



**TENDER FOR
Development of Container Handling Facilities on EPC Basis at
Sittwe & Paletwa in Myanmar Under Kaladan Multi-Modal
Transit Transport Project
(Volume-II)**

Tender No. IWAI//KPMU/ 44 /CONTAINER/2018

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1.0 GENERAL INFORMATION

1.1 Background

At present, India has high dependency on the Siliguri Corridor also referred as Chicken's Neck, a narrow strip of Indian Territory wedged between the countries of Bhutan and Bangladesh, as it is the only access to the seven North East states. Routing all cargo destined through this corridor causes significant transportation delays and cost overheads.

The Government of India (GoI) had realised this shortcoming long back and conceived Kaladan Multi-modal Transit Transport (KMTT) Project in 1990s to identify an alternative route to India's landlocked north eastern states via Mizoram, sharing boarder with Myanmar. This trade route was planned to:

- Provide alternative to ship goods to the landlocked north-eastern States.
- Reduce dependency on Siliguri Corridor to avoid jams and delays.
- Lower the cost and distance of movement from Kolkata to Mizoram and beyond.

As per the studies carried out by M/s RITES, a multi modal transport system was proposed and accordingly a decision was taken to connect Sittwe to Paletwa through waterways and Paletwa to Indo Myanmar boarder through a road. On 2nd April, 2008 GoI and Government of Myanmar (GoM), signed frame work agreement and protocols to initiate this project. Ministry of External Affairs (MEA) appointed Inland Waterways Authority of India (IWAI) as KMTT Project Development Consultant (PDC) on 19th March 2009 and further IWAI through M/s ESSAR Projects (I) Ltd (EPIL) is carrying construction of Port and IWT Terminals at Sittwe and IWT Terminal at Paletwa including navigation aids from sea to Sittwe as well as Kaladan river; dredging in Sittwe port area and between Sittwe and Paletwa; and construction of 6 IWT vessels of capacity of 300 T each.

The above said Kaladan project was designed for handling breakbulk cargo at Sittwe and Paletwa. Accordingly the facilities have been designed for these types of commodities only. However, considering the range of breakbulk commodities handled currently, containerisation is the most efficient way to handle this cargo. It is realised that containerisation of the cargo anticipated for this project has several advantages such as safety and security of goods, lesser handling cost, flexibility of terms of transit of goods as per international trade practices. Accordingly, a DPR for provision of container handling at Sittwe and Paletwa terminals was prepared by AECOM India Private Ltd.

It is envisaged that containerized cargo from India or any other origin will be discharged at Sittwe, reloaded on to the Inland transport vessels for Paletwa and thereafter transported to its inland destination in Myanmar or to Mizoram by road. Similarly, any cargo originating from Mizoram or Myanmar hinterland can be transported by road to Paletwa, then to Sittwe by IWT passage and reloaded on to the sea going vessels for export / India / Yangon.



Figure 1.1 Kaladan Project Details

IWAI is in the process of selecting Contractor for the development of container handling facilities at Sittwe and Paletwa terminals.

This call for EPC bid is being addressed to potential Contractors for the Engineering, Design, Procurement of Materials, Construction/Installation, Testing, Commissioning and Performance Testing of Construction of container terminal with container handling facilities at Port of Sittwe and IWT terminal at Paletwa in Myanmar, under Kaladan Multi-Modal Transit Transport Project.

1.2 Site Location

The proposed container handling facilities are planned under KMTTP at 2 locations i.e., at Sittwe and Paletwa in The Republic of the Union of Myanmar (Formerly known as Burma) where breakbulk cargo handling facilities are recently constructed (**Figure 1.2**).



Figure 1.2 Location of Sittwe and Paletwa

Sittwe (formerly Akyab) is the capital of Rakhine State in Myanmar and is an estuarial island created at the confluence of the Kaladan, Mayu and Lay Mro rivers located on the Bay of Bengal. Paletwa (formerly Palangvum) is located in the Chin State, which shares borders with Bangladesh and India.

The port town of Sittwe is about 539 km from Kolkata through sea route, while Paletwa is about 158 km upstream of Sittwe on the river Kaladan.

1.3 Site Information

1.3.1 General

The site information included in the following paragraphs is only for guidance of the Tenderer. The Tenderer shall conduct all necessary field tests and surveys to satisfy 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 Overall Site Plans with Proposed Layout are shown in **Drawing 60544930-DRG-T-0000-CS-1001** and **Drawing 60544930-DRG-T-0000-CS-1002**.

1.3.2 Features near Sittwe Terminal

The terminal location at Sittwe is on the confluence of Kaladan River to the Bay of Bengal. The entire terminal is located on a reclaimed area with future expansion provision.

Upstream of Sittwe terminal a T-shaped port jetty is located, which is used for import of local consumer goods, beverages, onions and export of fish, prawns and rice products. Further upstream a passenger jetty referred as Mallika jetty and an L shaped Oil jetty are also positioned.

Between Port and Passenger jetties, a large area is proposed to be reclaimed by Government to be used for provision of housing. The main road which is running just behind the Sittwe facility on the landward side is a very busy commercial street. It has many small eateries, restaurants, shops and office on both of its sides. Most of the residential area are further west the main road as shown in **Figure 1.3**.



Figure 1.3 Site Features at Sittwe

1.3.3 Features near Paletwa Terminal

The Paletwa facility is situated about 158 km upstream of Sittwe on the east bank of Kaladan River, opposite to the village of Paletwa (**Figure 1.4**). It is primarily an agriculture village growing rice, banana, mango, groundnut, beetle nut and vegetables.

The village is connected to other nearby villages and Kyauk Taw with mostly unpaved single roads and villagers mostly depend on small boats to travel. However, recently government has planned a

paved double lane road to Paletwa and also a bridge just downstream of the village to provide road connectivity between both banks of the river.

A dense forest is marked immediately upstream of the facility. The river Kaladan takes a sharp 90 degree turn about 450 m upstream of the IWT facility and the general depths in this area are reported to be good.

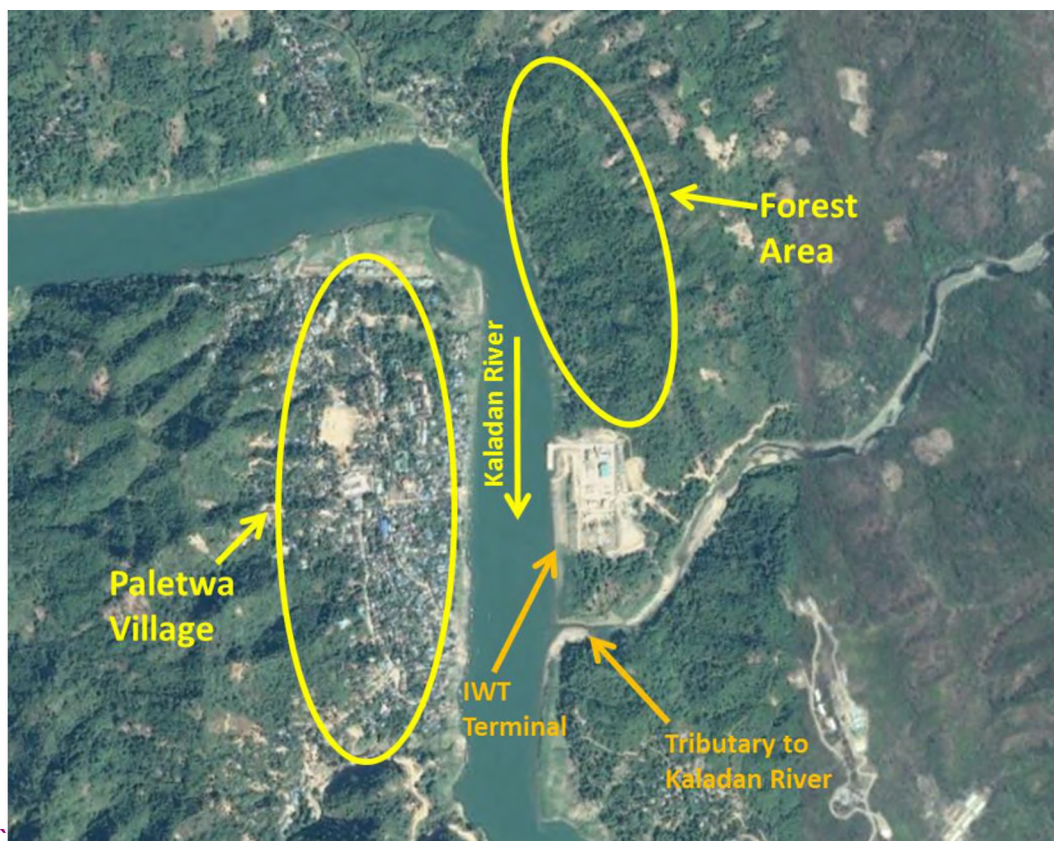


Figure 1.4 Site Features at Paletwa

1.3.4 Meteorological Information

The climate of the project area is categorized as tropical in nature, as per the Köppen and Geiger climate classification system, as it has significant rainfall for most of the months in a year, with a short dry season.

1.3.4.1 Temperature

The temperature variations throughout the year are shown in **Figure 1.5** and **Figure 1.6**. The average annual temperature is about 25.6 °C at both Sittwe and Paletwa. April is the hottest month, while January is recorded as coldest month of the year.

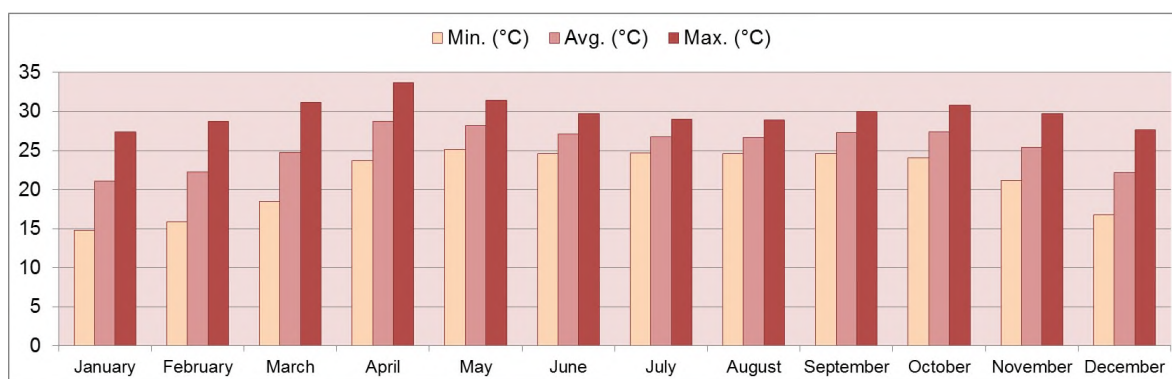


Figure 1.5 Annual Temperature Profile for Sittwe (Source: <https://en.climate-data.org/location/319/>)

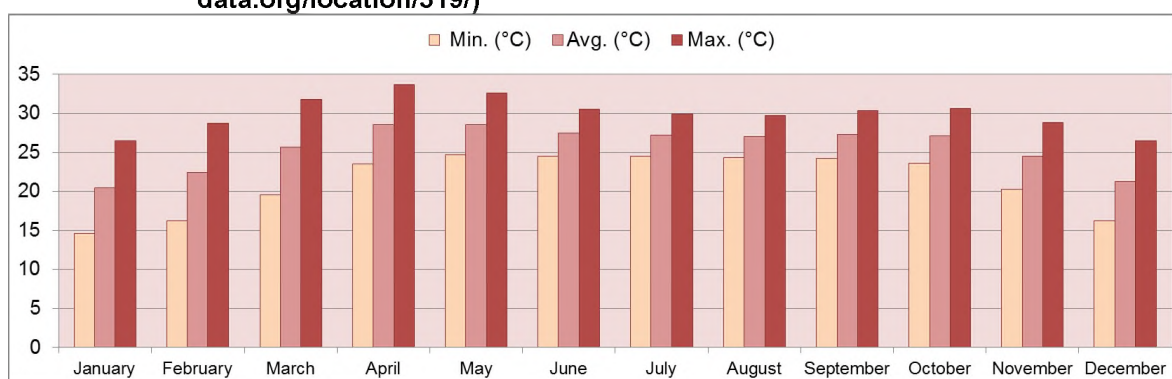


Figure 1.6 Annual Temperature Profile for Paletwa (Source: <https://en.climate-data.org/location/717984/>)

1.3.4.2 Rainfall

The region receives rainfall for most months in the year, with a very short dry season. The annual rainfall reported at Sittwe and Paletwa is 4664 mm and 3615 mm, respectively (Figure 1.7). Precipitation is the lowest in January. In July, the precipitation reaches its peak, with an average of 1,173 mm and 929 mm for Sittwe and Paletwa, respectively.

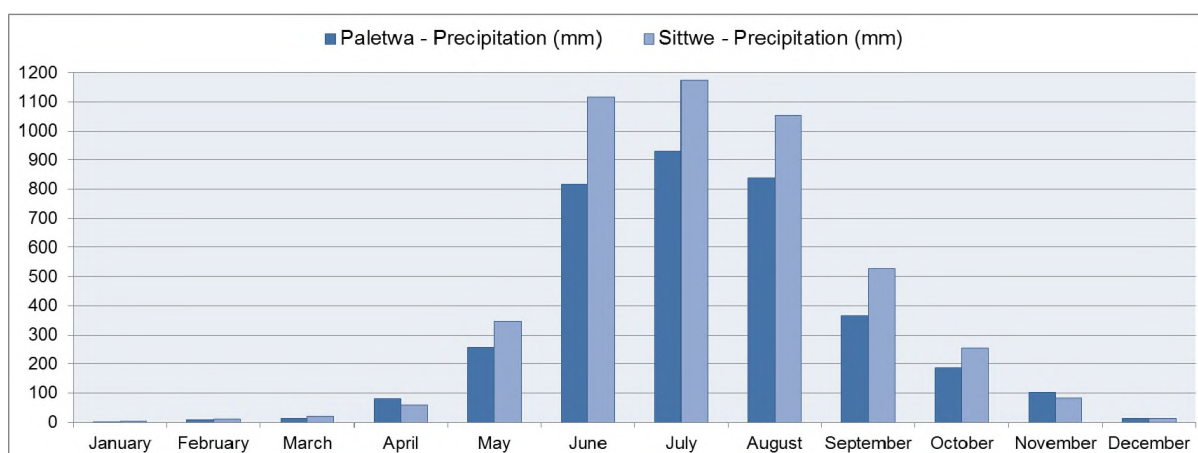


Figure 1.7 Annual Rainfall Profile for Sittwe and Paletwa

1.3.4.3 Wind

The wind rose diagram for Sittwe is as presented in **Figure 1.8**, while wind rose for Paletwa may be seen in **Figure 1.9**. The most prominent wind direction is NNE for Sittwe while ENE for Paletwa.

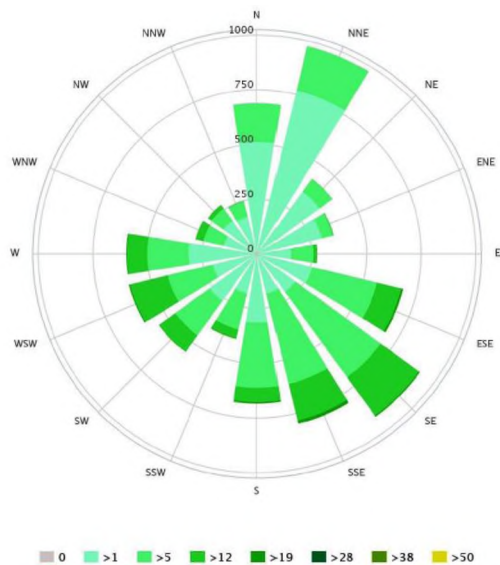


Figure 1.8 Wind Rose Diagram of Sittwe (Cited: EIA Report for Kaladan Project, 2015)

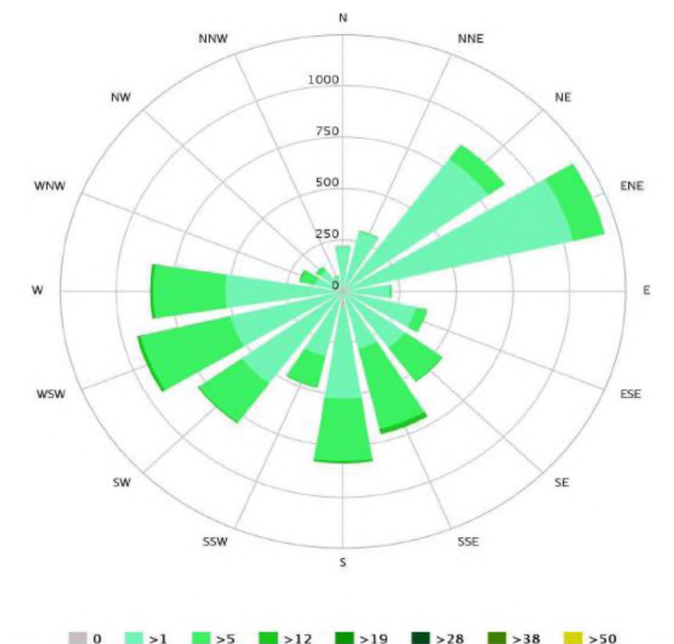


Figure 1.9 Wind Rose Diagram of Paletwa (Cited: EIA Report for Kaladan Project, 2015)

1.3.5 Oceanographic Information

1.3.5.1 Offshore Wave Condition

The offshore wave rose plots can be seen in **Figure 1.10** for Sittwe port. The wave data is extracted from ECMWF at the coordinates (20 Lat, 92.875 Long) and analysed for the year 2013. The predominant wave directions are SW and SSW (**Figure 1.10**). The maximum offshore wave height is seen up to 3 m, while about 80% of the year waves are observed in the range of 0.5 m and 1.5 m. The wave periods are observed up to 12 seconds maximum and 6 to 9 seconds are significant.

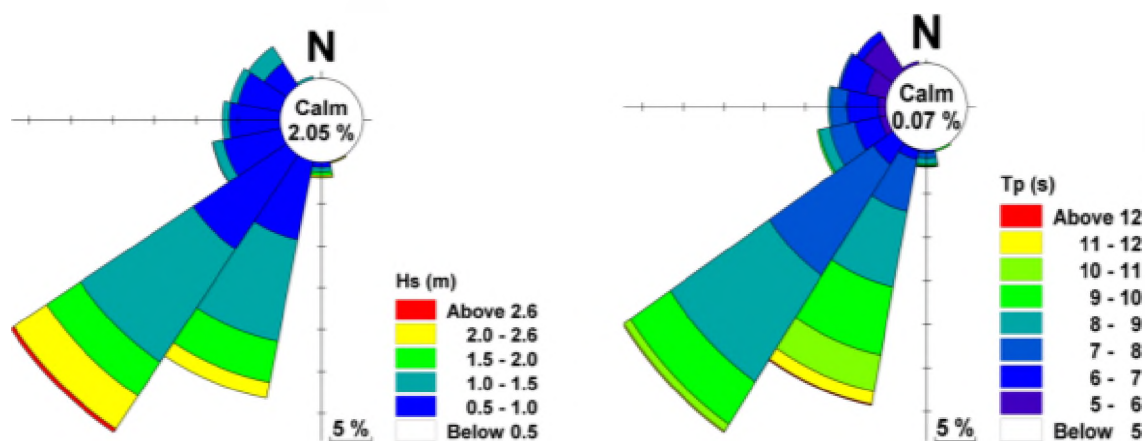


Figure 1.10 Wave Rose Plot- Sittwe (Offshore)

1.3.5.2 Tidal Levels at Sittwe

The astronomical tide data pertinent to Sittwe Port as referred to Chart Datum (CD) are given in **Table 1.1**. The CD adopted for Sittwe port is 1.3 m below Mean Sea Level (MSL).

Table 1.1 Tide Table – Sittwe

	Level w.r.t CD, (m)
Mean High Water Springs (MHWS)	2.4
Mean High Water Neaps (MHWN)	1.7
Mean Low Water Neaps (MLWN)	0.8
Mean Low Water Springs (MLWS)	0.1
Mean Sea Level (MSL)	1.3

1.3.5.3 Tide and Water Levels at Paletwa

The tidal level range near Paletwa jetty is very minimal due to the influence of the riverine flow and it ranges up to 1 m at peaks.

At Paletwa, tidal signatures may be observed between November and April, while river flow dominates in the monsoon months to evade tidal variations. The water levels at Paletwa jetty in 2013

were found to reach up to 7.4 m CD and drops down to 0.3 m CD. It is important to note that the water levels at Paletwa were reported to reach 12 m in the year of 2015, a year reported to be unusual event of flood.

1.3.5.4 Currents at Sittwe

Figure 1.11 shows the current float values at Sittwe. The maximum velocity identified near IWT Jetty is 1 m/s and in the channel is 0.6 m/s during the mid of the ebb tide.



Figure 1.11 Current Float Values Observed during Ebb Tide

1.3.6 Hydrographic Survey

The Employer has carried out hydrographic survey of the area. The survey details provided herein below are only for information of the Tenderer.

Recent hydrographic surveys are available near Sittwe and Platewa as shown in **Figure 1.12** and **Figure 1.13**. General depth near the Sittwe jetty may be seen as 4 – 5 m. It was reported that the approach channel to the Sittwe has been dredged to a depth of 7.9 m CD but the turning circle and pocket near the jetty could not be dredged to the desired width and depths due to the presence of ship wrecks.

The bathymetry downstream of the IWT jetty of Paletwa showed a narrow depth ranging from 0 – 2 m. On the contrary water depths upstream of Paletwa Jetty are quite good. Area near East bank on the upstream of the jetty are as deep as 8 -10 m.

