topsoil will be stripped off from the borrow pit and this will be stored in stockpiles in a designated area for height not exceeding 2m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- At location where private owners desire their fields to be levelled, the borrowing shall be done to a depth of not more than 1.5m or up to the level of surrounding fields.

1.1.4 Borrow Areas near Riverside

- The preservation of topsoil will be carried out in stockpile
- A 15 cm topsoil will be stripped off from the borrow pit and this will be stored in stockpiles in a designated area for height not exceeding 2m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- Borrow area near to any surface water body will be at least at a distance of 15m from the toe of the bank or high flood level, whichever is more.

1.1.5 Borrow Areas near Settlements

- The preservation of topsoil will be carried out in stockpile

- A 15 cm topsoil will be stripped off from the borrow pit and this will be stored in stockpiles in a designated area for height not exceeding 2m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- Borrow pit location will be located at least 0.75 km from villages and settlements. If unavoidable, the pit will not be dug for more than 30 cm and drains will be cut to facilitate drainage.
- Borrow pits located in such location will be re-developed immediately after borrowing is completed. If spoils are dumped, that will be covered with layers of stockpiled topsoil in accordance with compliance requirements with respect MOEF&CC/PCB guidelines.

1.1.6 Borrow Pits along the Roads

- The preservation of topsoil will be carried out in stockpile
- A 15 cm topsoil will be stripped off from the borrow pit and this will be stored in stockpiles in a designated area for height not exceeding 2m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- Borrow pits along the road shall be discouraged.
- If permitted by the Engineer; these shall not be dug continuously.
- Ridges of not less than 8m widths should be left at intervals not exceeding 300m.
- Small drains shall be cut through the ridges of facilitate drainage.
- The depth of the pits shall be so regulated that there bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of bank, the maximum depth of any case being limited to 1.5m.
- Also, no pit shall be dug within the offset width from the toe of the embankment required as per the consideration of stability with a minimum width of 10m.
- Minimum distance from road/ railway should be 50 metres.

1.1.7 Re-development of Borrow Areas

The objective of the rehabilitation programme is to return the borrow pit sites to a safe and secure area, which the general public should be able to safely enter and enjoy. Securing borrow pits in a stable condition is fundamental requirement of the rehabilitation process. This could be achieved by filling the borrow pit approximately to the road level.

Re-development plan will be prepared by the Contractor before the start of work in line with the owner's will and to the satisfaction of owner.

The Borrow Areas will be rehabilitated as follows

- Borrow pits will be backfilled with rejected construction wastes (unserviceable materials) compacted and will be given a turfing or vegetative cover on the surface. If this is not possible, then excavation slope should be smoothened and depression is filled in such a way that it looks more or less like the original ground surface.
- Borrow areas might be used for aquaculture in case landowner wants such development. In that case, such borrow area will be photographed after their post-use restoration and Environment Expert of Supervision Consultant will certify the post-use redevelopment.

The Contractor will keep record of photographs of various stages i.e. before using materials from the location (pre-project), for the period borrowing activities (Construction Phase) and after rehabilitation (post development), to ascertain the pre and post borrowing status of the area.

14 **DRAWINGS**14.1 **DRAWING LIST**

S. No.	DRAWING No.	TITLE
1.	I-525/HT/1001	- Layout Plan
2.	I-525/HT/1002	- Topographical Survey Layout
3.	I-525/HT/1003	- Bathymetry Survey Layout
4.	I-525/HT/1004	- Location Plan of Boreholes
5.	I-525/HT/1005	- General Arrangement of Jetty , Approach Trestle & Conveyor Gallery (1 to 8)
6.	I-525/HT/1006	- General Arrangement of Administrative Building (1 of 2)
7.	I-525/HT/1006	- Cross Section & Elevations of Administrative Building(2 of 2)
8.	I-525/HT/1007	- General Arrangement of Worker's Amenity Building
9.	I-525/HT/1008	- Typ. Layout & Elevations of Security Office & Weigh Bridge Control Room
10.	I-525/HT/1009	- General Arrangement of Gate Complex
11.	I-525/HT/1010	- General Arrangement of Covered Storage Shed
12.	I-525/HT/1011	- Detail of Roads
13.	I-525/HT/1012	- Typical Plan and Cross Section of Culvert Over Green Belt Canal
14.	I-525/HT/1013	- Schematic Layout of Water Supply System
15.	I-521/ST/1014	- Layout of Storm Water Drainage
16.	I-521/ST/1015	- General arrangement of Fly ash silo & Profile of Pipe conveyor PC-1/PC-2
17.	I-521/ST/1016	- Cross Section of Fixed Type Barge Loader
18.	I-521/ST/1017	- Cross Section of Mobile Harbour Crane
19.	I-521/ST/1018	- Cross Section of Gantry Type Barge Unloader
20.	I-525/HT/1019	- Power Single Line Diagram
21.	I-525/HT/1020	- Sub-station Equipment Layout
22.	I-525/HT/1021	- High Mast and Cable Layout
23.	I-525/HT/1022	- Control Architecture

Annexure 1
Geotechnical Investigation Report