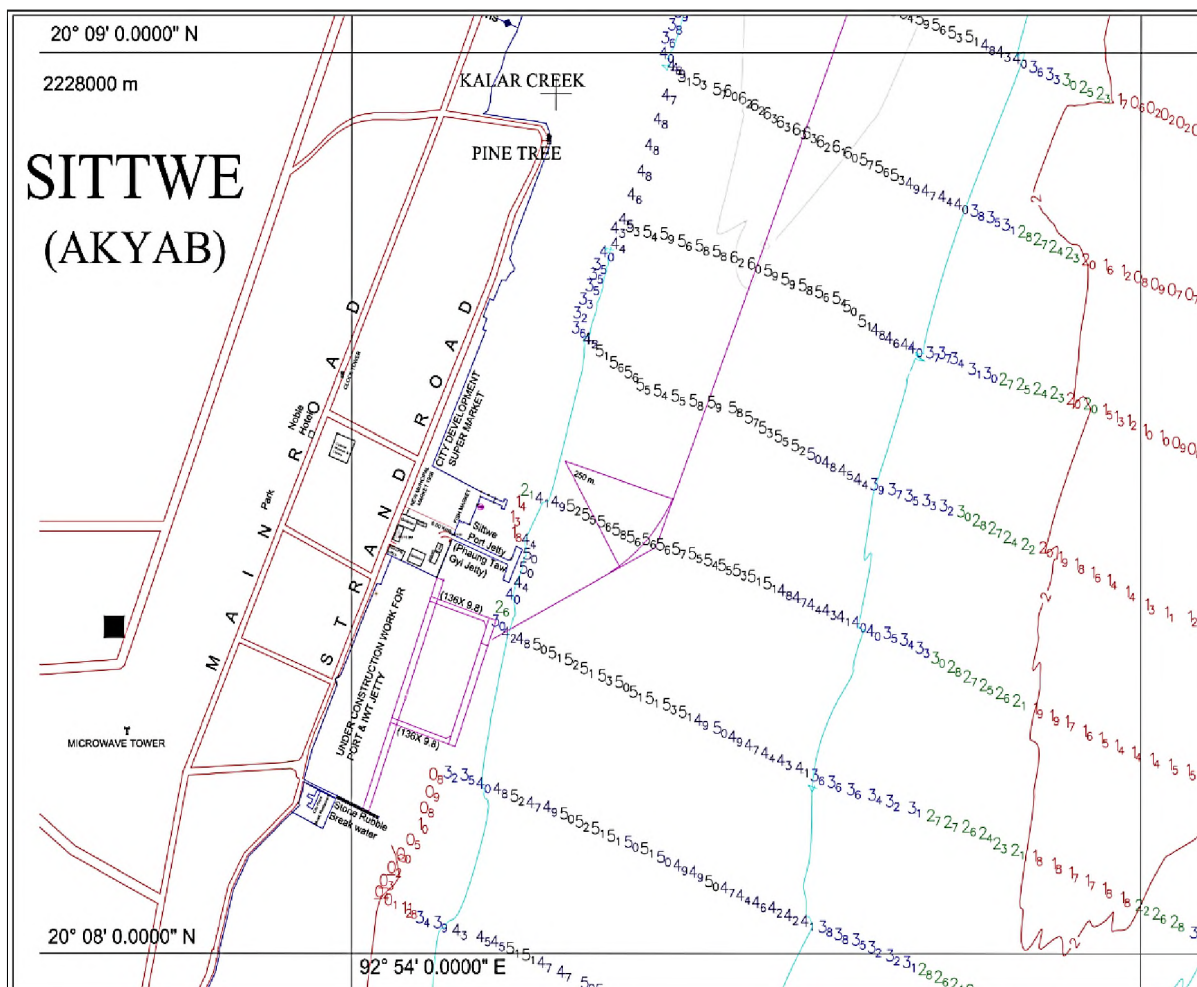


Figure 1.12 Hydrographic Survey around Sittwe Jetty

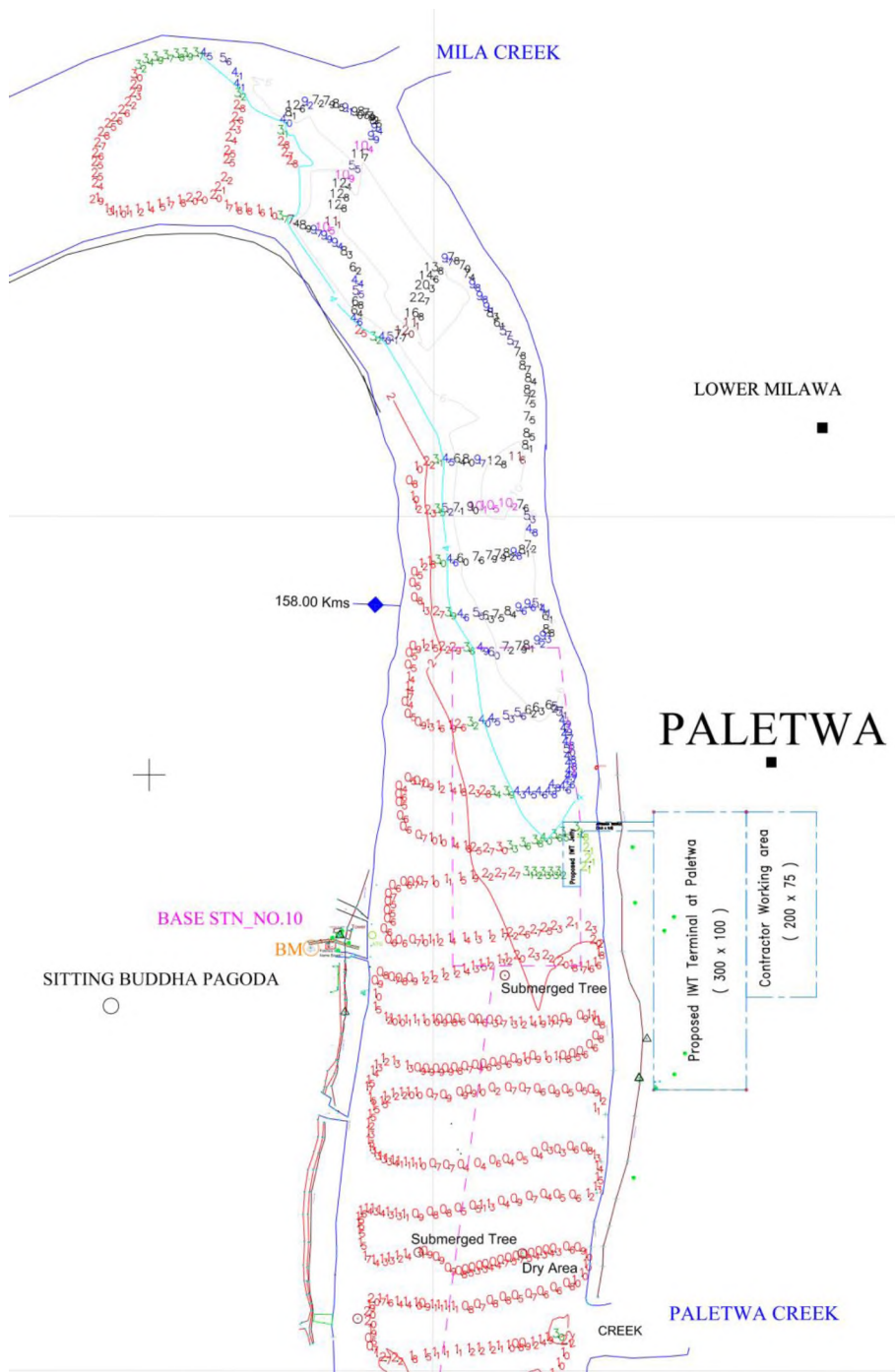


Figure 1.13 Hydrographic Survey around Paletwa Jetty

In general, water depth of more than 2.5 m is available in the Kaladan River between Sittwe and Paletwa but there are some marked shoals or areas having limited depths, mainly as three locations namely Sanghataung, Launggadoo and Paletwa (Figure 1.14).

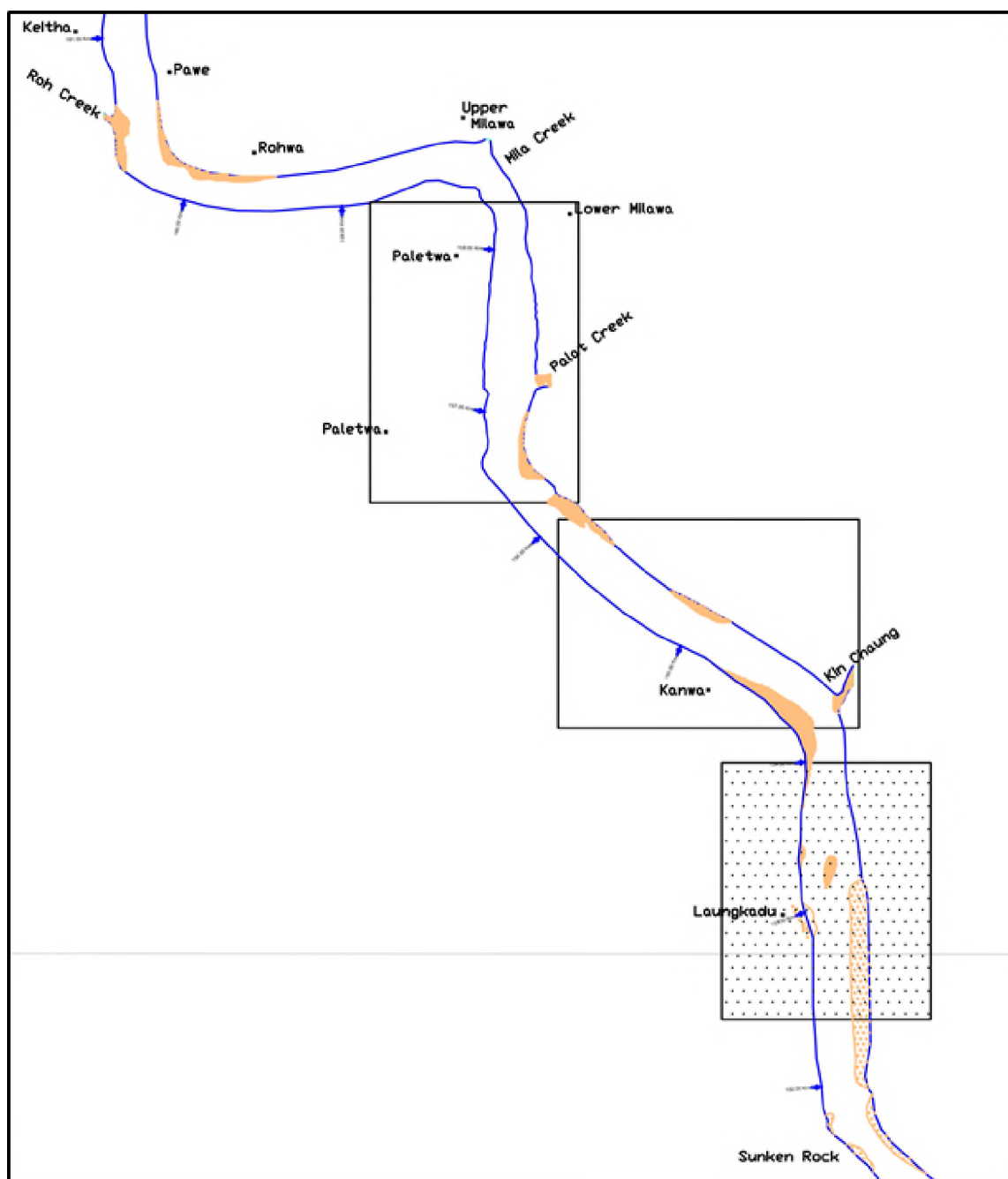


Figure 1.14 Shoal Locations in River Kaladan

1.3.7 Topographic Information

The topographic survey details for the backup area at Sittwe and Paletwa are shown in the **Drawing 60544930-DRG-T-0000-CS-1003** and **Drawing 60544930-DRG-T-0000-CS-1004** respectively. The survey drawings are only for information of the Tenderer.

1.3.8 Geotechnical Information

The Employer has carried out onshore as well as marine geotechnical investigations at Sittwe and Paletwa. The geotechnical details provided herein below are only for the information of the Tenderer.

1.3.8.1 Marine Geotechnical Data at Sittwe

Six bore logs were undertaken till the depth of 50 m at the Sittwe jetty. The location of the boreholes is shown in **Figure 1.15**. The soil at Sittwe jetty is identified to dense grey silty sand in the top layers and dense grey siltstone in the layers below 35 m depth (**Table 1.2**).



Figure 1.15 Marine Borehole Locations – Sittwe Port

Table 1.2 Marine Bore Log Sub Strata Details – Sittwe Port

Bore Hole No	Co-ordinates	Depth (m)	Description	N Value
BH 01 (J5)	489785.292 E, 2226710.55 N	0.0 – 20.0	-	-
		20.0-30.0	Dense Grey Sand, silt and clay	16.0 - 23.0
		30.0-35.0	Sandy Shale - Silty Shale	>100.0
		35.0-40.0	Dense Grey Siltstone	-
BH 02 (J6)	489806.558 E 2226769.881 N	0.0 – 10.0	Grey silt and fine sand	1.0 - 7.0
		10.0 - 20.0	-	-
		20.0-35.0	Medium Dense Grey fine Sand, silt and clay	10.0 - 25.0
		35.0 - 40.0	Stiff Light Grey clayey silt and fine sand	20.0 - 50.0
		40.0 - 50.0	Dense Grey slightly weathered Siltstone	-
BH 03 (J7)	489832.836 E 2226846.123 N	0.0 - 5.0	Very soft grey Silt and clay	1.0 - 12.0
		5.0 - 35.0	Medium Dense Grey fine Sand, silt and clay	10.0 - 14.0
		35.0-45.0	Stiff Light Grey clayey silt and fine sand	16.0 - 32.0
		45.0 - 50.0	Dense Grey massive Siltstone	-
BH 04 (J8)	489841.721 E, 2226870.172 N	0.0 - 30.0	-	-
		30.0-45.0	Stiff Grey clayey silt and fine sand	11.0 - 33.0
		45.0 - 50.0	Dense Grey massive Siltstone	-
BH 1	489856.368 E, 2226918.6445 N	0.0 – 35.0	-	
		35.0 - 46.0	Grey Clayey silt trace fine sand	24.0 - 29.0
		46.0-50.0	Dense Grey moderate to weathered Siltstone	80.0 - 100.0
		50.0 - 54.0	Dense Grey massive Siltstone	>100
BH 2	489766.5 E, 2226671.72 N	0.0 – 6.0	-	
		6.0 - 15.0	Stiff Light Grey clayey silt and fine sand	5.0 - 10.0
		15.0-30.0	Dense Grey fine sand, Silt and some Clay	10.0 - 20.0
		30.0 - 38.0	Stiff Grey Silt & clay trace fine sand	20.0 - 25.0
		38.0 - 40.0	Dense Grey slightly weathered to massive Siltstone	80.0
		40.0 - 50.0	Dense Grey massive Siltstone	

1.3.8.2 Land Geotechnical Data at Sittwe

Three bore logs were undertaken till the depth of 8 m on the landward side at Sittwe. The location of the boreholes is shown in **Figure 1.16**. The soil at Sittwe jetty is identified to be silty sand in the top layers and clayey silt in the layers below 3.5 m depth (**Table 1.3**).



Figure 1.16 Land Borehole Locations – Sittwe Port

Table 1.3 Land Bore Log Sub Strata Details – Sittwe Port

Bore Hole No	Depth (m)	Description	N Value
BH 01	0.0 – 15.0	Silty Sand	6-16
	15.0 – 25.5	Clayey Silt	13-15
BH 02	0.0 – 3.5	Silty Sand	7-19
	3.5 – 6.5	Silty Clay	6-18
	6.5 – 8.0	Sand	11-20
BH 03	0.0 – 3.5	Silty Sand	6-44
	3.5 – 8.0	Clayey Sand	4-15
BH 04	0.0 – 43.5	Clayey Silt	27
	43.5 – 50.0	Clayey Silt	27

1.3.8.3 Marine Geotechnical Data at Paletwa

Five bore logs were undertaken till the depth of 20 m to 30 m on the jetty alignment, including three land and two river boreholes (Figure 1.17). The soil strata at Paletwa jetty is Dense Grayish Brown Sand in the top layers followed by a layer of Dense Grey weathered Slaty Shale to Slate. For depths below -15 m CD Dense Grey massive Siltstone is observed. The details are given in Table 1.4.



Figure 1.17 Borehole Locations – Paletwa Jetty

Table 1.4 Marine Bore Log Sub Strata Details – Paletwa Jetty

Bore Hole No	Co-ordinates	Elevation/ Depth (m)	Description	N Value
BH 01 (BA1) (Land)	485510.792 E 2355945.187 N	(+7.0) – (+6.0)	Dense Grayish Brown Sandy silt and clay	70.0 - 120.0
		(+6.0) – (-6.0)	Dense Grey slaty Shale to Mudstone	
		(-6.0) – (-12.0)	Dense Grey massive Slate	
BH 02 (BA2) (Land)	485499.735 E 2355945.976 N	(+9.5) – (+4.5)	-	
		(+4.5) – (+3.5)	Dense Grayish Brown Sand, silt and clay	50.0 - 100.0
		(+3.5) – (+2.0)	Dense Grey weathered silty Shale	
		(+2.0) – (-16.0)	Dense Grey slaty Shale to Mudstone	
BH 03 (BA3) (Land)	485541.451 E 2355945.374 N	(+14.0) – (+10.5)	Dense Grayish Brown Sand, silt and clay	12.0 - 66.0
		(+10.5) – (+8.0)	Dense Grey weathered slaty Shale	
		(+8.0) – (-5.5)	Dense Grey weathered slaty Shale to Mudstone	
		(-5.5) – (-11.5)	Dense Grey weathered slaty Shale to Slate	
		(-11.5) – (-15.0)	Dense Grey massive Slate	
BH 04 (BJ1) (Riverbed)	485460.724 E 2355944.584 N	(-3.5) – (-7.5)	Dense Grey Sand and Silt	26.0 - 58.0
		(-7.5) – (-20.0)	Dense Grey weathered slaty Shale to Mudstone	
		(-20.0) – (-30.0)	Dense Grey weathered slaty Shale to Slate	
BH 05 (BJ2) (Riverbed)	485461.372 E 2355891.896 N	(-2.5) – (-5.0)	Dense Grey Sand and Silt	26.0 - 58.0
		(-5.0) – (-16.75)	Dense Grey weathered slaty Shale to Mudstone	
		(-16.75) – (-24.0)	Dense Grey massive Siltstone	

1.3.8.4 Land Geotechnical Data at Paletwa

Three bore logs were undertaken till the depth of 20 m to 30 m on the landward side (**Figure 1.18**). The soil strata at Paletwa jetty is Dense Sand & Silt with some Clay. The details are given in **Table 1.5**.



Figure 1.18 Land Borehole Locations – Paletwa Jetty

Table 1.5 Land Bore Log Sub Strata Details – Paletwa Jetty

Bore Hole No	Co-ordinates	Elevation/ Depth (m)	Description	N Value
BH 01	485613.850 E 2355784.500 N	(+16.6) – (+12.1)	Dense sand & Silt Some Clay	15-17
		(+12.1) – (+7.6)	Stiff Sandy & Clayey Silt	16-32
		(+7.6) – (-2.9)	Dense Silt & Fine Sand Some Clay	16-28
		(-2.9) – (-5.0)	Dense Sand & Silt Trace Clay	37-42
BH 02	485577.850 E 2355783.162 N	(+17.1) – (+15.6)	Dense sand & Silt Some Clay	11-12
		(+15.6) – (+12.6)	Stiff Sandy & Clayey Silt	12
		(+12.6) – (+5.1)	Dense Silt & Fine Sand Some Clay	12-16
		(+5.1) – (+2.1)	Stiff Sandy & Clayey Silt	16-28
		(+2.1) – (-1.35)	Dense Sand & Silt Trace Clay	28-30
BH 03	485545.912 E 2355759.916 N	(+18.31) – (+13.21)	Dense Silt & Fine Sand Some Clay	4-13

1.3.9 Ship Wreck Location at Sittwe

In December, 2012 during a sonar survey, two ship wrecks were reported near the Sittwe facility (**Figure 1.19**) while dredging activity. Wreck 1 is reported to be about 20 - 50 m downstream of the Port Jetty while Wreck 2 is 90 m east of the Port jetty. Reportedly, no dredging was carried out at the marked locations during 2012.

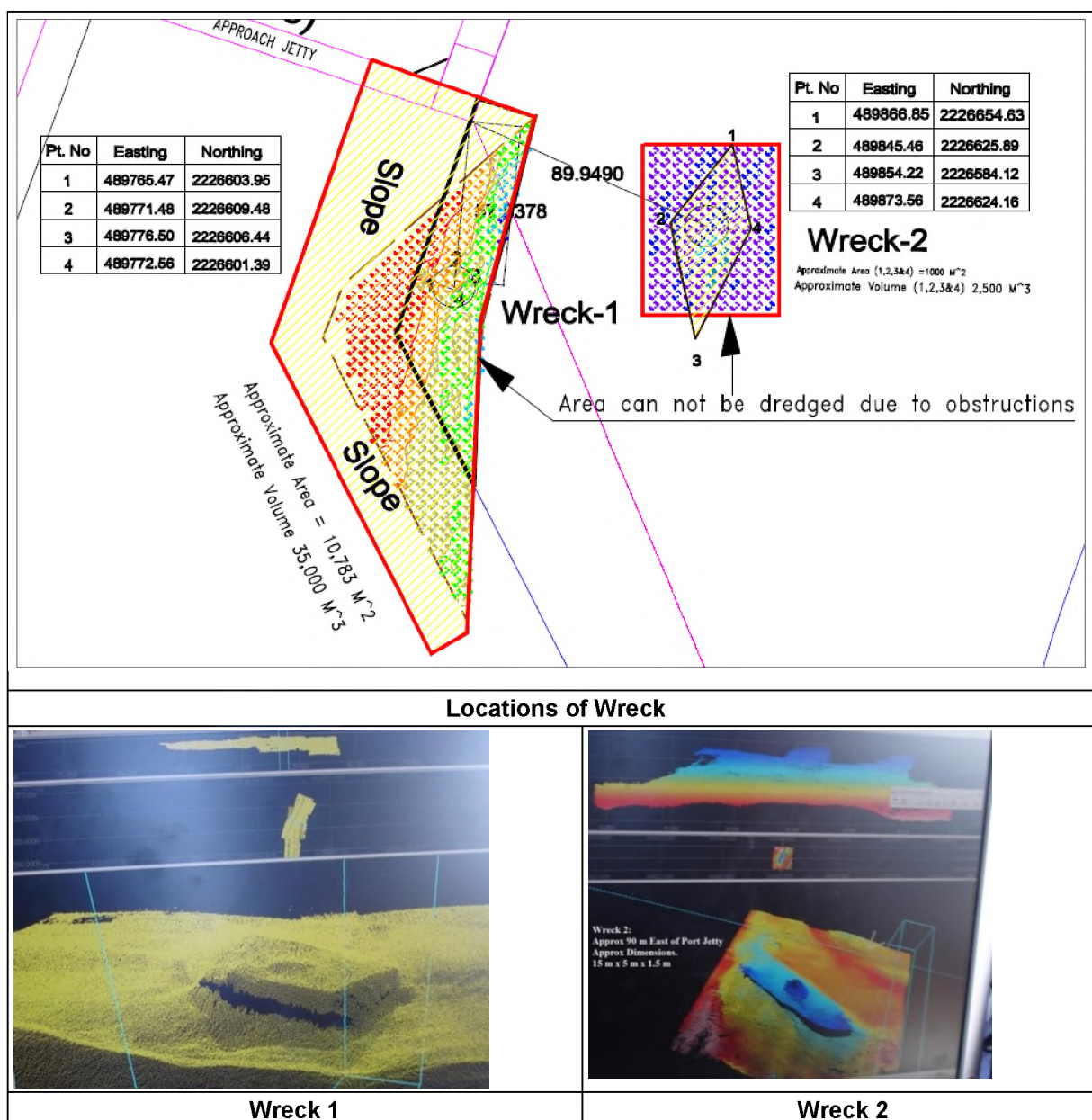


Figure 1.19 Ship Wreck Location in Front and Downstream of Port Jetty at Sittwe

1.3.10 Model Studies

Details of mathematical model studies are available in the DPR prepared by M/s Aecom India Pvt. Ltd. The model study details are for the information of the Tenderer.

1.4 Details of Existing Project Facilities

The existing project facilities are provided herein below only for information of the Tenderer.

The existing project anticipates cargo going to Northeast via road from rest of the India to be accumulated at Kolkata from where it is to be transported to Sittwe in sea-going vessels. The cargo

will then be downloaded at Sittwe and reloaded to IWT barges to be transported to Paletwa from where it may be dispatched in trucks via road to Mizoram and other NE states.

A total of three jetties are planned with all associated facilities, a port jetty and an IWT jetty at Sittwe and an IWT jetty at Paletwa. Details of these facilities are provided in the subsequent sub-sections.

1.4.1 Approach Channel

1.4.1.1 Sittwe Port

The navigational channel from the Sea to Sittwe Port is planned for a depth of 7.9 m below CD and width of 52.15 m for the safe navigation of 6,000 DWT vessels at present. Navigational aids are also provided for safe navigation.

1.4.1.2 Paletwa IWT Terminal

The IWT barges constructed for the Inland transport have a draft of 1.5 m and hence a channel of 2.0 m below CD is provided from Sittwe to Paletwa with a width of 37.5 m. An extra allowance of 42.5 m in the channel width and 2.2 m CD in the depths is been provided at the locations such as Sanghataung, Launggadoo, Paletwa, where rocky outcrops are reported.

1.4.2 Terminal at Sittwe

1.4.2.1 Jetties

There are two jetties adjacent to each other, i.e., Port Jetty to cater to sea going vessels coming from Kolkata and IWT Jetty to load Inland cargo. The layout of the facility is provided as **Figure 1.20**.

The Port jetty at Sittwe is 219 m long and 15.2 m wide. The deck top level of this jetty is +5.60 m CD. While, the IWT Jetty is 54 m long, 15.2 m wide and has a deck top level of +4.40 m CD.

Both the jetties are connected to backup area through an approach trestle having a length of 136 m. The width of approach is 9.5 m and 9.8 m for Port and IWT jetty, respectively.

1.4.2.2 Back Up Area

Total back up area developed at Sittwe is 300 m × 120 m, while another 200 m × 120 m is kept for future expansion. The entire area is reclaimed up to +5.0 m CD.

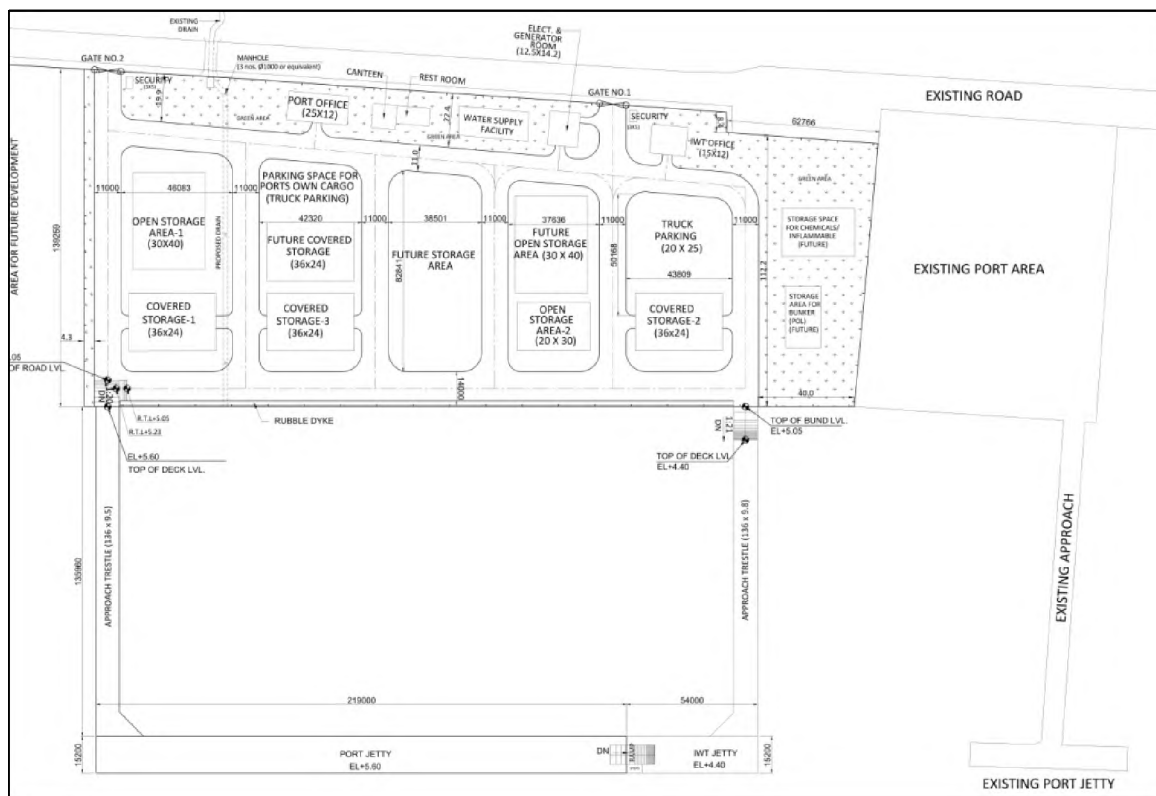


Figure 1.20 Layout of Facility at Sittwe



Figure 1.21 Pictures of Jetties at Sittwe

1.4.2.3 Storage Facilities

The Port Jetty has two covered storage sheds of size 36 m × 24 m each with suitable partitions for storage of food grains, fertilizers, other agricultural products and cement. Future provision for covered storage area of size 36 m × 24 m for cement, food grains, and finished consumer goods has also been made. It also has an open storage area of 30 m × 40 m for cargo that is least susceptible to climatic conditions like such as timber, steel and Iron.

The IWT jetty is also complimented with a covered storage sheds of size 36 m × 24 m with adequate partition and an open storage area of size 30 m × 20 m for iron, steel, machinery & other miscellaneous general cargo. In order to cater to future expansion of facilities or anticipated increase in cargo, future open storage areas of 30 m × 40 m is also earmarked.



Covered Sheds



Inside view of the Covered Shed at Sittwe



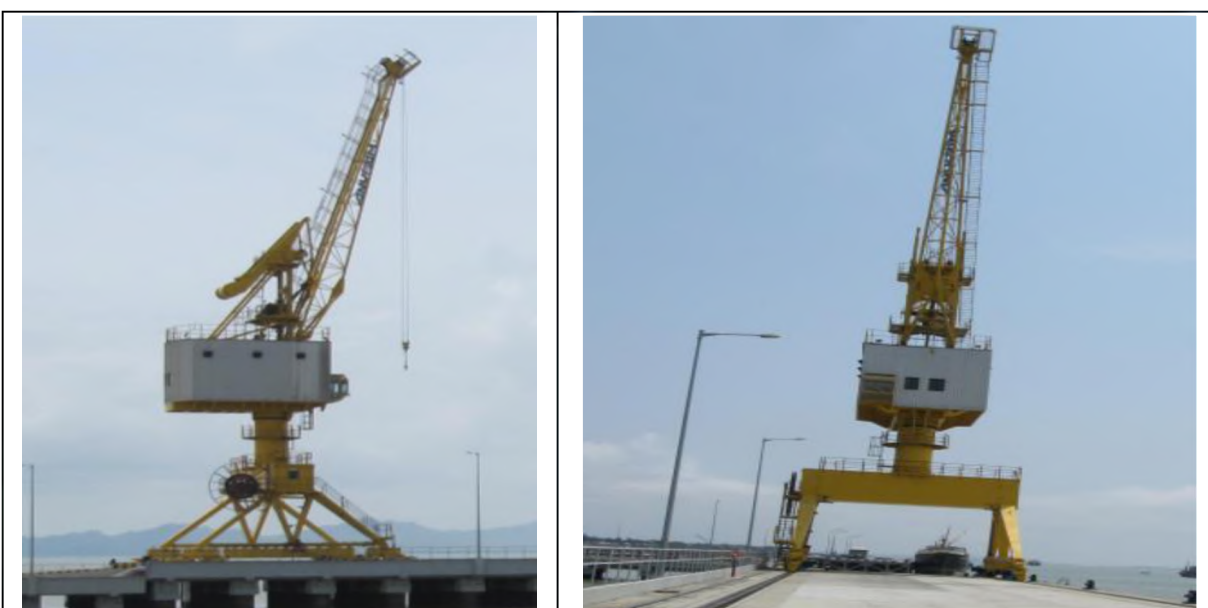
Open Storage Area

Figure 1.22 Storage Provisions at Sittwe

1.4.2.4 Handling Equipment

The cargo at Port jetty will be serviced using Rail Mounted Level Luffing Crane (RMC) having a capacity of about 10 T and reach of about 25.5 m. The total rail length for crane is 219 m (2 rows), centre to centre (C/C) clearance is 11.7 m and a vertical clearance of 8 m. At present the crane has provision of only sling handling for breakbulk. Other equipment for cargo handling at Port jetty are four (04) tractors of 40 HP each, sixteen (16) trailers of 4 T and four (04) forklifts of 3 T of capacity.

At IWT jetty all loading will be done using Mobile Tyre Mounted Cranes of 10 T capacity and maximum reach of 12 m. Additionally, there will be two (02) tractors of 40 HP each, eight (08) trailers of 4 T and two (02) 3 T forklifts to support operations.



Level Luffing Crane at Sittwe (Left side is showing side view and Right side is showing front view with c/c)



Mobile Tyre Mounted Cranes of 10 T capacity



Forklifts of 3 T of capacity each



Figure 1.23 Handling Equipment at Sittwe

1.4.2.5 Other Facilities and Services

The terminal facilities include truck parking, office space, generator shed, electrical room, pump houses, water storage tanks, canteen and rest rooms (**Table 1.6**).

Table 1.6 Other Facilities at Sittwe

Facilities	Sittwe
Port Office	322 sqm
IWT Office	195 sqm
Security Room	15 sqm
Canteen and Rest Room	240 sqm
Electrical and DG room	180 sqm
Truck Parking area	25 m × 20 m
Underground Water Tank	Service Water – 250 cum

Facilities	Sittwe
	Drinking Water - 90 cum Fire Water – 500 cum
Overhead Water Tank at 20 m height	Service Water – 50 cum Drinking Water – 30 cum
DG sets	500 KVA and 320 KVA
Fuel Storage Tank	33 cum only for port demand

A total of 120 -150 people are anticipated to work at Sittwe. Only day light operations are envisaged at both the locations however, at Sittwe operations may be scaled to 3 shifts if required as support facilities are planned for peak demand, i.e., 3 shift employing 60 – 65 people in each shift.

It is important to mention that groundwater is extracted and saved in the underground tanks. The existing water storage is sufficient for current operations. The 320 KVA DG set is quite sufficient for the present, however, the authorities have also applied to Myanmar Electricity Board to provide power to Sittwe terminal and the proposal is under consideration.

At present fuel storage tank cater to only demand for DG sets and port equipment. It is reported that bunkering for IWT vessels is not planned at Sittwe.

1.4.3 Terminal at Paletwa

1.4.3.1 IWT Jetty

The IWT jetty at Paletwa is 70.86 m long with an apron width of 19.2 m for loading and unloading operations. The jetty at Paletwa has two deck levels, lower deck is about 38.76 m long having a deck level of +4.0 m CD while upper deck has a length of 32.1 and deck level of +6.0 m CD (**Figure 1.24**).

An approach trestle of 74.45 m of length and 9.5 m of width is provided to connect jetty to the back-up area.

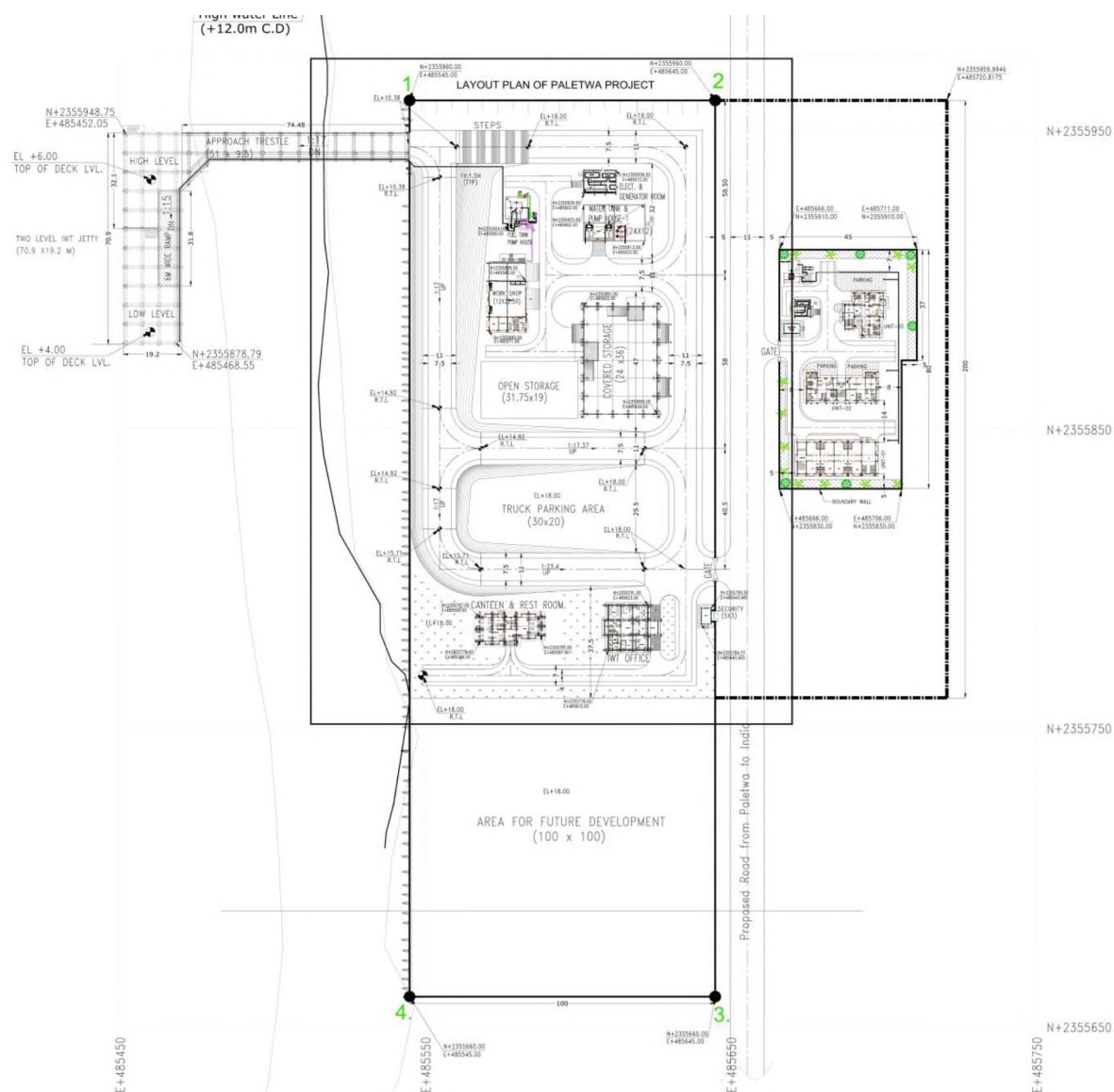


Figure 1.24 Layout of Facility at Paletwa

1.4.3.2 Back Up Area

Total back up area at Paletwa is 300 m × 100 m, out of which only 200 m × 100 m is developed at present and rest 100 m × 100 m is earmarked for future demand.

1.4.3.3 Storage Facilities

The IWT terminal at Paletwa consists of a covered transit storage shed of size 36 m × 24 m with suitable partitions for segregation of commodities and an open storage area of size 31.75 m × 19 m (Figure 1.25).



Covered Sheds



Open Storage Area

Figure 1.25 Storage Provisions at Paletwa

1.4.3.4 Handling Equipment

A 10 T crane having an outreach of 12 m is planned to service the break bulk cargo and operations will be supplement with four (04) 10 T trucks, two (02) 3 T forklifts.



Figure 1.26 Handling Equipment at Paletwa

1.4.3.5 Other Facilities and Services

In addition to the above, the terminal facilities include truck parking, office space, generator, electrical room, pump houses, water storage tanks, canteen and rest rooms (**Table 1.7**).

Table 1.7 Other Facilities at Paletwa

Facilities	Paletwa
IWT Office	195 sqm
Security Room	15 sqm
Canteen and Rest Room	240 sqm
Electrical and DG room	180 sqm
Truck Parking area	50 m × 12 m
Underground Water Tank	Service Water – 65 cum

Facilities	Paletwa
	Drinking Water – 150 cum Fire Water – 400 cum
Overhead Water Tank at 20 m height	Service Water – 50 cum Drinking Water – 30 cum
DG sets	180 KVA and 80 KVA (additional 125 KVA and 80 KVA for township)
Fuel Storage Tank	33 cum only for port demand

A total of about 50 – 60 people are expected to work at Paletwa during day light operations only.

Groundwater is proposed to be used to cater to water demand. The existing water storage and DG sets are sufficient for current operations. At present fuel storage tank cater to only demand for DG sets, port equipment and emergency bunkering for IWT vessels.

At Paletwa a housing unit is also planned for workers, officers with family accommodation for about 50 persons.

1.4.4 Vessel Characteristics for IWT

The current barges which are been made for plying between Sittwe and Paletwa are constructed for break bulk. The LOA, width and depth of these vessels are 45 m, 9.5 m and 2.3 m, respectively (**Figure 1.27**). A total of 6 such barges are been constructed for the IWT, having cargo carrying capacity of 300 T.

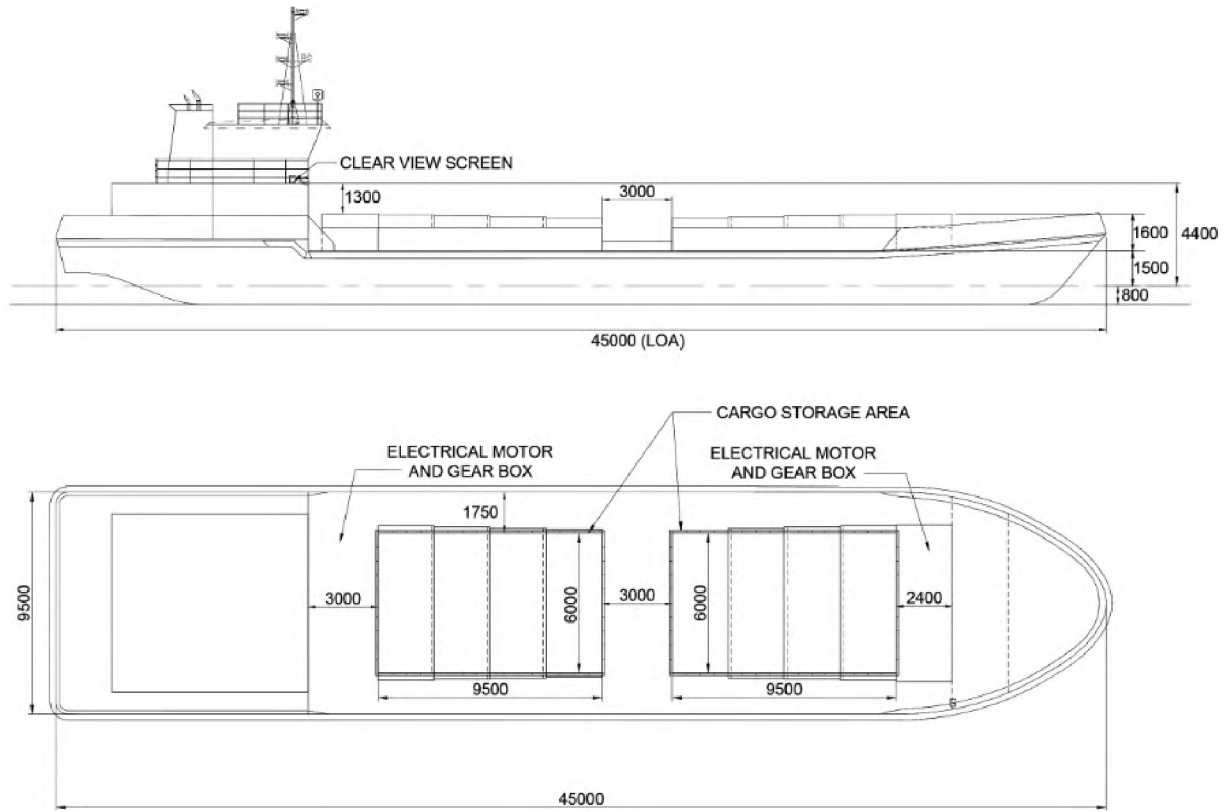


Figure 1.27 Dimensions of Existing Barges

2.0 EMPLOYER'S REQUIREMENTS

2.1 Jetty Structures and Approach Trestle

The Employer's Requirements are that the Contractor shall carryout the Engineering, Design, Procurement of materials and Construction of the jetty structures and approach and other associated works as outlined in this tender document.

There shall be one Port jetty and one IWT jetty at Sittwe with connecting approach trestle and one IWT jetty at Paletwa for the proposed container handling facility. The details of these jetties are given in the following table:

Jetty Structure	Length of Jetty	Minimum Width of Deck of the Jetty	Design Dredged Level / bed level at Jetty w.r.t. CD	Deck Level w.r.t. CD
Port Jetty at Sittwe	160 m	30.00 m	-12.7 m	+5.6 m
IWT Jetty at Sittwe	60 m	45.00 m	-12.7 m	+5.6 m
Approach at Sittwe connecting Port jetty with land side facilities	121 m	10 m	-	+5.6 m
IWT Jetty at Paletwa	60 m	45.00 m	-8.0 m	+6.0 m

- i) The general arrangement showing layout plan and sections of jetties with approach trestle at Port of Sittwe are shown in the **Drawing 60544930-DRG-T-0000-CS-1005** and **Drawing 60544930-DRG-T-0000-CS-1006**. The width of Port jetty / approach trestle shall be enhanced at their junction for the smooth movement / turning of the ITVs as shown in the layout plan.
- ii) The proposed IWT jetty at Paletwa is connected with land through exiting approach trestle. The general arrangement showing layout plan and section of IWT jetty at Paletwa is shown in the **Drawing 60544930-DRG-T-0000-CS-1007** and **Drawing 60544930-DRG-T-0000-CS-1008**. The deck of existing approach is sloping in 1:17 starting from land side (+ 10.35 m CD) to existing jetty (+6.0 m CD). As the same approach shall be used for proposed new jetty with deck level +6.0 m CD, the jetty structure shall be planned to suit the said slope of 1:17 for smooth movement of the ITVs.

- iii) While the location, alignment, length, deck size and levels, minimum width and type of sub-structure (piled structure) of the jetties and approach trestle are frozen, the sections of the jetty structures, member sizes shown in the drawings, if any, are only indicative.
- iv) The jetty structures shall have all the required accessories/fixtures including but not limited to the following:
 - a. Rubber fenders including all its ancillaries as per specifications
 - b. Bollards
 - c. Safety ladders
 - d. Handrails
 - e. Rubbing strip for the protection of edges of jetties from rubbing of mooring ropes
 - f. Mooring rings
 - g. Drain pipes at required locations
 - h. Light posts.Typical details of jetty fixtures are shown in the **Drawing 60544930-DRG-T-0000-CS-1009** for the information of the Tenderer.
- v) The berthing line of the new jetties shall be in line with the existing jetties at both Sittwe and Paletwa locations.
- vi) The proposed jetties shall be designed for mobile harbour crane loads, which shall be procured and installed by the Contractor.
- vii) An expansion joint between the existing and proposed jetties shall be provided to avoid transfer of any loads / stresses from new jetty to existing and vice versa.. Further, expansion joints shall be provided as per the design.
- viii) Screed shall be provided above the deck slab of the jetties and approach, which shall be sloped for draining of the storm water.
- ix) The approach shall be provided with hand railing on both sides.

2.2 Onshore Facilities

The Employer's Requirements are that the Contractor shall carryout the Engineering, Design, Procurement of materials and Construction/installation of the Onshore Facilities along with associated works as outlined in this tender document:

The scope of the works under onshore facilities at both the Port of Sittwe and Paletwa terminal includes:

- i) Site grading
- ii) Development of Container Yard
- iii) Workshop building, Workers amenity room and D.G. room
- iv) Reefer gantries
- v) Boundary wall
- vi) Internal roads
- vii) ITV parking area
- viii) Water supply system
- ix) Storm water drainage
- x) Firefighting system
- xi) Fuel storage tank
- xii) Power distribution, lighting and communications

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 honor the Conditions of the Contract in all respects. The broad description of various items under onshore facilities is given below.

2.2.1 Site Grading

The existing ground levels are at around + 4.5 m CD at the Port of Sittwe. The backup area shall be developed to provide finished level of +5.05 m CD by suitable filling.

The existing ground levels range from +19.0 m to + 20.0 m CD at the Paletwa terminal. The backup area shall be developed to provide finished level of +18.0 m CD by suitable soil cutting.

2.2.2 Container Yard

The container yard pavement area of about 11,500 sqm at Sittwe and about 4,300 sqm at Paletwa shall be developed to suit required stacking of containers and movement of reach stackers and ITVs.

The area earmarked for container stacking is shown in **Drawing 60544930-DRG-T-0000-CS-1010** at Sittwe and in **Drawing 60544930-DRG-T-0000-CS-1011** at Paletwa.

The yard pavement shall accommodate electrical conduits and pits, which are to be provided for HT electrical, general lighting, communications and reefer arrangements.

2.2.3 Workshop building, Workers amenity room and D.G. room

The workshop building comprises a repair workshop and servicing facilities for mechanical and electrical repairs for all equipment. This will also house the spare part warehouse and the offices of the workshop and service facility staff. The size of the workshop building is about 30 m × 16 m for both Sittwe and Paletwa terminals.

A workers amenity room of about 14 m x 6 m shall be provided at both Sittwe and Paletwa terminals, which shall suit for a total of 19 persons for machine operations, accommodation, lockers, toilets, shower, drinking water facility and hand wash provisions.

D.G. room of 5 m x 5 m shall be constructed to accommodate D.G set and associated facilities at both Sittwe and Paletwa. The indicated size of room is minimum and it shall suit the contractor's design.

The layouts and section for workshop, workers amenity room for Sittwe are shown in **Drawing 60544930-DRG-T-0000-CS-1012**, **Drawing 60544930-DRG-T-0000-CS-1013** and **Drawing 60544930-DRG-T-0000-CS-1014**.

The layouts and section for workshop, workers amenity room for Paletwa are shown in **Drawing 60544930-DRG-T-0000-CS-1015**, **Drawing 60544930-DRG-T-0000-CS-1016** and **Drawing 60544930-DRG-T-0000-CS-1017**.

2.2.4 Reefer Gantries

Reefer containers are planned to be stacked in 1 + 2 high. Plug in and plug out the power supply and monitoring the reefer container parameters are the operations carried out in each reefer boxes. To carry out these operations of reefer boxes which are stacked above ground level, reefer gantry including associated works like power plugs, power distribution panels, cables, compact substation, etc. shall be provided. The gantry shall suit to serve 18 reefer containers (6 containers * 3 stack heights) at both Sittwe and Paletwa. The general arrangement of reefer gantry is shown in **Drawing 60544930-DRG-T-0000-CS-1025**.

2.2.5 Boundary wall

Boundary wall shall be provided along the periphery of the proposed container terminal at both Sittwe and Paletwa as per ISPS requirements. The total length of the boundary wall at Sittwe is about 470 m and at Paletwa is about 300 m. The general arrangement of boundary wall is shown in **Drawing 60544930-DRG-T-0000-CS-1018** for Sittwe and **Drawing 60544930-DRG-T-0000-CS-1019** for Paletwa.

2.2.6 Internal Roads

Internal roads at proposed container yard at both Sittwe and Paletwa shall be two lane carriage way 7.5 m wide rigid pavement with 1.75 m shoulders on both sides to allow the movement of ITVs, Reach stackers and occasional movement of Mobile harbour crane. The length of the road is about 500 m at Sittwe and 370 m at Paletwa.

The plan and section of internal roads are shown in **Drawing 60544930-DRG-T-0000-CS-1020** for Sittwe and **Drawing 60544930-DRG-T-0000-CS-1021** for Paletwa.

2.2.7 ITV Parking area

Suitable rigid pavement shall be developed for ITV parking area earmarked as shown in **Drawing 60544930-DRG-T-0000-CS-1001** at Sittwe.

2.2.8 Water supply system

Potable water is required for personnel and ship supply and rest of the requirements shall be fulfilled with raw water. The existing break bulk facility has a provision of 2 overhead tanks (50 cum for service water and 30 cum for drinking water) along with underground storage tanks. The water requirements for the proposed container handling facility including firefighting purposes shall be accommodated through the said existing facilities by laying required pipelines from existing underground tanks and overhead tanks and required pumps shall be provided. The Contractor shall install the required capacity pumps, lay the pipelines from existing facilities to the new container handling facilities and complete the entire water supply system including associated civil, mechanical and electrical works at both Sittwe and Paletwa terminals.

2.2.9 Storm water drainage

Storm Water Drainage shall be through a system of underground covered drains to discharge the collected runoff into the natural waterways already existing so that storm water gets drained from all

areas of port operations quickly. The container yard surface shall have required slope to drain of surface water to the underground cover drains. The proposed drainage System network for container Terminals are presented in **Drawing 60544930-DRG-T-0000-CS-1022** for Sittwe and **Drawing 60544930-DRG-T-0000-CS-1023** for Paletwa.

2.2.10 Firefighting system

The ground water stored in existing underground 500 cum tank at Sittwe and 400 cum tank at Paletwa shall be used for firefighting purposes of proposed container handling facilities. The firefighting system shall consist of an underground ring main with spur lines to cover the facilities in the yard. Hydrants shall be provided at maximum 60 m spacing. Each hydrant connection shall be provided with a suitable length of hose and nozzle to permit effective operation. The main firefighting pumps shall be located to cover container yards. In addition jockey pumps shall be provided to maintain the minimum pressure of 3.5 kg/cm² in the remotest hydrant.

In addition, fire alarm system and fire extinguishers shall be adequately provided at workshops, workers rest rooms, etc.

2.2.11 Fuel storage tank

At present there is a provision of underground tanks of capacity 33 cum for fuel storage at both the locations. For proposed container terminal requirements, additional fuel storage of 40 cum is required at both the terminals keeping a provision for 5 days. An area of 11 m × 11 m is earmarked at both locations for the construction of required fuel storage facility for supplying to D.G set, reach stacker, mobile harbour cranes, ITVs, etc. The size of RCC fuel tank at both the locations shall be kept 5 m × 5 m x 2.2 m including freeboard of 0.6 m.

2.2.12 Power distribution, lighting and communications

It is important to provide sufficient power ensuring that service continuity should be adequate with the port equipment requirements. The distribution system shall be simple to operate and maintain high reliability, being accessible for inspection and repair with safety.

The designing of the electrical distribution system shall ensure that the Voltage at the utilization equipment is maintained within the tolerance limits under all load conditions since poor voltage regulation is detrimental to the life and operation of the equipment.

2.2.12.1 Power Distribution System

Electrical power is required for illumination of jetties, approach trestle, terminal areas, yards, sheds, roads, etc., apart from auxiliary services like water supply, firefighting system and buildings and reefer containers at both Sittwe and Paletwa locations. At present both the existing facilities are been supplied through DG sets. Even for the proposed facilities at both Sittwe and Paletwa, electricity shall be supplied through D.G. sets only. The Contractor shall complete the power distribution system including installation of required capacity DG at both Sittwe and Paletwa. The capacity of DG shall suit the electrical requirements of all the facilities required for effective operation of container terminals.

Tentative single line diagram for Electrical Distribution for Sittwe and Paletwa are given in **Drawing 60544930-DRG-T-0000-CS-1026** to **Drawing 60544930-DRG-T-0000-CS-1028**, and **Drawing 60544930-DRG-T-0000-CS-1029** to **Drawing 60544930-DRG-T-0000-CS-1031** respectively.

2.2.12.2 Lightning Protection

Lightning protection shall be provided for all structures in accordance with the local code of practice or other internationally recognized standards. The system shall be complete with air-terminations, down conductors, testing joints and electrodes.

2.2.12.3 System Grounding

All systems shall be properly and efficiently earthed. The grounding system shall be designed as per the requirements of IEEE-80/IEEE 665/IS-3043.

The earth mat of the section shall be designed such that the total ground impedance does not exceed 1.0 ohm.

Each large structure and building complex shall have a ground loop around its perimeter. The ground loops around each structure shall be connected to the ground grid.

The grounding system shall be connected to all metallic equipment, electrical as well as non-electrical (except underground pipelines), located at the terminals. All these shall be connected at two distinct points. This shall include all structures, buildings, etc.

2.2.12.4 Area Lighting

The contractor shall provide area lighting and street lighting, to the minimum required lux levels as specified below, by means of lighting posts and high mast towers. The lighting system includes the normal AC lighting and emergency AC lighting which contributes together 100% lighting as well as emergency DC lighting in selected areas of the terminal during emergency conditions. The emergency AC lighting shall provide about 20% of the total AC lighting in select areas. The scope shall include all associated works like cables, trenches, foundations, lighting fixtures etc. complete.

Following average levels of illumination shall be ensured, while designing the lighting installation:

Jetties and Approach	: 50 Lux
Terminal and Yard area	: 50 Lux
Roads and Permanent ways	: 20 Lux
ITV Parking Area	: 15 Lux
Workers restroom/ Workshops	: 300 Lux

2.2.12.5 Communication

The existing communication system (telephone, public address system and radio communication system) shall be used for the proposed container handling facilities also at both terminals. Additional works like laying of wires, cables, installation of load speakers, weather proof speakers at selective locations shall be carried. The contractor shall provide CCTV cameras at the strategic locations of terminal area, boundary wall and jetties.

2.3 Dredging

The Employer's requirements are that the Contractor shall carry out the dredging works as outlined in this Tender Document:

- i) The area where the contractor is required to carry out Dredging Works is shown in **Drawing 60544930-DRG-T-0000-CS-1024** at Sittwe. No dredging is anticipated at Paletwa as desired depths are available.
- ii) The Contractor shall achieve the defined dredge depths as shown in the drawing. All dredged areas shall be swept before issue of Taking Over certificate by the Employer. Sweeping methodology shall get approved by the Contractor from the Employer well in advance.
- iii) Disposal of the dredged material shall be done as per the directions of the employer.
- iv) The Contractor shall remove and dispose of scraps, construction debris etc., if encountered during dredging operations, and dispose these at the designated disposal areas.

2.4 Equipment

The Employer's Requirements are that the Contractor shall carry out Engineering, Design, Procurement of Materials, Manufacturing, Supply, Erection, Testing, Commissioning and Guaranteeing

the Performance of following Equipment including all other associated works as outlined in the Tender document.

Equipment	Sittwe	Paletwa
Mobile Harbour Crane	1	1
ITVs (Internal Terminal Vehicle)	4	4
Reach Stackers	2	2

- i) The Contractor shall design the jetties, approach trestle and terminal areas for the loads due to above equipment.
- ii) The Contractor shall train Employer's Operational and Maintenance Staff as per an Approved Training Plan for duration of minimum two weeks. The Contractor shall submit test, warranty/guarantee certificates and other relevant documents of the various parts used in the Equipment for their quality and performance. This does not however absolve the responsibility of the contractor.
- iii) Testing and commissioning of the container handling facility in accordance with the mutually agreed programme shall be undertaken.
- iv) A list of the spare parts and adjustment tools for maintenance, along with quantities shall be provided with the Tender.
- v) For Supply of spare parts for three years and five years of uninterrupted operation and maintenance of the terminal, Optional price is to be quoted.
- vi) For Additional training of the Employer's personnel for operations and maintenance of the container terminal, Optional price to be quoted.
- vii) Defect Notification Period shall be provided as per the Contract Conditions.
- viii) The Contractor shall adhere to and honour the Conditions of the Contract in all respects.
- ix) The Contractor while executing the Works shall observe/follow good industry practice, which however shall meet the Employer's Requirements.

3.0 DESIGN CRITERIA

3.1 Jetty Structures and Approach

3.1.1 Codes and Standards

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

Table 3.1 provides a list of the primary codes and guidelines which will be used for the structural design of the marine structures. A consistent set of standards will be used for each element of the works, with supplementary codes and guidelines used where additional requirements are needed.

Table 3.1 Codes and Standards

IS 456: 2000	Plain and Reinforced Concrete – Code of Practice, Fourth Revision
IS 800: 2007	General Construction in Steel – Code of Practice, Third Revision
IS 875 (Part 1): 1987	Code of Practice for Design Loads (Other than Earthquake) for Building and Structures - Part 1, Dead Loads – Unit Weight of Building Materials and Stored Materials, Second Revision Incorporating Amendment No.1, Reaffirmed 1997
IS 875 (Part 2): 1987	Code of Practice for Design Loads (Other than Earthquake) for Building and Structures - Part 2, Imposed Loads, Second Revision, Reaffirmed 1997
IS 875 (Part 3): 1987	Code of Practice for Design Loads (Other than Earthquake) for Building and Structures - Part 3, Wind Loads, Second Revision, Reaffirmed 1997
IS 1893 :1984	Criteria for Earthquake Resistant Design of Structures
IS 1893 (Part 1): 2002	Criteria for Earthquake Resistant Design of Structures - Part 1: General Provisions and Buildings, Fifth Revision
IS 4651 (Part II): 1989	Code of Practice for Planning and Design of Ports and Harbours, Part II Earth Pressures

IS 4651 (Part III): 1974	Code of Practice for Planning and Design of Ports and Harbours, Part III Loading, First Revision, Reaffirmed 2012
IS 4651 (Part IV): 2014	Code of Practice for Planning and Design of Ports and Harbours, Part IV, General Design Considerations, Second Revision, Reaffirmed 2005
IS 4651(Part V): 1980	Code for Planning and Design of Ports and Harbours Part V, Layout and Functional Requirements, Reaffirmed 2012
IS 2911 (Part 1/Sec2)	Code of Practice for Design and Construction of Bored Cast In situ Piles
IS 2911 (Part 4)	Load Test On Piles
IS 13920 :1993	Ductile detailing of reinforced concrete structures subjected to seismic forces
IS 6403 :1981	Code of Practice for Determination of Bearing Capacity of Shallow Foundations
BS 6349; Part 4 : 1994	British Standard for Maritime Structures, Part 4: Code of Practice for Design of Fendering and Mooring Systems
IRC: 6-2010	Standard Specifications and Code of Practice for Road Bridges, Section II: Loads and Stresses, Fifth Revision
EN 1998	Eurocode 8 : Design of structures for Earthquake resistance
PIANC	PIANC Guidelines for the Design of Fender System, 2002
PIANC	PIANC Guidelines for Seismic Design of Marine Structures

3.1.2 Design Life

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

- Jetty and Approach Trestle - 50 years
- Fenders, Bollards and ladders - 15 years

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

3.1.3 Design Vessel Sizes

The design vessel sizes range and characteristics to be considered for the design of port and IWT jetties are provided in (Table 3.2).

Table 3.2 Parameters of Ship Sizes for Container

	Design Ship Sizes (DWT)	Overall Length (m)	Beam (m)	Loaded Draft (m)
Port Jetty (Sittwe)	6000	124	7.2	7.2
	20000	172	26.1	9.5
IWT Jetty (Sittwe)	6000	124	7.2	7.2
	20000	172	26.1	9.5
	300	45	9.5	1.5
IWT Jetty (Paletwa)	300	45	9.5	1.5

3.1.4 Salient Levels

3.1.4.1 Port of Sittwe

Deck level	:	(+) 5.6 m CD
Mean High Water Spring (MHWS)	:	(+) 2.40 m CD
Mean Sea Level	:	(+) 1.30 m CD
Design seabed level	:	(-) 12.70 m CD

3.1.4.2 Terminal at Paletwa

Deck level	:	(+) 6.0 m CD
Design bed level	:	(-) 8.0 m CD

3.1.5 Marine Growth

An allowance in dimension of the submerged structures due to marine growth shall be taken in to account. For design 50 mm thick marine growth shall be added to the dimension of any submerged element.

3.1.6 Loads

3.1.6.1 Dead Load

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

Concrete (Reinforced) : 25.00 kN/m³

Sea water : 10.25 kN/m³

Steel : 78.50 kN/m³

The dead load due to the following shall be used in design:

- Substructure and Superstructure
- Superimposed Dead load
- Miscellaneous items such as services, ladder, railing, light poles etc.

3.1.6.2 Live Load

Table 3.3 Live Load

S. No.	Load Type	Jetty	Approach
1.	Live Load	30 kN/m ² (or) IRC Class AA (or) 40 feet Internal Terminal vehicles (ITVs) whichever governs	15 kN/m ² (or) IRC Class AA (or) 40 feet Internal Terminal vehicles (ITVs) whichever governs

Note: Impact for IRC vehicular load shall be as per IRC 6:2010

3.1.6.3 Equipment loads

Table 3.4 Equipment Load

Load Type	Sittwe Jetties	Paletwa Jetty
Equipment Load	Mobile harbour crane with lifting capacity of 31 T @ 42 m	Mobile harbour crane with lifting capacity of 31 T @ 21 m

Note: The impact factor for the crane & other specialized mechanical handling equipment shall be considered as per clause 5.1.3 of IS: 4651(part III) which includes:

- No impact factor in the design of pile.
- Impact factors for vehicular loadings shall be as per IRC-6:2010.

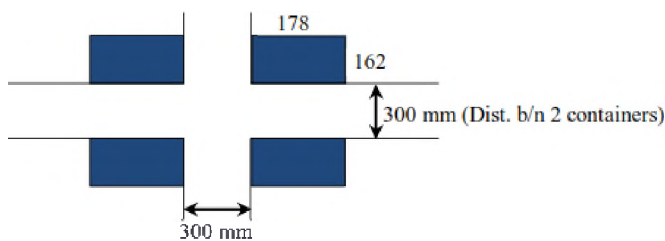
3.1.6.4 Container stacking loads

Triple stacking Container Load shall be considered for design of all berthing jetties

Table 3.5 Corner Loads due to 20 ft & 40 ft Containers Stacked in Tiers on the Deck Surface

Container Stacks	Reduction in Weight	20 ft container Corner load (kN)	40 ft container Corner load (kN)
1	0%	60	76
2	10%	108	137
3	20%	144	183

The plan dimensions of corner casting over which the containers are placed shall be considered as below:



3.1.6.5 Wind Load

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

$k_1 = 1.0$ (as per Table-1 of IS 875: Part 3)

$k_2 =$ for terrain (category 1) = 1.05 (as per Table-2 of IS875: Part 3)

$k_3 =$ Topography factor = 1.0 (cl.5.3.3 of IS875: Part 3)

Basic wind speed of 20.0 m/s and 55 m/s shall be considered for operating (service) condition and survival (extreme) condition respectively.

3.1.6.6 Seismic Load

Seismic load shall be calculated considering following parameters:

Peak Ground acceleration (PGA) = 0.35g

As per clause 4.2.2.4, EN 1998-2, the earthquake effect shall be determined by applying at all nodes points horizontal force given by

$$F_i = \frac{4\pi^2}{T^2} \frac{S_d(T)}{g} d_i m_i$$

Where,

T = Period of the fundamental mode of vibration for the direction under consideration

g = acceleration due to gravity

m_i = mass of concentrated at the i-th point

d_i = Displacement of the i-th nodal point

$S_d(T)$ = Spectral acceleration of the design spectrum

3.1.6.7 Wave Load

Wave force shall be determined as per Shore Protection Manual & Coastal Engineering manuals. The significant wave height & time period for 50 years return period shall be considered 1.3 m and 3 s for both operating and extreme conditions. An allowance in dimension of the submerged structures due to marine growth shall be taken into account. Wave load shall be considered only for the structures at the Port of Sittwe.

3.1.6.8 Current Load

Water current force shall be determined as per method recommended in Pile Design and Construction Practice by Tomlinson considering design speed of current as 1.04 m/s in operating as well as storm conditions at both locations. An allowance in dimension of the submerged structures due to marine growth shall be taken into account.

3.1.6.9 Berthing Load

Berthing Energy

Berthing loads shall be determined in accordance with PIANC. For the purpose of calculating the Berthing energy the site conditions are to be taken as exposed to moderate wind and swells with berthing conditions as moderate.

Table 3.6 Parameters for calculation of Berthing Energy

Description	Unit	Vessel size				
		300	6000	10000	15000	20000
Displacement Tonnage, WD	T	325	9675	15700	22900	30100
Overall length, LOA	m	45	124	144	162	181

Beam of the Vessel, B	m	9.5	16.9	19.4	21.7	26.1
Draught of the vessel, D	m	1.5	7.2	8.2	9.1	9.5
Berthing velocity	m/s	0.45	0.35	0.2	0.2	0.2
Berthing Angle	Deg.	10	10	10	10	10
Factor of safety		2	2	2	2	2

Fendering System

A suitable fender system shall be designed to absorb the design berthing energy of the vessel and to keep the vessel's hull pressure below the limit of 40 T/m².

3.1.6.10 Mooring Load

Mooring load under operating condition shall be calculated as per IS: 4651 (Part 3). Mooring Pull under operating condition shall be applied at two Bollard points on the jetty.

Bollards of capacity 80 T & 10 T shall be required as per IS 4651 (Part 3) for jetties at Sittwe & Paletwa respectively. Hence, the jetties shall be designed for full capacity of the bollard in extreme conditions.

3.1.6.11 Temperature Loads

Design Temperature rise and fall of $\pm 15^{\circ}$ C shall be considered for analysis of structures.

The Co-efficient of Thermal Expansion for Reinforcing Steel and for Normal Weight Concrete : 12×10^{-6} / $^{\circ}$ C

3.1.6.12 Shrinkage and Creep Stresses

In addition to temperature fall of 15° C, equivalent temperature fall of 13° C shall be considered towards shrinkage assuming shrinkage strain $\epsilon = 0.00015$ & coefficient of thermal expansion of $\alpha = 12 \times 10^{-6}$.

Creep coefficient shall be considered as 1.1 for calculating long term effects.

3.1.6.13 Load Combinations

The load combinations shall be in accordance with IS:4561 (Part 4):2014. Load combinations for assessing serviceability limit states and collapse limit states are provided in Table 3.7 and Table 3.8, respectively.

Table 3.7 Load Combination-Serviceability Limit States

Primary Loads	DL + SIDL	CL	CL(non-op)	LL	WL	WC	BL	ML	S	T	EQ
Transient Short term crackwidth	1.0	-	1.1	1.0	1.0	1.0	1.0		1.0		-
	1.0	1.1		1.0	1.0	1.0		1.0	1.0		
Deflection at expansion joint	1.0	1.1		1.0	1.0	1.0			1.0		1.0
Sustained Long term crackwidth	1.0	-	1.0	0.5	1.0	1.0			1.0	1.0	-

Note: DL- Dead Load; LL - Uniform live load; CL(Op) - Operating Crane Load; CL(Non-Op)- Non-Operating crane load; WL(Op) - Operating wind load; WL(st) - Storm wind load; WC(Op) - Operating Wave & water current load; WC(st) - Wave & water current load in storm conditions; BL- Berthing load; ML-Mooring load; T - Temperature variation; EQ - Earthquake load; S – Secondary stresses

Table 3.8 Load Combination-Collapse Limit States

Primary Loads	DL + SIDL	CL	CL (Non-op)	LL	WL	WL (st)	WC	WC (st)	BL	BL (ab)	ML	EQ	
ULS Combinations	1.5	-	1.5	1.5	1.0	-	1.2	-	1.5			-	
	1.5	1.5		1.5	1.0	-	1.2	-	-		1.5	-	
	1.2	-	1.2	1.2	1.0	-	1.0	-				1.2	
	1.5	-		-	1.0	-	1.0	-				1.5	
	1.2	-	1.2	1.2	1.0	-	1.0	-	-	1.0			
	1.2	-	1.2	1.2	-	1.2	-	1.0	-	-			-
	1.2	1.2		1.2	1.0	-	1.0	-					-
	0.9		0.9	0.9	1.0		1.0	-	1.5				-
	0.9	0.9		0.9	1.0		1.0	-	-		1.5		-
	0.9		0.9	0.9	-	1.5		1.0					-

	09		0.9	0.9	1.0	-	1.0	-			1.5
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Note: DL- Dead Load; LL - Uniform live load; CL(Op) - Operating Crane Load; CL(Non-Op)- Non-Operating crane load; WL(Op) - Operating wind load; WL(st) - Storm wind load; WC(Op) - Operating Wave & water current load; WC(st) - Wave & water current load in storm conditions; BL- Berthing load; ML-Mooring load; T - Temperature variation; EQ - Earthquake load; S – Secondary stresses

3.1.7 Materials

Material suggested for construction of new jetty structure and their specification is given in Table 3.9.

Table 3.9 Material Specifications

Structural Concrete	M-40
Levelling Concrete	M-15 of 100 mm thick
Reinforcement	Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500
Cement	Ordinary Portland Cement of minimum grade 53 as per IS:12269
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

3.1.8 Minimum Cover

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

Pile & Pile muffs : 75 mm

Beams : 50 mm

Slab : 50 mm

3.1.9 Serviceability Checks

3.1.9.1 Deflection Limits

The deflection for reinforced concrete structures shall conform to IS 456: 2000, Clause 23.2.

Deflection of Pile at deck level shall be restricted to $L/350$.

3.1.9.2 Crack width Limits

Crack width for reinforced concrete structures shall be as recommended in Table-3 of IS 4651: Part 4:2014 and presented in Table 3.10.

Table 3.10 Allowable Crack Width

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

Sustained Load = Long term load combinations for crack width

Transient Load = Short term load combinations for crack width

3.2 Onshore Facilities

3.2.1 Codes and Standards

The codes and standards stated here below or elsewhere in these documents shall be the latest editions. 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 / Engineer.

All works shall satisfy the requirement of latest relevant codes, standards and regulations for the works as per Tender. 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 – (Part 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 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
MJ Tomlinson	- Pile Design and Construction Practice

Relevant codes for Utilities items like water supply, power supply, drainage, lighting as indicated in Specifications.

3.2.2 Design Life

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

- Buildings - 40 years
- Pavements - 25 years
- Equipment - as per manufacturer's recommendations.

Above design lives are defined as a period within which the asset will continue to be serviceable for design loads without collapse subject to the regular inspection and preventive maintenance but not the major repairs and rebuilding.

3.2.3 Buildings

Required buildings shall be constructed as per Clause 2.2, Volume II of the Tender Document. All RCC framed buildings shall be designed satisfying the provision of IS:456 and structural steel elements shall be designed as per IS:800. Loading shall be as per IS:875 & IS:1893. The buildings shall be provided with adequate arrangements for plumbing, sanitary, electrical fittings, illumination, air-conditioning, water distribution etc. Following minimum considerations shall be followed:

- Grades of concrete : M-30 for all items as suggested in relevant codes
- Grade of steel : Thermo-mechanically treated corrosion resistant steel Fe500
- Grade of 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
- 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 building shall be 1500 mm above the finished ground level.

- All external walls shall be of 230 mm thick, all partition walls shall be minimum 115 mm thick with 1:4 cement mortar.

3.2.4 Water Supply System

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

- Hydraulic design of the pipeline shall be using Hazen-williams formula
- All pipelines shall be laid 1.2 m below ground
- The residual pressure in the pipeline at the farthest point shall be 2 kg/sq.cm
- The pumps shall be of centrifugal type.
- The ON/OFF system shall be provided for pumping potable water to amenities room, shed and vessels.

3.2.5 Roads

Internal roads of 11 m wide shall be provided at both Sittwe and Paletwa locations. These roads shall be designed for the loads due to ITVs, reach stackers and mobile harbor crane which shall be procured by the Contractor.

Location	Overall Width	Carriageway Width	Width of Paved Shoulders on either side of Carriageway	Approximate length
Sittwe	11 m	7.5 m	1.75 m	500 m
Paletwa	11 m	7.5 m	1.75 m	370 m

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

Geometric Parameter

- Maximum longitudinal grade : 3.0%
- Cross slope : Unidirectional 2.5% 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 : 1 MSA for all Roads
- Pavement type : Rigid

Specification

- 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
 - Axle load
 - Single Axle : 10.2 T
 - Tandem Axle : 22.0 T

The culverts required for the cross drainage works shall be designed as per the IRC codes. The length of culvert shall be adequate to suit the size of roadway. The overall clear width of culvert shall be minimum 5 m.

3.2.6 Storm water Drainage

Storm water drainage shall be designed with the following basic consideration:

- The design rainfall intensity shall be taken as 65 mm/hr.
- The drainage system shall be planned to carry storm run-off from the proposed areas shown in the scope drawings.
- No allowance for sillage shall be kept.
- A maximum velocity of 2.5 m per second 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

RCC channels shall be provided for carrying storm water and all pipes, if any shall be RCC NP3 except below the road. Pipes shall be of NP4 type below road.

3.2.7 Civil and Structural Works

3.2.7.1 Loads and Load Combinations

Design loads shall comply with the requirements of IS: 875 & IS: 1893, as a minimum, unless more stringent requirements are specified herein. The following type's loads shall be considered in general for the analysis and design of structures and foundations.

3.2.7.1.1 Dead Loads

Dead loads shall include the weight of all structural and architectural components and other permanently applied external loads. Selfweight of materials shall be calculated on the basis of unit weights given in IS: 875 (Part I).

3.2.7.1.2 Equipment Loads

All structural components shall be designed to accommodate anticipated Static and dynamic loading from 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.

Manufacturer's technical specifications shall be followed for any other equipment loading considerations during detailed design stage.

3.2.7.1.3 Live Loads

Live loads shall consist of uniform live loads. Uniform live loads are unit loads, which are sufficient to provide for movable and transitory loads, such as the weight of people, portable equipment and tools, equipment, or parts, which may be moved over or placed on floors during maintenance operations. These uniform live loads shall not be considered on floor area, which are permanently covered with equipment.

Foundations and fixing arrangements for items of equipment, which generates vibration, shall be designed to prevent transfer of such vibrations to the adjoining structures.

Floors and supporting members, which are subject to heavy equipment loads shall be designed on the basis of the weight of the equipment in addition to a live load of 500 kg/sqm or specifically designed live load whichever is more.

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	In accordance with IS-875 for live load plus 25 kg/sqm for dust load to be considered on plan area
MCC Floor	250 kg/m ² +1.2T/m of Panel
Ground floor	1500 kg/m ²
Suspended floors	1500 kg/m ²
Workshop	Loads due to 10 T capacity crane shall be considered. Along with the vertical loads, lateral and longitudinal loads shall also to be considered due to crane operations / movement.

3.2.7.1.4 Wind Load

All structures will be designed for wind loads in accordance with IS: 875 (Part 3). A basic wind speed of 20 m/s and 55 m/s shall be considered in operating and storm conditions respectively.

3.2.7.1.5 Seismic Load

Seismic load shall be calculated considering following parameters:

Peak Ground acceleration (PGA) = 0.35g

As per clause 4.2.2.4, EN 1998-2, the earthquake effect shall be determined by applying at all nodes points horizontal force given by

Where,

T = Period of the fundamental mode of vibration for the direction under consideration

g = acceleration due to gravity

m_i = mass of concentrated at the i-th point

d_i = Displacement of the i-th nodal point

S_d(T) = Spectral acceleration of the design spectrum

3.2.7.2 Load Combinations

Design load combinations shall comply with the requirements of IS: 875 & IS: 1893, as a minimum, unless more stringent requirements are specified herein in the Tender Document.

3.2.7.3 Deflection Check

The deflection for steel structures, conform to IS 800: 2007, Clause 5.6.1, Table 6 and that for reinforced concrete structures, conform to IS 456: 2000, Clause 23.2.

3.3 Dredging

3.3.1 Tolerances

Tolerances allowed in the Dredged areas are:

Vertical: Nothing above defined dredged Depth. 300 Millimetres below defined dredged Depth.

Slopes: The Steepest Slope to be achieved is 1V:4H

Horizontal: + 2500 Millimetres at the Toe lines.

3.3.2 Siltation

The Contractor shall remove any siltation or sloughing within the minimum design profiles that occur during the course of the work before final acceptance all at his cost.

Should the Contractor wish to perform over-Dredging of material to allow for extra sedimentation arising from his own operations, he shall request the approval of the Employer for such over-Dredging of material. Approval will not be given unless the Contractor can prove, to the full satisfaction of the Employer, that the over Dredging of material in question will not endanger the stability of berthing structures or the stability of the dredged slopes.

The Contractor shall not be entitled to payment for the extra material thus dredged.

3.3.3 Operating Conditions

The weather conditions inclusive of oceanographic data as applicable to site have been indicated herein above in 'Site Information' for the information of the bidders.

3.4 Equipment and Electrical Works

For design criteria of following works / items, respective clauses of Volume-II shall be referred:

Volume II: Employer's Requirements, Specifications and Drawings

- Clause 6 (Equipment – MHC, Reach stacker, ITVs)
- Clause 7 (Power Distribution, Lighting and Communications)

4.0 GENERAL REQUIREMENTS

4.1 Site Acceptance and Mobilisation/Demobilisation

4.1.1 Acceptance of Site

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

4.1.2 Mobilisation

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

4.1.3 Demobilisation

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

4.1.4 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.

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

4.1.5 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.

4.2 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 buoing, 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.

4.2.1 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.

a) 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.

b) 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

4.2.2 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.

4.2.3 First Aid and Fire Protection

a) 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.

b) 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 firefighting action at the site and temporary work yard;

Provide and maintain a first aid kit containing bandages, medicines and sterilised materials for first aid treatment of minor injuries at the Contractor's Site Office.

4.2.4 Construction Safeguards

a) 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.

b) Access

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

c) 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.

4.2.5 Navigational Aids

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

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

4.2.6 Protection of the Public

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

4.3 Environmental Protection

The Contractor shall comply with all the conditions stipulated by the relevant statutory and regulatory organisation of Govt. of Myanmar.

Fires

Fires and burning of rubbish on the Site are not permitted except when authorised 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.

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.

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.

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.

Environment

The Contractor prior to the commencement of works, shall prepare and implement a Environment Management Programme. The Contractor shall deploy most suitable construction equipment to minimise the suspension of fine sediments at the work site

4.4 Contractor's Laboratory and Equipment

4.4.1 Field Laboratories

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

4.4.2 Diving Support

The Contractor shall provide requisite number of qualified divers, together with all support equipment to carryout works in accordance with the Contract drawings and specifications.

4.4.3 Field Laboratories

The Contractor shall be responsible for the supply, use and maintenance of all his crafts, equipments used for Dredging, vessels etc. necessary for the satisfactory execution and completion of Dredging of material. He shall ensure that these are suitable for the works and are maintained in such a manner

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as to ensure their efficient working. The Employer may direct that plant, which is not efficient and is prejudicial to the quality of the work to be removed from site and replaced by a plant to the Employer's satisfaction.

4.5 Submission of Documents during Project Execution

4.5.1 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.

4.5.2 Work Schedule, 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 one reproducible transparency and two paper prints, maximum size 610 mm x 810 mm and on CD (in AutoCAD format).

4.5.3 Maintenance Plan

4.5.3.1 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.

4.5.3.2 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.

4.5.4 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 laborers employed, effective operation time of equipment, overtime hours), progress made in the Works. 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.

4.5.5 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 will 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.

4.5.6 Design and Drawing Submissions

4.5.6.1 Design Submissions - General

All design submissions shall be made in triplicate. A further digital copy 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.

4.5.6.2 Submission of Calculations

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

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

4.5.6.3 Submission of Drawings

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

1. All drawings shall be in metric millimeter dimensions, and be finally prepared in ink with legible lettering on either A0 1189mm x 841mm using AutoCAD format compatible with AutoCAD 2010 or lower version. The submitted prints shall be clearly legible throughout and there shall be no ambiguity.
2. All drawings shall be submitted in digital format on compact disc, as well as three paper prints.
3. Drafting Standards employed in the preparation of all drawings shall be sufficient to produce legible 297mm x 420mm (A3) reduced drawings.
4. Drawings from various sub-contracting services, specialist suppliers etc. shall also be presented in a similar manner (identical title blocks/format etc.) to provide a matched set of drawings.
5. All drawings shall clearly show the status and revision of the drawings. Revised drawings shall clearly indicate the nature and details of the revision work and also revision cloud & revision mark shall be marked wherever revised.
6. All drawings shall clearly identify the drafts-person responsible together with the identity of the drawings checker.
7. Each drawing shall show the scale(s) of the components illustrated by the drawing related to the original drawing size, A0, A1, A3 etc.

4.6 Quality Control and Assurance

4.6.1 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 and
- 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.

4.6.2 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.

4.6.3 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.

4.6.4 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.

4.6.5 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 nonconformance 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

4.6.6 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.

4.7 Field Surveys and Investigations

4.7.1 Hydrographic and Topographic Surveys

4.7.1.1 Survey Grid

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

Survey stations and tide gauges 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.

4.7.1.2 Electronic Positioning and Data Processing System

The Contractor shall at his own expense, provide, install, operate and maintain an approved Electronic Positioning System (EPS) which shall fully cover the site of the Works and be constantly in operation during the course of the Dredging of material and disposal works. At the discretion of the Employer, any failure of this system to operate may result in a suspension of Dredging and disposal of material work until the system is remedied. The system shall be installed, tested and set to work continuously during all Dredging and disposal of material and survey operations.

The system shall consist of ship borne receivers on the equipments and the survey-launch, distance measuring units, the requisite number of shore stations-interfaces, track plotters, integrated automatic data handling and storage facilities and sufficient spares to enable uninterrupted operation of the system. Topographic surveys shall be carried out using Total Station.

The system shall be fully operational before start of the Contract works. Once operational, the system shall remain in continuous operation until the post-Dredging survey is completed and the final survey and as-built drawings have been signed and accepted by the Employer.

The Electronic Positioning System, which should be either RTK (Real Time Kinematics) or LRK (Long Range Kinematics), shall at all times have a repeatable accuracy in horizontal direction of plus or minus 1.5 m for any point within the work site.

4.7.1.3 Survey Launch

The Contractor shall provide and operate to the satisfaction of the Employer an all-weather seaworthy launch suitable for surveying during the execution of the Contract. The launch shall be of steel hull construction with a draft of around 1.0 m. It shall have maximum speed not less than 10 knots, excellent control and maneuverability. It shall have a panoramic view from the wheel house. The survey launch shall be equipped with a multi frequency Echo Sounder type Atlas Deso 20 (30 / 210 kHz) or equivalent including inboard transducers and interfacing facility, be capable of digital display, recording on dry paper and have sufficient number of spare parts and consumables. The wheel house shall have sufficient space to accommodate and conveniently operate the survey equipment.

The size of launch shall be such that it can accommodate about 6 people. It shall also have a minimum deck space of 3 m by 5 m and shall be equipped with safety equipment as per statutory requirements.

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

4.7.1.4 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. In order to facilitate the setting out of the works, the centre line of the channel and boundaries of port basin must be accurately established by the Contractor and approved by the Employer. It must then be accurately referenced in a manner satisfactory to the Employer. 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.

After obtaining approval of the Employer, Dredging works can commence and the profile shall form the basis for measurement. The work of setting out shall be deemed to be a part of general works preparatory to the execution of work and no separate payment shall be made for the same

4.7.1.5 Marine and Land Surveyors

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 marine and land surveyors.

4.7.1.6 Tide Gauges

The Contractor shall establish tide gauges / poles based on Chart Datum in the vicinity of the site and monitor tide levels during the period of Dredging of material. Tide gauge must be Pressure/Radar (preferably radar) tide gauge with manual tide pole. At the time of initial and final survey both the recordings will be taken into consideration

4.7.1.7 Survey Drawings

The Contractor shall provide the Employer with all echo-rolls produced during the survey together with tabulations of the soundings and drawings showing the event fix positions and reduced soundings.

The Contractor shall deliver to the Employer on site within 7 days of the completion of each survey, 4 copies and 1 transparency of each drawing together with an electronic copy of the complete survey compiled using internationally recognised drafting software. One set of software with soft key and demonstration shall be given to the Employer for checking of survey data and processing. These will be returned to the Contractor after completion of the Work.

4.7.2 Geotechnical Investigations

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

4.7.3 Post Construction Survey

The completion of the works shall 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.

4.7.4 Surveys for Dredging Section of Works

4.7.4.1 Pre-Dredging Survey

Contractor shall carryout a pre-Dredging survey as a part of this Contract. The survey shall be carried out in the presence of the Employer and shall be performed in a manner approved by the Employer.

Before commencing Survey on any day all equipment/instruments shall be checked and calibrated as per mutually agreed methodology or as instructed by the Engineer. Calibrations shall be rechecked on completion of the day's work.

In case of Hydrographic Surveys Soundings shall be taken on lines at 5 m intervals. Soundings shall be taken to nearest 100 mm. The level of sea bed shall be recorded by means of echo sounding equipment using frequencies dual 30 / 210 kHz simultaneously. However, for printing sounding charts and invoice purposes soundings taken on 210 KHz frequency shall only be used. The Contractor shall supply all necessary equipment and attendance for carrying out such surveys. The equipment shall be calibrated in the presence of the Employer in the survey area before and after each survey. The electronic positioning equipment shall be calibrated before and after each survey as directed by the Employer. Data of 210 kHz will only be considered for calculations and for deciding the surface levels of sea bed. On completion of survey, the Contractor shall prepare record drawings showing surface levels of bed reduced to Chart Datum. The required number of copies of these drawings shall be signed by the Contractor and the Employer.

4.7.4.2 Post Dredging Survey and Final Acceptance

When the Works have been completed as defined in the contract, the area shall be surveyed by the Contractor and witnessed by the Employer along with an approved third party. Post dredge survey shall be undertaken only after Contractor has himself ascertained that all areas have been dredged to specified depths.

Contractor shall give minimum 48 hours prior notice.

Surveys shall be carried out in same manner as pre-dredge survey with the addition of a multi-beam echo sounding system. Finally all dredged areas shall be swept to ensure that there are no missed high spots. High Spots detected shall be cleared by the Contractor and the patch area re-swept. Sweeping Methodology shall be pre-approved by the Engineer. On completion of the surveys and sweeping the sounding results shall be mutually verified and agreed upon between the Employer and the Contractor, and the Contractor shall then prepare record drawings to a scale as approved by the Employer, to show the post-Dredging surface levels of the sea bed.

In case any areas are found to be not dredged to specified depths, the survey shall be carried out again after the spots are cleared.

Only 210 kHz data will be considered for all payments and finalizing final dredge levels

4.8 Employer's Responsibilities

4.8.1 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 Chart Datum (CD). 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 CD.

4.8.2 Contractor's Working Area

The Contractor may use the backup area available during the construction of jetties and he has to reduce his working area progressively during the development of backup area and handover entire area after completion of the Works. The Employer will allocate suitable working area to the Contractor during execution of the Works and his decision is binding on the Contractor in this regard.

5.0 SPECIFICATION – CIVIL

5.1 Materials

5.1.1 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.

5.1.2 Water

Water used in construction for all civil & structural works shall be clean and free from injurious amount of oil, acids, alkalies, organic matters or other harmful substances, which may be deleterious to concrete, masonry or steel. The ph value of water sample shall be not less than 6. Potable water shall be considered satisfactory.

Tests on water samples shall be carried out in accordance with IS:3025 and they shall fulfil all the guidelines and requirements given in IS:456.

The Employer may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall not have average 28 days compressive strength lower than 90% of the strength of concrete prepared with distilled water.

The Employer may require the Contractor to get the water tested from an approved laboratory before starting the construction work and in case the water contains any oil/organic matter or an excess of acid, alkalies or any injurious amount of salts etc., beyond the permissible maximum limits given in IS:456, the Employer may refuse to permit its use. In case there is any change in source of water, water samples shall be tested again to meet the specified requirements.

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

Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for preparation of cement mortar, concrete as well as for curing of plain/reinforced concrete and masonry works. Sea water shall not be used for hydrotesting and checking the leakage of liquid retaining structures also.

5.1.3 Aggregate

5.1.3.1 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.

5.1.3.2 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 5.1.3.1 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 gradings of coarse aggregates, proposed to be used. The Employer may allow "All-in-aggregates" to be used provided they satisfy the requirements of IS:383.

5.1.3.3 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.

5.1.3.4 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.

5.1.4 Sand

5.1.4.1 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.

5.1.4.2 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.

5.1.4.3 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.

5.1.4.4 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.

5.1.5 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 ordinary Portland cement shall be used and the Contractor is required to quote on this basis only.

5.1.5.1 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 deterioration 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.

5.1.5.2 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.

5.1.5.3 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.

5.1.6 Bund Materials

5.1.6.1 Gannular Fill Material (Murrum)

The murrum shall be granular with fines smaller than 75 microns not exceeding 15% and shall be free from rubbish, clay and other deleterious material.

The maximum laboratory dry density (IS 2720, Part 8) shall not be less than 1.6 T/cum.

5.1.6.2 Rock Fill Material

This shall consist of quarry run material, free from deleterious matter, of size 100 mm to 450 mm.

5.1.7 Steel

5.1.7.1 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.

5.1.7.2 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works shall be Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500, conforming to IS:1786. Reinforcement steel shall be purchased only from primary suppliers and that purchased from secondary suppliers shall not be accepted

5.1.7.3 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

5.1.7.4 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 fittings. (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.

5.1.7.5 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.

5.1.7.6 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.

5.1.7.7 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.

5.1.8 Bricks

5.1.8.1 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.

5.1.8.2 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.

5.1.8.3 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 leveled 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.

5.1.8.4 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.

5.1.9 Stones

5.1.9.1 General

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

Method of identification of natural building stones	IS:1123
Recommendations for dimensions and workmanship of natural building stones for masonry work	IS:1127
Recommendations for dressing of natural building stones	IS:1129

5.1.9.2 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 alkalis, 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 3/4th thickness of the wall. Height of the stone shall not be more than 300 mm.

5.1.9.3 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.

5.1.10 Admixtures

5.1.10.1 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.

5.1.10.2 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.

5.1.11 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.

5.1.12 Bitumen/Bituminous Materials

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

Specification of Paving Bitumen	IS:73
Specification for bitumen mastic for flooring	IS:1195
Specification for bitumen felts for water proofing and damp proofing	IS:1322
Specification for Bituminous compounds for water proofing and caulking purposes	IS:1834
Specification for preformed fillers for expansion joint in concrete pavements and structures	IS:1838
Specification for bitumen mastic for use in water proofing of roofs	IS:3037
Specification for bitumen primer for use in water proofing and damp proofing	IS:3384
Specification for Bitumen Mastic for Tanking and Damp proofing	IS:5871
Specification for Glass fibre base coal tar pitch & bitumen felts	IS:7193
Code of practice for damp proofing using bitumen mastic	IS:7198
Specification for bitumen Mastic, Anti Static and electrically conducting grade	IS:8374

The type and grade shall be as shown on the drawings or as directed by Employer. Tests and acceptable criteria shall be as per relevant IS Codes.

5.1.13 PVC Pipes

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

5.1.14 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

5.1.15 Paint

5.1.15.1 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.

5.1.15.2 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 enduring 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.*

5.1.16 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.

5.2 Plain and Reinforced Concrete Works

5.2.1 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 rigid pavement, crown wall underground and over ground structures, floors etc. Any special requirements as shown shall supersede over the provisions of this specifications.

Apart from this specification, construction of concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS:456 and other relevant codes mentioned therein.

In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern.

5.2.2 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'.

5.2.3 Grades of Concrete

Unless otherwise noted, the grades of concrete shall generally be as per **Table 5.1**.

Table 5.1 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.

5.2.4 Type of Concrete Mix

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

5.2.4.1 Nominal Mix Concrete

This concrete shall be made (without preliminary tests) by adopting nominal concrete mix with proportions of materials as specified in **Table 5.2**.

Table 5.2 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
<p>Note:</p> <ol style="list-style-type: none"> 1. The proportions of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregates becomes larger. Graded coarse aggregates shall be used. 2. The cement content of the mix shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio, as specified, is not exceeded. 	

5.2.4.2 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 5.1** 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.

5.2.5 Concrete Mix Proportioning

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

The Employer shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Employer shall order fresh trial mixes to be made by the Contractor. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of start of work. The design mix shall conform to the guidelines of IS:10262.

5.2.5.1 Maximum Density

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

5.2.5.2 Water-Cement Ratio

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

5.2.5.3 Consistency

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

5.2.5.4 Workability

The concrete mix proportion shall be such that the concrete is 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 the table 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 5.3** below. However, the actual values to be followed shall be established depending on aggregate sizing, mix proportions, placing conditions, etc. and shall be got approved by the Employer.

Table 5.3 Values of Workability

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

5.2.5.5 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Workability of concrete shall be such that concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform and as 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 below table.

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

Exposure	Type of Cement	Plain Concrete		Reinforced Concrete	
		Minimum Cement Content (Kg./m ³)	Maximum Water-Cement Ratio	Minimum Cement Content (Kg./m ³)	Maximum Water-Cement Ratio
Normal	OPC* PPC* PSC*	Nominal mix	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

5.2.6 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 below.

Table 5.5 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
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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.

5.2.7 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.

5.2.7.1 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.

5.2.7.2 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.

5.2.7.3 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.

5.2.7.4 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.

5.2.8 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.

5.2.8.1 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 funnel 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.

5.2.8.2 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.

5.2.8.3 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.

5.2.8.4 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.

5.2.8.5 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.

5.2.9 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.

5.2.10 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.

5.2.11 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.

5.2.12 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.

5.2.13 Protection of Freshly Laid Concrete

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

5.2.14 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.

5.2.15 Field Tests

5.2.15.1 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 below table.

Table 5.6 Mandatory Tests on Sand & Stone Aggregates

Sl. 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.

5.2.15.2 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.

5.2.15.3 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 5.7** 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 5.1 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 5.2.3, 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 5.7 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

5.2.15.4 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.

5.2.15.5 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 51 & above	4 4 plus one additional sample for each additional 50m ³ or part thereof
NOTE: At least one sample shall be taken from each shift.	

5.2.15.6 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.

5.2.15.7 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.

5.2.15.8 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*

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

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 5.8** may be assumed.*

Table 5.8 Assumed Standard Deviation

Grade of Concrete	Assumed Standard Deviation (N/mm²)
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 5.8**, it shall be permissible to use that value.*

5.2.15.9 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.

5.2.16 Inspection and Testing of Structures

5.2.16.1 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.

5.2.16.2 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 5.2.16.3 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 nonconformance to specification of formwork, improper curing or any other reason. The number and type of tests to be carried out shall be determined by the Employer whose decision shall be final and binding on the Contractor.

5.2.16.3 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 authority for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Employer shall be final and binding on the Contractor. In case the results of the tests are unsatisfactory, the Employer may instruct the Contractor to demolish and reconstruct the structure.

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

5.2.17.1 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.

5.2.17.2 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.

5.2.18 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.

5.2.19 Form Work

5.2.19.1 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 and 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 : ± 6 mm
 - (ii) 3m to 4.5m : ± 9 mm
 - (iii) 4.5m to 6m : ± 12 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

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:

- upto 600mm wide and upto 6m in length - 6mm
- over 600mm wide and for any length - 12mm

Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6mm.

5.2.19.2 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 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 5.2.17.

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 1/100th of the projected length. Where architectural considerations and adjunctive work are critical, smaller form cambers shall be adopted as decided by the Employer.

All vertical wall forms may be designed and constructed for the following minimum pressure. The pressures listed in **Table 5.9** are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

Table 5.9 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.

5.2.19.3 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.

5.2.19.4 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.

5.2.19.5 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.

5.2.19.6 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.

5.2.19.7 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 structural members	:	24 to 48 hours as may 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.

5.2.19.8 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.

5.2.20 Exposed Concrete Work

5.2.20.1 Form Work

Other things remaining same as per Clause 5.2.19, 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.

5.2.20.2 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 5.2.17.1 with the written permission of the Employer.

5.2.20.3 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.

5.2.20.4 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. 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.

5.2.20.5 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.

5.2.20.6 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.

5.2.20.7 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.

5.2.20.8 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.

5.2.20.9 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.

5.2.20.10 Cover

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

5.2.20.11 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 Precasting bed approved by the Employer.

Necessary lifting hooks of suitable (but not less than 12mm dia) diameter M.S. rounds shall be provided for handling.

Unless otherwise specified, the exposed surfaces of precast members shall be integrally finished smooth. For precast slabs or planks, the top surface shall be finished with 1:3 (1 cement: 3 sand) cement mortar. Surface used as walkways shall be given a non-skid finish.

The precast concrete units shall be marked clearly on top surface with the letter "T" for identification of surfaces at the time of erection and shall be stored properly until required for erection. The precast units shall be handled and erected by methods approved by the Employer to protect them from damage.

The Contractor shall take all necessary precautions for safe handling during the course of erection. The Contractor shall replace all such units, which are damaged during the course of erection.

5.2.21 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.

5.2.22 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.

5.2.23 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.

5.2.24 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.

5.2.25 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 5.2.8.4 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.

5.3 Pile Foundations

5.3.1 General

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

5.3.2 Bored cast in-situ Piles

5.3.2.1 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 M40 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 temporary casing upto its required levels shall be provided.

Construction of bored piles shall be carried out in accordance with the relevant sections of IS:2911 (Part I/sec 2) and only routine pile load test shall be conducted as per IS:2911 (Part 4) except where otherwise specified, described or directed by the Employer.

5.3.2.2 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.

5.3.2.3 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.

5.3.2.4 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.

5.3.2.5 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.

5.3.2.6 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.

5.3.2.7 Control of Alignment

The pile shall be cast as accurately as possible to the vertical. Any pile deviating from its proper alignment to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile ties shall, at the discretion of the Employer, be replaced or supplemented by additional piles at no extra cost. If any pile is deviated and extra material is consumed due to strengthening of cap etc. such material shall be to Contractor's account.

5.3.2.8 Obstruction

If any obstruction is encountered, the installation shall cease and Contractor shall notify the Employer and submit for his approval, proposals for overcoming the difficulties. Notwithstanding any such approval, the Contractor will be entirely responsible for ensuring that the piles are completed to the required line, position and depth.

5.3.2.9 Volume Check

Concreting shall start as soon as possible after driving the liner or completion of boring. The volume of concrete placed shall be observed in the initially cast piles and the average figure obtained shall be used to check whether there is undue deviation in concrete consumption for the subsequent piles. If actual quantity is found to be considerably less, special investigation shall be conducted and appropriate measures taken.

5.3.2.10 Inspection

For bored piles, the Contractor shall have the Employer's inspection to the bore hole for proper plumb, location, compaction of founding surface, pressure of water and other requisites. The depth of the

borehole shall be measured by means of a chain to which a plumb weighing not less than 100 g is attached. The Contractor shall provide all the equipment required for the above inspection and he shall co-ordinate this work with the Employer. Concreting shall start only after the Employer has approved the borehole. All facilities, equipment and labour required for inspection by the Employer mentioned above shall be provided by the Contractor promptly and free of cost.

5.3.2.11 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.

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 minimum of 10% of piles selected by the Employer, shall be conducted using the low strain sonic diagnostic system consisting of hammer, low 'g' accelerometer with amplifier, pile integrity tester, portable computer system, graphics printer etc. all complete. The test shall be conducted by the qualified and experienced specialists in this field. Employer's decision shall be final regarding approval of piles passing integrity test but of questionable workmanship.

5.3.2.12 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.

5.3.2.13 Finishing Pile Heads

The top of the piles shall be brought up above the finished level to permit all laitance and weak concrete to be removed and to ensure that it can be properly keyed into the cap. Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete and bonded into the old.

5.4 Site Grading

5.4.1 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.

5.4.2 Material

5.4.2.1 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

5.4.2.2 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.

5.4.2.3 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.

5.4.2.4 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)

5.4.2.5 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.

5.4.3 Compaction

5.4.3.1 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.

5.4.3.2 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 1,000 m² 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 900 mm 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 1,000 m² of fill placed in reclamation area. The location and depth of the test sample shall be determined on site by the Employer.

Additional testing shall be carried out on the top 300 mm of fill in reclamation area as follows:

Test	Test Frequency (Not less than one test per)
Dry density	600 m ²

Moisture content/maximum dry density relationship	1000 m ²
Particle size distribution	1000 m ²
Atterberg limits	1000 m ²
Linear shrinkage	1000 m ²
CBR	1000 m ²
Sulphate content	1000 m ²
Chloride content	1000 m ²

5.4.4 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.

5.5 Road & Pavement Works

5.5.1 General

This section covers the specification for the construction of 2 lane / single lane roads, and paved open areas.

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 container handling equipment to operate at their optimum rates and to allow for storm water to the drainage system.

5.5.2 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.

5.5.3 Screenings

5.5.3.1 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

5.5.3.2 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.

5.5.3.3 Application of Screenings

After the coarse aggregate has been rolled as described in Clause 5.5.2, screenings shall be applied uniformly and gradually over the surface to completely fill the interstices. Dry rolling shall be continued while the screenings are being spread so that the jarring effect of the roller will cause them to settle into the voids of the coarse aggregates.

The screenings shall not be dumped in piles on coarse aggregate but shall be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders.

The screenings shall be applied at a uniform and slow rate (in three or more applications) so as to ensure filling of all voids. Rolling and brooming shall continue with the spreading of the screenings. Either mechanical brooms or hand brooms or both may be used. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface making the filling of voids difficult or preventing the direct bearings of the roller on the coarse aggregates. The spreading, rolling and brooming of screenings shall be performed on sections which can be completed within one day's operation and shall continue until no more screenings can be forced into the voids of the coarse aggregates. Damp and wet screenings shall not be used under any circumstances.

5.5.3.4 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.

5.5.3.5 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.

5.5.3.6 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.

5.5.4 Flexible Pavements

5.5.4.1 General

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

5.5.4.2 Bitumen Premix Carpet

Material

- i) **Coarse aggregate:** The aggregate shall consist of crushed stone of clean, hard, tough, durable rock of uniform quality and shall be clean, free from excess of dust, flat or elongated pieces, soft or disintegrated stone, clay or other deleterious matter. The size of aggregate shall be as mentioned in the drawings.
- ii) **Sand:** The sand shall consist of clean hard, durable, uncoated, coarse dry particles and shall be free from injurious amounts of dust, soft or flaky particles, organic matter or other deleterious substances.
- iii) **Binder:** The binder shall be bitumen of penetration 80/100 conforming to IS:73. The bitumen shall be stored in drums at roadside. Any drum leaking or damaged shall not be accepted.

5.5.4.3 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	
Corse Aggregate 12mm <i>and down thick II layer)</i>	3.5m ³	
Bitumen 80/100		
<i>a) For 50 thick I layer</i>	375kg.	68.3kg.
<i>b) For 25 thick II layer</i>	185kg.	
Coarse sand as sealing aggregate	0.6 m ³	

5.5.4.4 Laying

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.

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.

5.5.4.5 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.

5.5.4.6 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 5.5.4.2.

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/100m ² of road surface
Coarse aggregates	=	6.3mm passing IS. 10mm
Square mesh retained on IS sieve 2.36mm	=	- 0.9m ³ /100m ² 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.

5.5.5 Lean Concrete Base

5.5.5.1 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.

5.5.5.2 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.

5.5.5.3 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.

5.5.5.4 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.

5.5.6 Rigid Pavement

5.5.6.1 Mix proportion / and strength

Mix shall be designed as per the design and the flexural strength shall not be less than specified value at 28 day in the field. The strength which is known as mean flexural strength shall depend upon quality control. The following relationship shall be used in calculating mean flexural strength.

$$S = \frac{S^1}{1 t. V/100}$$

Where

S = average strength at 28 days for which the mix is to be designed (kg/ sq.cm. or N/mm² or MPa) as specified.

S¹ = minimum (flexural) strength in the field at 28 days (kg/sq.cm. or N/mm² or MPa) as specified.

t = factor (dimensionless) depending on specified tolerance level as per table II

V = co-efficient of variation (percent) specified as per table I (dimensionless percentage)

Value Of Coefficient Of Variation (Percent) V For Different Ranges Of Strength

Degree of quality control	Minimum specified flexural Stretch (Kg/cm ²)					
	Less than 40		Greater than 40		40	
	Tolerance Level	Coefficient of variation V	Tolerance Level	Coefficient of variation V	Tolerance Level	Coefficient of variation V
Very Good	1 in 15	10	1 in 15	7	1 in 20	7
Good	1 in 10	15	1 in 15	10	1 in 15	10
Fair	1 in 10	20	1 in 10	15	-	-

Note: (1) Very Good Quality Control: Control with weight hatching, use of graded aggregates, moisture determination of aggregates, etc. Rigid and constant supervision by the Quantity Control Team.

(2) Good Quality Control: Control with weight hatching, use of graded aggregates, moisture determination of aggregates, etc. Constant supervision by Quality Control Team.

(3) Fair Quality Control: Control with volume hatching for aggregates. Occasional checking of aggregates moisture. Occasional supervision by Quality Control Team.

Value for Tolerance Factor (t)

Tolerance level	1 in 10	1 in 15	1 in 20	1 in 40	1 in 100
No. of samples					
10	1.37	1.65	1.81	2.23	2.76
20	1.32	1.58	1.72	2.09	2.53

30	1.31	1.54	1.70	2.04	2.46
Infinite	1.28	1.50	1.64	1.96	2.33

5.5.6.2 Water Cement Ratio

The actual and designed quantity of water shall be used in the mix. The cement content shall be kept within a range of 350 Kg/cum to 425 Kg/cum only. The water cement ratio should invariably be kept between 0.39 to 0.42.

5.5.6.3 Trial Mix

Trial mix shall be made and beam tested for flexural strength as per requirement of IS 516- 1959. Nine sets of beams shall be tested, three for 7 days and three for 28 days. If the difference between the highest and lowest value at 28 days in any trial mix is more than 15% of strength of these beams, the test shall be discarded and further trial mix made. Crushing Strength of concrete shall be approved for the flexural strength.

5.5.6.4 Preparation of base

Before fixing the form work for laying concrete, the base shall be checked for proper compaction, density and levels.

5.5.6.5 Trial Bays

Before commencement of work and whereas paver is not used, a trial bay of 3.5m x 3.5m and of same thickness as that of designed pavement shall be laid at an approved place. After laying the concrete, cores shall be taken out when concrete is 7 days old, to determine the degree of compaction achieved, should any of the cores show honey combing, the trial bay shall be re-laid. The method of compaction and spreading and also desired surface finish shall be approved.

5.5.6.6 Form Work

Steel Formwork

All side forms shall be of mild steel except for curves having radius less than 45 meters. The steel forms shall be of M.S. channel section and depth equal to thickness of pavement.

A section shall have length of 3 metres except on curves of less than 45m radius, where shorter section or wooden formwork may be used. In case of transverse joints, a full length of the bulk head shall act as formwork. When set to grade and staked in place, no deviation of the top surface from the specified level shall be allowed. Use of bent, twisted or worn-out form shall not be permitted. The method of connection between the two length of forms shall be such that the joint formed is free from play or movement. Atleast three stakes for bracing pins or stakes shall be provided for each 3.00m of

form and the bracing and support must be ample to prevent the springing of the forms under the pressure of the concrete or weight or thrust of machinery operation on the forms.

Wooden forms

Wooden forms shall normally be used only for curves having radii of less than 45m. Wooden forms shall be wrought on one side, these shall have minimum base width of 100 mm and depth equal to edge thickness of concrete. These forms, when specially permitted to be used on straights, shall have minimum length of 3.0m. Forms shall be held by stakes set at intervals not exceeding 2m, two stakes to be placed at each joint. The forms shall be firmly nailed or secured to the side stakes, and securely braced at pint where necessary so that no movement will result from the pressure of the concrete or the impact of the tamper and during finishing work. Wooden forms shall be capped along the inside upper edge with 50mm angle iron, well recessed and kept flush with the face of wooden forms.

Setting of Forms

The forms shall be jointed neatly. After the forms are placed and set the base of the forms shall be thoroughly tamped in an approved manner. All forms shall be cleaned and oiled each time before they are used. Forms shall be set, for at least one day's work ahead of concreting and shall remain in position for at least 12 hours after laying of concrete or longer as directed by the EIC. When forms have to be fixed on existing concrete bases they shall be secured at the side by M.S. stakes of 20 dia properly anchored into the base. Holes of suitable size for stakes shall be drilled at least 75 mm deep into the base and after the stakes are inserted they shall be properly wedged so that the stakes shall not get loosened during compaction of concrete.

The trueness of form shall be checked by means of a 3m straight edge and any deviation greater than 1.5 mm shall be rectified. No deviation from the straight edge shall be permitted at the joints.

5.5.6.7 Batching and Mixing

All the ingredients of concrete shall be batched by weight. Weigh hatching shall be done with fully computerized weigh batching plant of minimum 30 cum / hour capacity (or as indicated). Where combined hatching and mixing plants are not available, weigh hatchers of adequate capacity shall be used for weighing of aggregates and cement. Power driven mechanical concrete mixers of adequate capacity in conjunction with weigh batches shall be used.

A small quantity of water will be added before loading of aggregates and cement. The remaining water shall be added during the mixing operation. The mixing shall be done for at least two minutes and until a uniform colour and consistency are achieved.

Quantity of concrete mixed in any one batch shall not exceed the rated capacity of the mixer. The drum of the mixer shall be completely emptied before ingredients for the next mix are charged into it. Concrete mixed as above shall not be modified by addition of water or otherwise in order to facilitate handling or for any other purpose.

5.5.6.8 Placing and Compaction of Concrete

Concrete shall be transported without delay and incorporated in the works within 20 minutes from the time of discharge. The concrete shall be deposited and spread to such a depth that when compacted and finished, it shall conform to the grade and cross section specified in the plan to ensure the minimum slab thickness shown on the drawing to be obtained at all points.

In order to obtain adequate compaction, the concrete shall be spread so as to stand proud of the finished level and produce a surcharge. With screed and internal vibrator, slabs of thickness not exceeding 20cm shall be laid in one layer. Where medium duty pavers are used, this limit shall be raised to 25 cm. Concrete for slabs of greater thickness shall be laid in two equal layers. The second layer shall be laid over the unfinished but compacted first layer within half an hour (within setting time of the cement used) of the laying of the first layer.

Concrete shall be deposited in such a manner as to require as little handling as possible. Spreading, compacting and finishing (except final completed belt finishing) operations shall be within a period not exceeding one hour from the time the mixing starts. In case of dry and hot weather, this time will not exceed 35 minutes. Concrete shall be placed around man-holes or other structures after these have been brought to the correct alignment.

Compaction of concrete

Compaction shall be carried out by electrically operated needle and screed vibrators as stipulated hereafter. Needle vibrators shall be used all over the area for obtaining initial compaction of concrete. These shall be of diameter not less than 4.5 cm. If the vibrators are pneumatic, the pressure must not be below 4 Kg/ cm². If electrically operated they shall have a minimum frequency of 3500 impulses per minute. Minimum number of petrol driven vibrators as specified by the EIC with minimum frequency of 3500 per minute shall be provided at each work head as a stand by arrangement. The screed and internal vibrator shall conform to IS. 2506-1985 respectively.

Vibrating screed consisting of a steel section or timber section weighing not less than 15 Kgs per metre with a tamping edge of not less than 7 cm. width and having a vibrator mounted thereon shall follow needle vibrators to obtain full compaction. The face of the wooden tamping edge of the screed shall be lined with an M.S. plate to be rigidly fixed by means of counter sunk screws. Where screed vibrators are used for compaction, at the discretion of the EIC for compaction of edges and joints, vibrators may be supplemented by hand tamping and Roding for securing satisfactory results. Under no circumstances, honey combing of concrete at joints or elsewhere shall be permitted.

When using vibrating screed for compaction it shall not be dragged over the concrete. During the initial passes, it shall be lifted to the adjacent forward position in short steps. Subsequently, it shall be slowly slid over the surface with its axis slightly tilted away from the direction of sliding and the operation repeated until a close, dense surface is obtained.

Concreting shall be carried out in one operation between the expansion joints and construction joints without any break at the dummy joints.

Concrete shall be deposited on the base as near the forms as possible without touching them. It shall then be shoveled against the sides, maintaining equal pressure and deposited approx. 50 mm higher than the depth of forms, care being taken that it is worked well around the forms. The concrete shall not be dumped from the bucket directly upon or against the forms.

Workmen shall not be allowed to walk on freshly laid concrete. All operations shall be carried out from suitable wooden bridges spanning the lane.

5.5.6.9 Use of Pavers

The contractor shall use slip form/ fixed form paver as indicated for depositing, consolidation & finishing of concrete pavement. The paver(s) shall be of adequate capacity and suitable width of work bridge so as to complete concrete pavement within stipulated/ agreed period of completion.

5.5.6.10 Joints in Concrete Pavement (using sealing compound)

General

Joints shall be of the types and dimensions as indicated and shall be located as indicated.

Dummy Joints

The dummy joints shall be 8 mm wide and shall extend vertically from the surface of the slab to a depth equal to 1/3 to 1/4 of the thickness of the slab. The joint may be formed by depressing into the soft but compacted concrete a high tensile mild steel. 'Tee' or flat bar of depth not less than the required depth of the joint plus 25 mm. The bar used for forming the groove shall be coated with soft seal or other suitable lubricant and have built in handles rigidly fixed to facilitate its removal without spalling or crumbling the edges. When the steel bar is removed, joints shall be nearly reformed immediately with proper tools and with mortar/fine material from the slab itself. No additional cement mortar shall be used. Alternatively the slot may be formed by sawing the concrete with a joint cutting machine (diamond cutter) of approved design within 6 hours of placing under moderate climatic conditions and when the concrete has sufficiently hardened. Under extreme cold conditions, this period may be suitably increased based on experience. In all cases, except where cutting is done with saw, the joint edges shall be bull nosed. Care shall be taken that the edges of the joints are not damaged. The edge shall not stand proud of the concrete slabs.

Construction Joints

The construction joints shall be 10 mm wide and straight and vertical through the full thickness of the slab. The vertical edge of the concrete on the side of the joint shall be treated with a coat of lime wash or bituminous paint before the adjacent bay is concreted. A groove 2.5 cm deep and 1 cm wide shall be formed at the top surface of the joint to receive the sealing compound. The groove shall be formed

in the same manner as that for a dummy joint. The edges of the groove shall be bull-nosed and not stand proud of the concrete surface.

Expansion Joints

The expansion joints shall be straight and shall extend through the full thickness of the slab and shall be of the shape and dimensions shown on the drawings. The slab edges adjacent to the joint shall be formed truly vertical. The joints shall be filled with a 2 cm thick filler board. Cold applied joint sealant (polysulphide or polyurethane) of approved make with minimum ten years of performance guarantee will be used as joint sealant. The guarantee should be taken in writing from the contractor before the approval of joint sealants. The technical specifications of the cold applied joint sealants (irrespective of whether polysulphide or polyurethane) should meet the requirements mentioned in BS-5212, BS 4254 and EN-141875- 2003 (for hydrolysis/water resistance test). In addition, the Movement Accommodation Factor (MAF) of the sealant should be minimum $\pm 30\%$.

The groove to receive the sealing compound may be formed by cutting the extra filler board to the required depth.

Sealing of Joints

All joints shall be sealed as soon as practicable after 28 days of placing of the slabs. The joints shall be finished flush with the finished concrete surface if the sealing of joints is done in summer and 3mm below the finished concrete surface, if the sealing of joints is done in winter. After the sealing compound has hardened, the excess sealing compound, if any, adhering to the slab outside the joints shall be removed by scraping or otherwise and the surface left clean. The pavement shall be opened to traffic only after the completion of joint sealing over the entire pavement.

Cleaning of Joints

All foreign materials in the joints shall be removed with pneumatic blower. The joints shall, thereafter, be cleaned with a coir brush. Fine particles clinging to the concrete faces shall be removed with the help of an air compressor only to avoid damage to the edges. The joints shall be cleaned and surface dried before the application of primer.

Application of Primer

The cleaned joint shall be primed with a 20-25 mm side painter 1s brush, while painting, light pressure shall be applied so that the primer penetrates into the pores of concrete. The primer shall be applied twice on one side (i.e. by forward and reverse movement of brush) The primer shall be applied in the thinnest possible complete film and then left for some till the primer feels "tacky " soon after the primer is applied, the joint is covered with 10-15 cm wide paper strips so that no dust is deposited on the primer.

Sealant joints

Only cold applied Polysulphide or Polyurethane joint sealant of approved make will be used in rigid pavements. The criteria for selection of the joint sealant will depend on the minimum performance guarantee of ten years offered by the firm. This performance-based selection would accrue better cost effective results rather than using a joint sealant without any guarantee. The technical specifications of the cold applied joint sealants (irrespective of whether polysulphide or polyurethane) should meet all the requirements mentioned in BS-5212, B4254 and EN- 141875-2003(for hydrolysis/water resistance test).In addition, the movement accommodation factor (MAF) of the sealant should be minimum $\pm 30\%$.

While the joints shall be sealed flush with the adjacent pavement surface in summer, in winter they shall be filled to a depth of 3-4 mm below the surface. This procedure will reduce the possibility of ingress of grit and other foreign matter into the sealing compound as well as dislodging of the hardened sealing compound under traffic.

5.5.6.11 Joints in pavement concrete, (using polysulphide/polyurethane material)

General

Joint shall be of the types and dimensions specified and be located in all as directed by Garrison Engineer. The edges of the groove/joints shall be bull nosed & not stand proud of the concrete surface.

Dummy Joints

The size of joints shall be as indicated/ specified.

The joint shall be formed using mechanical equipment (diamond cutter) within 6 hour of placing of concrete under moderate climatic conditions and when the concrete has sufficiently hardened. Cutting or sawing by a sawing mounted at movable frame and driven mechanically will also be permitted as a method for making the joint. Care shall be taken that the edge of the joints are not damaged.

In case of sudden rain or storm, the work can be concluded at the dummy joint but the latter will then be formed into a construction joint.

Construction Joints

Construction joints shall also be provided at places where concreting is stopped due to unforeseen circumstances. The size of joints shall be as specified and as shown on drawings.

Construction joints shall be straight and vertical through the full thickness of the slab. The vertical edge of the concrete of the side of the joint shall be treated with a coat of lime wash or bituminous paint before the adjacent bay is concreted. A groove of dimension as specified in contract shall be formed. The groove shall be formed in the same manner as that for a dummy joint.

Expansion Joints

The expansion joints shall consist of a joint filler board as detailed in the drawing. The depth of the non-extruding filler pad joint filler board) shall be cut by 25mm from top to prepare the joint.

Joints shall be straight and shall extend through the full thickness of the slab and shall be of the shape and dimensions shown on the drawings. The slab edge adjacent to the joint shall be formed truly vertical. The joints shall be filled with approved joint filler.

Before the provision of expansion joint, the face of the already laid concrete slab shall be painted with the approved primer at the rate of 2.6 liters per 10 square metres. The expansion pad shall be properly cut to shape. Bond breaker tape shall be applied on the top face of the pad before inserting the closed cell backup rod. It shall then be placed in position abutting the painted face of the already laid concrete slab. The adjacent slab shall then be concreted. The faces of the pad against which the new concrete slab is to be laid shall also be painted with the approved primer before laying the concrete. While concreting a neat groove as per drawing shall be formed on top of the pad taking care that the edges are absolutely straight and that the groove so made does not get filled with any material like concrete, mortar and other rubbish.

Expansion joints shall be provided both longitudinally and transverse direction at spacing as shown on drawing or as directed by Engineer-in-Charge.

Procedure of Joint Filling with Polysulphide/Polyurethane Sealant

The technical specifications of the cold applied joint sealants (irrespective of whether polysulphide or polyurethane) should meet all the requirements mentioned in BS-5212, BS 4254 and EN-141875-2003 (for hydrolysis/water resistance test). In addition, the Movement Accommodation Factor (MAF) of the sealant should be minimum ± 30 %. The criteria for selection of the joint sealant of approved make will be a minimum performance guarantee of ten years offered by the firm. This performance-based selection would accrue better cost effective results rather than using a joint sealant without any guarantee. Contractor shall not procure the materials required for joint filling unless the samples are approved by the GE and ten years of guarantee is given in writing by the contractor. The primer and sealant shall got tested by GE from a reputed testing laboratory who has the NABL accreditations like Indian Rubber Manufacturer's Research Association's Laboratory/CRRI/IIT/NIT/SEMT Wing, CME Pune before approval. The test certificate shall be obtained for every 5 MT of material incorporated in the work.

Joint Preparation

Before commencing joint sealing operations, the following shall be ensured: -

The groove extends fully across the bay between consecutive longitudinal joints in the case of transverse joints and is continuous in the case of longitudinal joints.

No concrete and foreign matter shall be left in the groove.

In case of expansion joint, the filled materials is exposed to the full length of the joint and expansion joint filler is tightly packed.

Joint surface must be dry, free from dust, coating, bituminous mastics, concrete curing agencies, could release agents, oil, grease and loose particles.

All joints shall be thoroughly cleaned out by compressed air and sanding with emery paper or other approved means and shall be approved by Engineer-in- Charge before they are sealed.

The cleaned and prepared joints shall be primed on the sides of the joints up to the depth where sealing component is to be provided and filled with approved sealant.

Wipe out oil and grease by solvent soaked cloth (such as Xylene, Toluene or Acetone or Gardo clean).

Before sealing, insert a bond breaker tape and bond breaker (closed cell polyethylene frame rod) caulked tightly into the base of the sealing groove to prevent the sealant from adhering to the base of slot. Width of bond breaker (backup rod) shall be 20 to 25% more than the joint so that there is no seepage of sealant through joints edges.

Fixing/Masking Tape

Fix masking tape to prevent edges of joints becoming dirty due to spillage of sealant at the time of pouring.

Application of Primer

Suitable primer shall be first applied to the vertical faces of the concrete joint before pouring cold applied sealant confirming to specifications, in order to improve the adhesive qualities of the product. Primer as specified by manufactures shall be applied to the joint vertical surfaces and allowed to dry for 30 minutes to 2 hours depending on the climatic condition. The surfaces shall be primed twice@ 0.075litre (minimum) primer per square metre.

If the primer film has become completely tack free, the surface must be re-primed before applying the sealant.

If the primed areas are left unsealed overnight the primer film must be removed by grit blasting or grinding and the joints interfaces shall be re-primed.

Mixing

Mixing and application of sealant will be through mechanical means to avoid any human error. The mixed product shall be used immediately as per manufacturer's instructions within its pot life i.e. within

30 minute. The mixed sealant should be kept for a few minutes to allow air to escape before commencement of jointing filling.

Application or Pouring of Sealant

Mixed sealant shall be applied by mechanical means (machine application) based on the manufacturer's instructions and shall be executed by his approved and trained applicator. Application temperature of sealant should be in between 5 to 45 degree Celsius (or as per manufacturer's instructions). It should be filled to a level 2 to 3mm below the top of the pavement leaving a recess to protect the sealant from damage. To prevent accidental spillage of sealant on the top surface and to give a neat finish masking tape should be applied on front edges of joint in such a manner that the material will not be spilled on the exposed surface of the concrete. Any excess filler on the surface of the pavement shall be removed immediately and the pavement surface cleaned. All necessary precautions as per the manufacturer's recommendations shall be taken. The sealant should be immediately tooled either with stainless steel or wooden spatula of the size of the joint to give a smooth finish before it begins to set. Masking tape shall be removed immediately after the sealant has been tooled. The sealant should be allowed to cure as per manufacturer's instructions during which period no traffic should be allowed on the pavement.

The test certificate shall be obtained for every 5 MT of material incorporated in the work.

Some Miscellaneous Aspects

The sealant are sensitive to temperature while in storage as well as during mixing. Temperatures for all phase of handling of the sealing compounds viz mixing, placing and curing conditions must be in accordance with manufacturer's recommendations.

All safety precautions during handing and application of these sealants as prescribed by the manufacturers shall also be strictly adhered to.

Precautions

Some people are sensitive to resins, hardeners, vapour etc. Therefore it is advisable to use hand gloves/ goggles and suitable protective clothing.

Avoid application below 10°C temperature.

Avoid application on damp or Moist surfaces.

Do not expose primer to naked flames or other sources of ignition. (e) Materials to be kept in no smoking area.

Containers should be tightly sealed when not in use.

In the event of .fire, extinguish with carbon dioxide or foam.

Should accident skin contact occurs, remove immediately with a resin removing cream, followed by soap and water. Do not use solvent.

In case of contact with eyes, rinse immediately with plenty of clean water and seek medical advise.

Use only in well ventilated areas.

All consumables (masking tape, empty cartridges etc) should be removed and disposed off safely.

Separation Membrane

A separation membrane shall be used between the concrete slab and the sub base. Separation membrane shall be polythene sheeting 250 microns thick laid flat without creases. Before placing the separation membrane, the surface shall be swept clean of all the extraneous materials using air compressor and screen sand layer shall be laid over cleaned surface. Wherever overlap of plastic sheets is necessary, the same shall be at least 300mm and any damaged sheeting shall be replaced at the Contractor's expense. The separation membrane may be nailed to the lower layer with concrete nails.

5.5.6.12 Finishing of Concrete

Straight Edging

Immediately after the compaction of concrete and the construction of joints but before the concrete has hardened and while the concrete is still in plastic state, the pavement surface shall be inspected for irregularities with a profile checking template and any needed correction made by adding or removing concrete by means of long handled floats and scraping straight edge followed by further compaction and finishing. The long handled floats may be used to smoothen and fill in open textured areas in the pavement surface but the final finishing is to be made with scraping straight edges.

The scraping straight edges are to be 3 metres long with flexible long enough to reach the other side of slab when operated from one side of the pavement. They are to be placed parallel to the forms at the side of the pavements and worked backwards and forward uniformly across the width of the slab. After this operation has been completed and the surface shall be brought to the required finish, the straight edges shall be moved forward by not more than half their length and this process repeated.

The straight edge testing and re-floating shall continue until entire surfaces:

are free from observable departure from the straight edge;

conforms to the required levels and cross section; and

when the concrete has hardened, it shall conform to the specified surface levels.

The foregoing work shall be carried out while the concrete is still plastic and workable and in such time sequence as to ensure the removal of water of laitance from the surface.

After the concrete has sufficiently hardened to about 12 hours and not later than 24 hours, the surface shall be tested again for high spots shall be marked and those exceeding 3 mm shall be ground down immediately. Care shall be taken to ensure that the grinding does not in any way damage the concrete surface.

The final surface finish is to be such that when tested with 3 metres long straight edge placed anywhere. within the same or adjoining slab in any direction on the surface there is no gap greater than 3 mm between the bottom of the straight edge of the surface of the pavement.

Belting

Just before the concrete becomes non-plastic the surface shall be belted with a two-ply canvas belt not less than 20 cm wide and atleast 1 metre longer than the width of the slab. Hand belt shall have suitable handles to permit controlled uniform manipulation. The belt shall be operated with short strokes transverse to entire line of pavement and with a rapid advance parallel to the centre line.

Brooming

After belting and as soon as surplus water, if any, has arisen to the surface the pavement shall be given a broom finish with an approved steel or fibre broom not less than 45 em wide. The broom shall be pulled gently transversely and in straight strokes over the surface of pavement from edge to edge. Adjacent strokes shall be slightly over-lapped. Brooming shall be perpendicular to the centre line of the pavement and so, executed that the corrugations thus produced will be uniform in character and width, and not more than 1.5 mm deep. No pressure will be applied to be broom and scoring shall be done under the weight of broom head without tearing the surface. Brooming shall be completed before the concrete reaches such a state that the surface is likely to be torn or unduly roughened by the operation. The broomed surface shall be free from porous or rough spots, irregularities, depressions, and pot-holes such as may be caused by accidental disturbing of particles of coarse aggregate embedded near the surface.

Edging

Immediately after belting/brooming has been completed, the edges of the slab shall be carefully finished with an edging tool of 6 mm radius and the pavement edges shall be left smooth and true to line.

Honey combing

As soon as the side forms are removed minor honey combed areas shall be filled with mortar composed of one part of cement to two parts of fine aggregate. Major honey-combed areas or segregated concrete or other defective work or areas damaged by the removal of the forms or

concrete damaged by rain or any other reasons shall be removed and replaced. The total area of honey-combed surface more than 2.5 sq.cm. each shall not exceed 4% of the area of the slab side. Honey-combing exceeding 300 cm² in area at any one location shall be considered as major honey-combing.

Every slab shall bear an impression not exceeding 3 mm in depth comprising the number allotted to the slab and the date on which it was laid. The impression shall be formed when the concrete is green so as to leave permanent mark of setting.

5.5.6.13 Curing and Protection of Concrete

Initial Curing

Immediately after completion of the finishing operations, the surface of the pavement shall be entirely covered with wetted burlap, cotton or jute mats. The mats used shall be of such length (or width) that as laid they will extend at least 450 mm beyond the edges of the slab. The mats shall be so placed that the entire surface and edges of the slab are completely covered. This covering shall be placed as soon as in the judgment of the Engineer-in-Charge, the concrete has set sufficiently to prevent damage to the surface. Prior to being placed with the wettest side down, the mats shall be so placed and weighed down as to cause them to remain in intimate contact with the surface covered, and the covering shall be maintained fully wetted and in position for 24 hours, after the concrete has been placed, or until the concrete is sufficiently hard to be walked on without getting damaged. Water shall be gently sprayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove a mat for any reason, the concrete slab shall not be exposed for a period more than half an hour.

Worn burlap or burlap with holes shall not be permitted. Burlap reclaimed from previous use other than curing concrete shall be thoroughly washed prior to use for curing purposes. If burlap is obtained in strips, the strips shall be laid to overlap at least 150 mm.

Burlap shall be placed from suitable bridges. Waling on freshly laid concrete to facilitate placing burlap shall not be permitted.

Alternately, Membrane curing/polythene film is advocated for curing especially in arid regions and curing done as specified.

Final curing

Upon removal of the burlap the slab shall be thoroughly wetted and cured as follows:

Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal dykes of clay about 50 mm high immediately covered with a blanket of sandy soil free from stones to prevent the drying up and cracking of clay. The rest of slab shall then be covered with sufficient sandy soil so as to produce a blanket of earth not less than 37 mm depth after wetting. The earth covering shall be thoroughly wetted while it is being placed on

the surface and against the sides of the slab and kept thoroughly saturated with water for 21 days and thoroughly wetted down during the mornings of subsequent days up to 29 days and shall thereafter remain in place until the concrete has attained the required strength when the covering shall be removed and the pavement cleaned and swept. If the earth covering becomes displaced during the curing period, it shall be replaced to the original depth and re-saturated.

Concrete shall not be subjected to any load or weight of any plant until atleast 14 days after laying. Concentrated loads or sharp objects like iron wheels of concrete mixer and any vehicular traffic including construction traffic will not be allowed on the concrete surface for 28 days.

5.5.6.14 Testing of pavement concrete

Testing of pavement concrete shall be in accordance with relevant IS Specifications.

Seven (07) - days strength

The concrete mix should be prepared for the flexural strength given in the design and will be accepted on 28 days strength. However the 7 days strength gives an early indication of the strength likely to be achieved. 7-days strength shall be determined at least 8 to 10 days prior to laying of concrete. At least 3 beams should be casted and tested for flexural strength as per IS: 516 of 1959. The strength achieved should be 75% of the 28 days strength. If it is less, then the concrete mix should be re-designed and re-tested. After the laying of concrete starts, determination of 7-day strength is not necessary.

Twenty-Eight (28) - days Strength

At least 3 beams for every slab (100ft x 12.5 ft x 1ft) will be casted and tested for flexural strength as per IS : 516 of 1959. The concrete mix should be prepared for the flexural strength given in the design. After at least 30 samples have been cast for slab laid in similar conditions their results should be tabulated and LCL determined as follows:

$$LCL = X - tv$$

Where

LCL = Lower Control Limit (minimum flexural strength)

X = Mean flexural strength from the samples tested,

t = Tolerance level factor,

v = Standard deviation of the samples tested.

LCL so determined should not be less than specified value. Along with the beams, cubes will also be cast and tested for compression as IS: 516 of 1959. The compressive strength will be tabulated along with the corresponding flexural strength to establish correlation between flexural and compressive strength.

Workability

Compacting factor tests and slump tests should be carried out as per IS: 1199 of 1959. In case concrete is being machine-laid, then only compacting factor tests should be carried out otherwise either of the two can be carried out at the discretion of the EIC. Compacting factor/ slump tests shall be carried out for every 10 cum of concrete mixed. The concrete shall not be laid unless the appropriate test has been carried out and authority given for start of laying. Any batch of concrete giving a compacting factor or slump which does not comply with the laid down value (+0.02 in case of compacting factor only) shall be rejected and removed from the site.

Acceptance of concrete

Concrete shall only be accepted if it satisfies the following main conditions:

LCL of every lot (atleast 30 samples) is not less than specified value,

Co-efficient of variation is not greater than 10%.

Tolerance Level Factor is 1.5.

There is no honey-combing in the concrete.

Critical Examination of Test Data

In case LCL of a lot is less, then the following procedure shall be adopted before core tests are undertaken:

Omit the slab having lowest average strength and reevaluate the remaining test date of the samples.

If the reevaluated data conforms to the above acceptance criteria, accept the lot less the slab omitted.

In case of unsatisfactory result, repeat the process by omitting the next lowest till all weak slabs are segregated for further testing by core cutting and the part lot gets specified value.

Core Tests

In case the concrete fails in flexure test i.e. the LCL is less than specified for a particular lot, then concrete shall not be rejected unless it also fails in core test. In core test, atleast two cores of the same will be cut per slab. The crushing strength of this core is then determined. The crushing strength should not be less than 0.8 times the corresponding crushing strength of 15 cm cubes. The crushing

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strength determination will be as per IS: 516 of 1959. In case the L/D ratio of the core is between 1 and 2, then the crushing strength of the cube will be reduced. The correction will be carried out as per the formula given below:

$$F = 0.11n + 0.78$$

Where F = Correction factor

L

n = - ratio (L and D are height and Diameter respectively of core

D

In case the concrete fails the flexure (LCL) test, but is found satisfactory in core test, it shall be accepted as the core test takes the precedence over the flexure test, However, in case the concrete fails both flexure as well as core test, then it shall be rejected and replaced.

All holes from which cores have been cut, will be filled with the same concrete from which the original slab was laid i.e., concrete of the same design mix.

5.5.6.15 Quality Control

The following quality control tests shall be carried out at frequencies specified against each during progress of work:

S. No.	Test	Test Method	Frequency
1.	Coarse Aggregates		
	(a) Flakiness Index	IS:2386 (Part-1)	one test for every 100 Cum of aggregates.
	(b) Impact Value	IS: 2386 (Part-4)	-do-
	(c) Los Angeles Abrasion Value	IS: 2386 (Part 4)	-do-
	(d) Deleterious materials	IS: 2386 (Part-2)	Before approval of the quarry and at every subsequent change in the source of supply.
	(e) Moisture content	IS: 2386 (Part-3)	Minimum of two test per day for

S. No.	Test	Test Method	Frequency
			correcting the water demand of the mix.
	(f) Soundness	IS: 2386 (Part-5)	Before approving the aggregates and every month subsequently.
	(g) Alkali aggregate reactivity	IS: 2386 (Part-7)	-do-
2.	Fine Aggregates		
	(a) Silt content	IS: 2386 (Part-1)	One test per 250 Cum.
	(b) Gradation of sand.	IS: 386 (Part-1)	-do-
	(c) Deleterious materials	IS: 2386 (Part-2)	Before approval of the quarry and at every subsequent change in the source of supply.
	(d) Moisture content	IS: 2386 (Part-3)	Regularly for correcting the water demand of the mix on daily basis.
3.	Cement Physical and chemical tests	IS: 269 IS:455 IS:1489 IS: 8112 IS:12269	Once for each source of supply and occasionally when called for in case of long/ improper storage. Besides the contractor also will submit daily test data on cement released by the manufacturer.
4.	Water Chemical tests	IS: 456	At approval of source of supply, subsequently at interval of three months.
5.	Mixed Aggregates Grading	IS: 2386 (Part-1)	1 test per 150 Cum.
6.	Concrete		

S. No.	Test	Test Method	Frequency
	(a) Slump test (Workability of fresh concrete)	IS: 1199	One test per each dumper load at both hatching plant site and paving site initially when works starts. Subsequently sampling may be done from alternate dumper.
	(b) Flexural strength of concrete	IS: 516	One test consisting of nine works test beam for every 150 cum of concrete. Three of the beams shall be tested at 7 day and three at 28 days for flexural strength. The remaining three beams shall be kept as reserve exclusive for government use for subsequent testing (if so desired by Government) and preserved for one year from completion of work under the contract. The contractor cannot claim testing of these beams for any purpose, as a matter of right.
	(c) Core strength on hardened concrete.	IS: 516	In case of doubt or in case of lab test not found satisfactory.
	(d) Thickness determination		From the level data of concrete pavement surface and sub base at grid points of 5/6.25m x 3.5m
	(e) Thickness measurement for trial length		3 cores per trial length.
	(f) Verification of level of string line in the case of slip form paving and steel forms in the case of fixed form paving		String line or steel form shall be checked for level at an interval of 5.0m or 6.25m. The level of tolerance allowed shall be + 2mm. These shall be got approved 1-2 hours before the commencement of the concreting activity.

Quality control test for levels alignments and texture shall be carries out as under:-

Level tolerance +5mm

Width of pavement and position of paving edges +10mm

Pavement thickness -5mm to +25mm

Alignment of joints, widths, depth of dowel grooves to be checked @ one joint per

400m length or a day's work whichever is more.

Surface regularly both transversely and longitudinally Once a day or one day's work, without disturbing the curing operation.

Texture depth:

S. No.	Time of Test	Number of measurements	Required Texture depth	
			Special Value	Tolerance
1	Between 24 hours and 7 days after the construction of the slab until the slab is first used by vehicles	An average of 5 measurements	1.00mm	+ 0.25mm
2	Not later than 6 weeks before the pavement is opened to traffic.	An average of 5 measurements	1.00mm	+ 0.25mm -0.35mm

5.5.7 Concrete Block Paving

5.5.7.1 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.

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.

5.5.7.2 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 as per MORTH specifications. The sub-base layer shall be laid on the prepared formation and compacted in accordance with MORTH specifications. 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 5.5.5 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 I 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.

Table I : Tolerances on Surface Level for Concrete Block Paving

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

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.

5.5.7.3 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, Clause 5.2, Plain and Reinforced Concrete.

Reinforcement, where used, shall comply with the Specification Clause 5.2, 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.

5.5.7.4 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 embankment, it shall be to the full width of the top of the embankment.

Material placed in the top 300 mm of embankments, shall exclude particle sizes greater than 75 mm and shall have a minimum subgrade CBR value as per requirement of relevant IS Codes.

The width to be excavated shall be 300 mm each side of the outside edges of the kerb or gutter. The subgrade shall be of uniform density as approved by the Employer. Rock, shale, or soft and yielding material shall be excavated 15 mm below subgrade elevation and replaced with suitable backfill material. The backfill material shall be compacted to meet the compaction requirements specified in Clause 5.4.3 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 Clause 5.2.

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 Clause 5.2, Plain and reinforced concrete Clause 5.2.14.

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.

5.5.8 Removal of Surplus Earth

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

5.5.9 Brick Pitching

5.5.9.1 Excavation

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

5.5.9.2 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.

5.5.9.3 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.

5.5.10 Traffic Markings

5.5.10.1 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.

5.5.10.2 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 ^o 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%

5.5.10.3 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.

5.5.10.4 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.

5.6 Storm Water Drainage

5.6.1 General

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

5.6.2 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 including nalla discharge.
- c) Pipe culverts for nalla discharge.
- d) Storm drain catch basins and related drainage structures and appurtenances.
- e) Storm drain outlets into sea including flap gates and related features.
- f) Sewage Collection & Transfer system

5.6.3 Materials

5.6.3.1 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.

5.6.3.2 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.

5.6.4 Execution

5.6.4.1 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.

5.6.4.2 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.

5.6.4.3 Repair and Retesting

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

5.6.4.4 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.

5.6.4.5 Tolerances

Pipe Inverts: Plus 10 mm, minus 10 mm

Catch Basin Grates: Plus 0.00 mm, minus 10 mm

5.6.5 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.

5.6.6 Construction of Catch Basins and Trench Drains

5.6.6.1 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.

5.6.6.2 Concrete Work

Cast-in-Place Concrete

Prior to placing formwork compact existing insitu soil and provide a layer of compacted bedding material.

Prior to placing the concrete, remove all water and debris from the forms. Place the concrete and screed the top surface of exposed slabs and walls. When the initial water has been absorbed, float the surfaces with a wood float and lightly trowel with a steel trowel to a smooth finish free from marks or irregularities. Finish exposed edges with a steel-edging tool. Remove forms and patch any defects in the concrete as required.

Cure concrete by preventing the loss of moisture for a period of 7 days. Accomplish with a membrane-forming curing compound. Apply the curing compound immediately after removal of forms or finishing of the slabs. Protect concrete from damage during the 7-day curing period.

Precast Units

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

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

5.6.6.4 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.

5.6.6.5 Cleaning

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

5.6.6.6 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.

5.6.7 Installation of Flap Gate

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

5.6.8 Rain Water Harvesting System

Rain water harvesting system shall be provided for Admin Building.

5.7 Earthwork

5.7.1 General

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

5.7.2 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.

5.7.3 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.

5.7.4 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.

5.7.5 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.

5.7.6 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.

5.7.7 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.

5.7.8 Filling & Backfilling Generally

During compaction the backfill as specified in Clauses 5.7.8.1 & 5.7.8.2 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.

5.7.8.1 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).

5.7.8.2 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 5.7.8.3 below.

5.7.8.3 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.

5.7.8.4 Hardcore Under Building Floor

Hardcore shall unless otherwise directed consist of gravels/crushed stone of 50 mm size and shall be free from dust, soil, rubbish, wood and other deleterious matter and shall be to the approval of the Employer. Approved hardcore materials shall be spread uniformly over prepared subgrade and packed properly, with interstices filled with sand. The hardcore shall then be compacted by suitable mechanical compactor to the satisfaction of the Employer. Top of the hardcore shall be flushed with sand to have smooth and curve surface for placing of polythene sheets.

5.7.8.5 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.

5.7.8.6 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.

5.7.8.7 Tolerance

After installation and compaction of fill and backfills the leveling 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.

5.7.9 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.

5.7.10 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.

5.7.11 Existing Levels

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

5.7.12 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 authority before work commences.

5.7.13 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 5.7.8.0 & 5.7.8.1. 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.

5.7.14 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.

5.7.15 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.

5.7.16 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.

5.7.17 Anti-Termite Treatment

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

5.7.17.1 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.

5.7.17.2 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.

5.7.17.1 and 5.7.17.2 shall be carried out simultaneously to establish the chemical barrier.

5.7.17.3 Treatment to Soil along the External Wall Perimeter

After leveling 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, 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 5.7.17.2 is disturbed/broken, additional treatment to such areas will be necessary.

5.7.17.4 Precautions

Precautions shall be taken not to disturb the treated areas by leveling, 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

5.8 Brick Masonry Works

5.8.1 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.

5.8.2 Materials

Refer specifications under 'Materials'.

5.8.2.1 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.

5.8.2.2 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.

5.8.2.3 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.

5.8.3 Construction Procedure

5.8.3.1 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.

5.8.3.2 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 (will) handle of trowel or wooden mallet. Its inside faces shall be buttered with mortar before the next brick is laid and pressed against it. After completion of the course, all vertical joint shall be filled from top with mortar.

All brick courses shall be taken up truly plumb; if battered, the batter is to be truly maintained. All courses shall be laid truly horizontal and vertical joints shall be truly vertical. The level and verticality of work in walls shall be checked up at every 1 m interval.

The masonry walls of structures shall be carried up progressively, leaving no 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 Clause 5.8.3.2. 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 Clause 5.8.3.2 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.

5.8.4 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.

5.8.5 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.

5.8.6 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.

5.8.7 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.

5.8.8 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.

5.8.9 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.

5.8.10 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 brickwork, 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.

5.9 Structural Steel Work

5.9.1 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 these 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.

5.9.2 Structural Steel

5.9.2.1 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_{ee}=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.

5.9.2.2 Structural Steel Types

(i) Rolled Shapes and Plates

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

(ii) 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 alongwith material.

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

i. Special Requirements

a. Carbon Steel

All carbon steel material shall meet the following:

Max. Carbon (Cmax) = 0.22%

Max. Carbon Equivalent (CE) = 0.45

(For CE formula refer 2.5.2)

b. Intermediate Strength Steel

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

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

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 fibre strain exceeds five (5) percent as defined by the formula.
Percent Strain = $\frac{100 t}{D}$
Where t = thickness of element
D = outside diameter
- Welded assemblies containing one or more elements with the thickness exceeding 65 mm.

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.

5.9.3 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.

5.9.4 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".

5.9.5 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".

5.9.6 Galvanising

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

5.9.7 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.

5.9.8 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.

5.9.9 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.

5.9.10 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.

5.10 Steel /Aluminium Doors, Windows and Ventilators

5.10.1 General

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

5.10.1.1 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.

5.10.2 Pressed Steel Door/Window/Ventilator Frame

Pressed steel door/window/ventilator frame shall conform to IS:4351.

The frames shall be made of 16gauge pressed steel bent to shape using bending machine, and mitred with square edges. The frames shall be provided with spacers by welding 50 mm x 5 mm flats to the portion of the frame in contact with the wall jambs @ 600 mm vertical spacing.

The frame shall be fixed to the masonry by means of 300 mm x 25mm x 6mm hold fast welded to the spacers and grouted with M-20 grade concrete in minimum 350 mm x 100 mm x 100 mm sized hole in the masonry.

In case of concrete, the frames shall be fixed by 96 mm long, 12 mm dia metallic counter sunk type dash fasteners through the frame and spacers.

Provisions for hinges, locking arrangement and other hardwares shall be provided in the frames by machine cutting required size cutout on the frame body and welded / screwed to 3 mm thick M.S. pad plates-already welded over the cut out from behind.

The frame surface shall be thoroughly cleaned of rust, mill scale, dirt, oil etc. and then finished with painting (by priming with red oxide zinc chromate primer conforming to IS:2074 and painting on forming to IS:1477 Part (II) or by approved shade electrostatic powder coating (25 micron).

5.10.3 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 hardwares such as tower bolt, aldrop etc.

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

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

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

In case of partly glazed door shutter. Glassas specified shall be fixed with glazing clips and solid drawn 10 mm x 10 mm, MS beading backed with putty and fixed by countersunk screws. Necessary rebate for fixing the glass shall be provided by arranging the shutter bracing accordingly.

The shutters shall be provided with locking device, handles and other hardwares as specified.

5.10.4 Steel Windows & Ventilator

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

5.10.4.1 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 properly 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.

5.10.5 Rolling Shutters

5.10.5.1 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.

5.10.5.2 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).

5.10.5.3 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.

5.10.5.4 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.

5.10.5.5 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.

5.10.5.6 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 workmans-like manner so that the operation of the shutter is easy and smooth.

5.10.5.7 Grilled Curtain

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

5.10.5.8 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.

5.10.6 Aluminium Glazed Doors/Windows/Ventilators

5.10.6.1 General

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

5.10.6.2 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/sq.M)

5.10.6.3 Workmanship

Frames shall be square and flat, the comer of the frame being fabricated to true right angles. Details of construction of frames. shutters etc. shal be as per drgs.

Side hung window shutters shall either be fixed to the frame with pivots, or aluminium alloy hinges. For fixing the hinges, slots shall be cut in the fixed frames and the hinges inserted inside may be riveted to the frame. The hinges shall normally be of the projecting type conforming to IS designation

A-5-M of IS 617, IS 733. In which case Peg stay of 300 mm long complete with Locking bracket and conforming to IS codes same as for hinges shall be provided. Friction hinges may also be provided in which case peg stays are not required.

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

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

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

The door shutters shall be fitted with pivots as specified. The handle for doors shall be of Aluminium and as per design. The door shutters shall be provided with locking device, floor spring, O/H door closer and any other hardwares, specified in item.

In case of composite Door/window/ventilator units, the units shall be coupled. Weather bar shall be provided whenever a coupling member is fitted over an external opening shutter.

Glazing shall be fixed to the extruded sections by means of extruded 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.

5.11 Steel Sheet Roofing and Siding

5.11.1 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.

5.11.2 Materials

5.11.2.1 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

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

5.11.3 Workmanship

5.11.3.1 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 Sheet

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 atleast 225 mm. Ridges & hips shall be fixed to the purlins with polymer coated hook bolts, thrust washer and polymer cap. Atleast one of the fixing bolts shall pass through the end laps of ridges and hips on either side. If it is not possible extra hook bolts shall be provided. Each endlap of ridges and hips shall be joined together by atleast galvanised iron seam bolts and GI washers. Ridges and hips shall fit squarely on the sheets.

Valleys and Flashings

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

Flashing shall be inserted into brick work or masonry joints to a depth of 50 mm and shall be filled with cement mortar (1:3). When flashing has to be laid at a slope, it shall be stepped at each course of masonry. The steps shall be cut back at an angle of atleast 30°.

Valleys shall be bent to shape and shall have at least 225 mm end lap and projection on either side under CGI sheet. Valleys shall be fixed to the 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 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.

5.11.3.2 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 galvanized by Hot-dip process as per IS-277. The bottom unexposed surface shall then be coated with alkyd backer of min. 7 microns Top exposed surface shall have epoxy primer of min. 7 microns followed by polyester top coat of min. 16 microns of specified colour.

Properties

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

Pencil Hardness	:	H-2H
Formability	:	2-3 t
Impact Resistance	:	40"/lb.
Salt spray test	:	750 hours
QUV-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

5.12 Wood Work

5.12.1 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.

5.12.1.1 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

5.12.2 Material

5.12.2.1 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 1S:4021 of good quality, well-seasoned and free from defects such as dead knots, cracks, sapwood etc. No individual hard and sound knot shall exceed 6 sq. cm in size with no dimension more than 50 mm and the aggregate area of such knots shall not be more than 1% of the area of the piece. There shall not be less than 5 growth rings per cm, width in cross-sections.

Moisture Content in Timber

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

Workmanship of Wood Work

Workmanship for wood and joinery shall be as per 1S:1200 and IS:4021.

Painting / Polishing of Wood Work

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

5.12.3 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.

5.12.3.1 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 5.12.2.1 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.

5.12.3.2 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 5.12.2.1 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 5.12.3.1 (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.

5.12.3.3 Glazed Wooden Door Shutter

Materials

i) Wood

Teakwood for various members like stiles, rails, etc. shall be as specified-in Clause 5.12.2.1 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 5.12.3.1 (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.

5.12.3.4 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.

5.12.3.5 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 1) 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)

5.12.3.6 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 5.12.3.1 (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.

5.12.3.7 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.

5.13 Roofing Treatment

5.13.1 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.

5.13.2 Material

The material shall consist of 2 pack clear / pigmented aliphatic polyurethane using polyurethane using polyether polyois (polyester or Castor Oil based polyois not acceptable), with iso-cynorate for rendering flame resistant characteristic. The 2 pack system, consisting of pigment and the solvent (Xylene/Toulene, no filler) shall be mixed in definite ratio by weight strictly as per approved manufacturer's specification, for preparing the coating for application. The coating shall have physical features like high resistance to impact, abrasion and cracking, superior tensile strength (80 kg/cm² after 4 weeks at ambient temp.),and perfectly smooth, dust free, glossy finish retained at least upto3 years. It should also be resistant to acid, alkalies and have a very low water absorption rate (0.5% max. at ambient temp. after 7 days).

The packs shall not be older than 9 months after the date of manufacture and packing

5.13.3 Workmanship

5.13.3.1 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.

5.13.3.2 Primer Coat

It shall consist of 2 pack polyurethane. Primer coat shall be mixed in the ratio as per manufacturer's specification. A single coal of this primer shall be applied by brush over the prepared bed as an adhesion coat.

The primer shall be allowed to dry for a min. of 8 hrs. time before the successive finishing coats are applied Finishing coats:

5.13.3.3 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.

5.13.3.4 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).

5.13.4 Guarantee

The applicator shall execute a form of Roofing Treatment Guarantee.

5.14 Plastering and Pointing

5.14.1 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.

5.14.2 Materials

5.14.2.1 Cement

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

5.14.2.2 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.

5.14.2.3 Water

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

5.14.2.4 Cement Mortar

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

5.14.3 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 5.14.2.4 above.

5.14.4 Workmanship

5.14.4.1 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.

5.14.4.2 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 5.14.4.1 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.

5.14.4.3 Scaffolding/Staging

Scaffolding/staging for plastering/pointing shall be as per specification under Brick Masonry, Clause no. 5.8.6 of Specification.

5.14.4.4 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.

5.14.5 Plain Cement Plaster

5.14.5.1 Preparation of Mortars

The mortars of specified mix shall be used as per the specifications of "Cement Mortar" described in Clause 5.14.2.4 above.

5.14.5.2 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 5.14.5.2. 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.

5.14.5.3 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.

5.14.6 Sand Face Plaster

5.14.6.1 Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in Clause 5.14.2.4.

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 5.14.5.2 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 5.14.5.3.

5.14.7 Exposed Aggregate Finish Plaster

5.14.7.1 Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in Clause 5.14.2.4. 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.

5.14.7.2 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 5.14.5.2.

Top layer shall be 20 mm thick admixture of white cement and grey cement (mix. ratio 1:1 by volume) mixed with while/coloured marble chips/pebbles of 6mm to 12mm nominal size as per item description. Mix ratio shall be 1cement: 1 marble chips/pebbles by volume Marble dust @ 15% by volume shall be added to the admixture. The pebbles to be used shall be well washed and drained. The admixture shall be thrown wet on to the under layer while it is still plastic using strong whipping motion at right angles to the 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 battens of 12mmx x 25mm size over the under layer.

The top layer admixture pressed flat over the underlayer filling uncovered parts by hand, so that the finished surface represents a homogeneous surface. Loose mortar etc. on the top surface shall be cleaned/removed by brushing/washing /spraying with water jet after initial setting of mortar.

5.14.7.3 Curing

Curing shall be as described above in Clause No. 5.14.5.3.

5.14.8 Pointing

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

5.14.8.1 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 5.14.2.4.

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 5.14.5.3

5.15 Floor Finishing

5.15.1 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 insitu 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

5.15.2 Cement Concrete Flooring General

5.15.2.1 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.

5.15.2.2 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.

5.15.3 Cement Concrete Granolithic Flooring

5.15.3.1 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.

5.15.3.2 Workmanship

Workmanship shall in general conform to IS : 5491.

Sub-base

Refer Clause 5.15.2.2 above.

Base Course (under-layer)

Refer Clause 5.15.2.2 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 5.15.2.2 above.

Curing

Refer Clause 5.15.2.2 above.

5.15.4 Heavy Duty Flooring

5.15.4.1 General

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

5.15.4.2 Workmanship

Sub-base

Refer Clause 5.15.2.2 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 5.15.2.2 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.

5.15.5 Precast Hydraulically Pressed Cement Tiles Flooring

5.15.5.1 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 apprd. shade.

Pigments

Pigments to be admixed with mortar or for grouting shall conform to Table 1 of IS 2114.

Cement Mortar

Cement mortar shall be of specified mix and thickness and shall be in accordance with Clause 5.15.2.1 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.

5.15.6 Cement Plaster Skirting

5.15.6.1 Material

Cement plaster skirting shall be laid with cement mortar as per Clause 5.8.2.1 specification under Brick Masonry Work and shall be of specified proportion and thickness.

5.15.6.2 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 5.14.4.1, 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.

5.15.7 Cast-In-Situ Terrazzo Flooring

5.15.7.1 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 specified which shall be of 10mm nominal size. Marble powder to be used in terrazzo topping shall pass through IS Sieve Terazzo. Marble chips shall be hard, sound, dense and homogenous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. All proportions of Materials used should be as directed by the Employer described in the item.

Pigment

Pigments to be used in Terrazzo shall be of permanent colour and shall conform to IS-2114, Table-1.

5.15.7.2 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 5.15.7.2. 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.

5.15.8 Cast-In-Situ Terrazzo Skirting and Dados

5.15.8.1 Material

Refer Clause 5.15.7.1 above.

5.15.8.2 Workmanship

Cast-in-situ Terrazzo in skirting and dado shall be of specified thickness and of same shade as 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 5.15.7.2 above. Other details shall be same as for flooring excepting grinding which shall be manual.

5.15.9 Precast Hydraulically Pressed Terrazzo Tile Flooring

5.15.9.1 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 5.15.7.1 above.

Cement Mortar

Refer Clause 5.15.5.1 above.

5.15.9.2 Workmanship

Refer Clause 5.15.8.2 above.

Curing

Refer Clause 5.15.7.2 above.

Grinding and Polishing

Refer Clause 5.15.7.2 above.

5.15.10 Terrazzo Tiles in Risers of Steps, Skirting and Dado

5.15.10.1 Material

Terrazzo Tiles

Same as in Clause 5.15.9.1 above. The average thickness of tiles shall however be 20mm.

Pigments

Same as in Clause 5.15.7.1 above.

Cement Mortar

Same as in Clause 5.15.5.1 above.

5.15.10.2 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 Sq.M. 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 5.15.7.2 above.

5.15.11 Glazed Tiles Work

5.15.11.1 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 5.15.7.1 above.

Cement Mortar

Same as in Clause 5.15.5.1 above.

5.15.11.2 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 5.15.7.2 above.

5.15.12 Glazed Tiles in Risers of Steps, Skirting and Dado

5.15.12.1 Materials

Same as in Clause 5.15.11.1 above.

5.15.12.2 Workmanship

Same as in Clause 5.15.11.2 above.

Curing

Same as in Clause 5.15.7.2 above.

5.15.13 Kota Stone Flooring

5.15.13.1 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.

5.15.13.2 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 gently 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 properly 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 5.15.7.2 mentioned above except that cement slurry shall not be applied on the surface before each polishing.

5.15.14 Kota Stone in Risers of Steps, Skirting and Dado

5.15.14.1 Materials

Same as in Clause 5.15.13.1 above.

5.15.14.2 Workmanship

Same as in Clause 5.15.13.2 above.

Curing, Polishing and Finishing

Refer Clause 5.15.7.2 above.

5.15.15 Marble Stone Flooring

5.15.15.1 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 5.15.7.1 above.

Cement Mortar

Same as in Clause 5.15.5.1 above.

5.15.15.2 Workmanship

Same as in Clause 5.15.13.2 above.

Curing

Same as in Clause 5.15.13.2 above.

Polishing and Finishing

Same as in Clause 5.15.7.2 above.

5.15.16 Marble Stone in Risers of Steps and Skirting

5.15.16.1 Materials

Same as in Clause 5.15.15.1 above.

5.15.16.2 Workmanship

Same as in Clause 5.15.13.2 above.

Curing, Polishing and Finishing

Same as in Clause 5.15.7.2 above.

5.15.17 P.V.C. Flooring

5.15.17.1 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.

5.15.17.2 Workmanship

Preparation of Base

The preparation of sub-base and base course shall be same as in Clause 5.15.2.2.

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.

5.15.18 Acid Resistant Tiles in Floors

5.15.18.1 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	$\pm 0.5\%$	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

5.15.18.2 Workmanship

The base course shall be in accordance with Clause 5.15.2.2 and background surface shall be prepared as per Clause 5.15.13.2 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.

5.15.19 Epoxy Floor Coating

5.15.19.1 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.

5.15.19.2 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.

5.15.19.3 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

5.16 Painting

5.16.1 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 whiting for paint and putty.
- IS 427 Distemper (dry), colour as required.
- IS 428 Distemper (Oil Bound), colour as required.
- IS 5410 Cement paint, colour as required.
- IS 384 Brushes, paints and varnishes, flat
- IS 486 Brushes, sash, tool, for paints and varnishes.
- IS 110 Ready mixed paint, brushing, grey filler enamels for use over primers.
- IS 426 Paste filter for colour coats.
- IS 345 Wood filler, transparent liquid.
- IS 3585 Ready mixed paint, aluminium brushing priming water resistant for wood work

5.16.2 White Washing

White washing in general shall conform to IS 6278.

5.16.2.1 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 sq. m. in area shall be made good with material similar to that of the surface. Surfaces affected by efflorescence, moss, fungi, algae, lichen etc. shall be treated in accordance with IS 2395.

Preparation of White Wash

The fat lime 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 ultramarine 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.

5.16.3 Colour Washing

5.16.3.1 Workmanship

Scaffolding

Scaffolding shall be as per Clause 5.16.2.1 above.

Preparation of Surface

Refer Clause 5.16.2.1 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 5.16.2.1. 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 5.16.2.1.

Protective Measure

Same as in Clause 5.16.2.1 above.

5.16.4 Dry Distempering

5.16.4.1 Workmanship

Scaffolding

Same as in Clause 5.16.2.1 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 5.16.2.1.

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 atleast 48 hours, the surface shall 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 5.16.2.1 above.

5.16.5 Oil Bound Distempering

5.16.5.1 Workmanship

Scaffolding

Same as in Clause 5.16.2.1 above.

Preparation of Surface

Preparation of surface shall in general be in accordance with above Clause 5.16.4.1 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 5.16.2.1 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 atleast 24 hours between consecutive coats to permit proper drying of the preceding coat.

The finished surface shall be even and uniform without patches, brush marks drops etc. Application of a coat in each room shall be finished in one operation.

14 cm. double bristled distemper brushes shall be used. After each days work/brushes shall be thoroughly washed in hot water with soap solution and hung down to dry.

Protective Measures

Same as in Clause 5.16.2.1 above.

5.16.6 Waterproof Cement Paint

5.16.6.1 Workmanship

Scaffolding

Same as in Clause 5.16.2.1 above.

Preparation of Surface

Preparation of surface shall be in accordance with Clause 5.16.2.1. 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 manufacturers recommendation. The paint shall be mixed in such quantity which can be used up within an hour of mixing to avoid setting and thickening of the paint.

Application of Paint

The surface shall be treated with minimum two coats of waterproof cement paint. No less than 24 hours 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 or 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 5.16.2.1 above.

5.16.7 Acrylic Emulsion Painting

5.16.7.1 Workmanship

Scaffolding

Same as in Clause 5.16.2.1 above.

Preparation of Surface

Same as in above Clause 5.16.5.1 under specification of oil bound distempers

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 5.16.2.1 above.

5.16.8 Acrylic Copolymer Aggregate Finish

5.16.8.1 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 smoothed, if the specified finish requires, by a plastic trowel.

5.16.9 Painting to Woodwork

5.16.9.1 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 smoothed off with abrasive paper used across the grain prior to painting, with the grain prior to the staining. Any knots, resinous, or bluish sap wood, cutting out of which is not justified shall be covered with red lead conforming to IS 103.

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

Particle boards surface shall be filled with a thin brushable filler and finished as for solid wood.

Priming

Priming shall be in accordance with IS 2338 (Part I and II). Dirt or any other extraneous material on the surface shall be removed and the priming shall be applied by brushing.

Priming shad be done on all exposed and unexposed surfaces. Unless specified otherwise, all joinery work intended to be painted shall receive atleast 2 coats of primer.

Type of primer shall be in accordance with Table-1 and Table-2 of IS 2338(Part-II).

Stopping and Filling

Stopping and filling shall be done after priming. Stopping shall be made to the consistency of stiff paste and shall be used to fill holes and cracks. Filter shall be used to level up slight irregularities of the surface. Filler shall be applied with a putty knife and subsequently rubbed down to a level surface with abrasive paper.

The filler coat shall be allowed to fully flatten and harden before subsequent coat is applied.

Application of Under Coat

Under coat shall be applied after the surface has been primed, stopped and filled, and rubbed down to a smooth surface. Under coat may be brushed or sprayed. After drying the coat shall be carefully rubbed down and wiped clean before the next coat is applied.

The type of under coat shall be depending upon the finishing and in accordance with Table-1 and Table-2 of IS 2338 (Part 11).

Finishing

The finishing paint shall be as specified in the item description and shall be applied either by the brush or by spraying.

Reference shall be made to the Table-1 and Table-2 of IS 2338 (Part-II)

Application of Clear Finishes

For the application of 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 smoothed 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.

5.16.10 Painting To Steel and Other Metal Surface

5.16.10.1 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.

5.16.10.2 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.

5.16.10.3 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.

5.17 Sanitary and Plumbing Works (Buildings)

5.17.1 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.

5.17.2 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.

5.17.3 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.

5.17.4 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 authority.

The Contractor shall be responsible for getting the entire installation approved by the authorities concerned as required and shall bear expenses if any, in connection with the same.

5.17.5 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 exist.

All equipment that require repairing shall be immediately serviced and repaired.

5.17.6 Water Supply

5.17.6.1 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 be 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 24 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.

5.17.6.2 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.

5.17.6.3 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.

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

Cutting, threading and jointing – Ref. Clause 5.17.6.1.

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.

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

5.17.7.1 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.

5.17.7.2 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.

5.17.7.3 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.

5.17.7.4 Jointing

a) All joints for CI soil waste and vent pipes conforming to IS:1729/IS:3989 shall be made with maleable pig lead and spun yard. Pig lead shall conform to IS:782 for caulking. Spun yard shall be of hemp and of good quality. It shall be soaked in hot coal-tar or bitumen and cooled before use. The quantity of lead to be filled per joint in various sizes of cast iron drainage pipes shall be as follows:

- 50 mm dia = 0.75 kg.
- 80 mm dia = 0.80 kg.
- 10 mm dia = 0.90 kg.

- 150 mm dia = 1.60 kg.

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.

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

5.17.8 Sanitary Fixtures and Fittings

5.17.8.1 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.

5.17.8.2 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.

5.17.8.3 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.

5.17.8.4 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-syphonage vent horn.

A low level earthenware cistern conforming to IS:774 of about 10 litres capacity, with 15 mm dia PVC inlet pipe and brass union with wiped solder joint, internal overflow arrangement, 40 mm dia CP brass flushing pipe, CI or MS supporting brackets shall be fixed with the water closet. The closet shall be fixed firmly in the floor with matching cement mortar. All exposed metallic surface shall be painted with two coats of white enamel paint of approved quality over a coat of primer. The cistern shall be fixed at a height not exceeding 300 mm between the top of the pan and the underside of the cistern.

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 conforming 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.

5.18 Water Supply and Distribution System

5.18.1 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 ships and buildings and the supply of raw water for landscaping and greenery.

5.18.2 Material

5.18.2.1 Pipe

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

5.18.2.2 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.

5.18.3 Execution

5.18.3.1 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 relaid. Pipe shall not be laid in water or when trench conditions are unsuitable for the work. Water shall be kept out of the trench until joints are complete. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no trench water, earth, or other substance will enter the pipes or fittings. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored.

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.

5.18.3.2 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.

5.18.3.3 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 Myanmar.

5.19 Masonry Boundary Wall

5.19.1 General

This section of the specifications includes the requirements for furnishing and installing of masonry boundary wall and barbed wire fencing Y shape on top of the wall and appurtenances as required providing a complete security system.

5.19.2 Materials

Refer specifications under 'Materials'.

5.19.3 Workmanship

The purpose of fencing is to provide a solid uninterrupted stone masonry boundary wall around the port area, and keeping only openings being the road.

Stone boundary wall shall be erected and installed by professional organization who are regularly engaged in this business, employing skill labour in this type of work to provide a complete security fencing system.

Refer to specifications under Plain and Reinforced Concrete for the different concretes and reinforcing steel for the construction of the boundary wall. Refer to specifications under Stone Masonry Work for the construction of the boundary wall. Refer to specifications under Structural Steel Work for the construction of the fence and appurtenances as required.

5.19.4 Construction

The Contractor shall submit for approval shop drawings of fencing, and appurtenances and shall not proceed with abreaction and installation thereof prior to approval by the Employer. The location and

alignment of the boundary wall shall be planned by the Contractor with the approval of the Employer. The wall shall be able to withstand the collision of vehicle with a speed of 10 km/hr.

The masonry boundary wall shall have stone masonry foundation with cement mortar 1:4 (1 cement: 4 coarse sand) on lean mix concrete 1:3:6 (1 cement: 3 coarse sand: 6 aggregates) base. Minimum height of the wall shall be 2.4 m. Reinforced Concrete (Grade M-25) coping beams shall be constructed on top of stone masonry wall. Barbed wire fencing Y shape on top of the wall with minimum height of 1.0 m shall be provided. Expansion joints shall be provided at 30 m centre to centre.

Barbered wire shall be fastened to the Y angles with wire ties at adequate spacing. Painting to the masonry boundary wall and structural steel shall be as per specifications under painting.

5.19.5 Clean Up & Repair

Upon completion of the masonry boundary wall, the Contractor shall clean all soiled places and repair the damages if any to the satisfaction of the Employer.

5.20 Berth Appurtenances

5.20.1 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

5.20.2 Fenders

Suitable type of fenders of Trelleborg make or any other equivalent fenders shall be used. The face of the new fenders shall be in line with the face of the existing fenders of the adjacent jetties both at Sittwe and Paletwa.

The supplier of the fenders should be actively involved in erection of fenders.

5.20.2.1 General

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 DUMBBEL L	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
ABRASIVE WEAR	JIS K6264	AKRON METHOD	1.5CC MAX	D5963- 04	BS ISO 4649	DIN 53516

PROPERTY	TEST STD & CONDITION		CRITERION	EQUIVALENT INTERNATIONAL STD		
				ASTM	BS ISO	DIN
					BS 903 A9	
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 (23°C) - Min 300 kg.sq. cm ASTM 638

Water absorption (weight change) -Max 3%

Chemical resistance to 10% NaCl -Max 1%
(weight change)

Elongation (23°C) -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 authority of the Employer.

5.20.2.2 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 ± 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.

5.20.2.3 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

5.20.2.4 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.

5.20.2.5 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.

5.20.2.6 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.

5.20.2.7 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.

5.20.2.8 Dimensions

Fenders shall meet manufacturer's specified dimensional tolerance.

5.20.2.9 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.

5.20.3 Bollards

5.20.3.1 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.

Jetty should have bollards at both corners. The Contractor shall provide bollards of suitable type at all locations of IWT jetty and Port jetty at Sittwe and for IWT jetty at Paletwa .

Painting and numbering of the bollards shall be done.

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

5.20.3.3 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.

5.20.3.4 Specifications for Casting

5.20.3.5 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, uniformity, correct grain size to develop shock resistance properties and to avoid any blow-holes.

5.20.3.6 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.

5.20.3.7 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.

5.20.3.8 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

5.20.3.9 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.

5.20.3.10 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.

5.20.3.11 Testing

5.20.3.12 Test Sample

All test samples shall be cast in the presence of the Employer or his representatives and shall be tested in his presence.

The test samples shall be cast separately from the casting. The test sampling shall be cast from moulds of the same material, which is used for casting and shall be poured at the same time and from the same melt as the casting they represent. The samples shall be treated along with the casting they represent.

The test samples shall be provided to the extent of 2% of the number of casting from each melt but in no case less than two samples per melt. When a casting is made from more than one melt, at least four tensile tests and four bend tests shall be made from samples situated as far apart as possible in the casting. Some of the test samples shall be taken as near the top and others from as near the bottom of the casting as is practicable.

The test samples shall be stamped in presence of the Employer so as to identify the casting to which they relate.

5.20.3.13 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, batchwise, 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.

5.20.3.14 Bolts, Nuts and Washers

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

5.20.3.15 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.

5.20.4 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.

5.20.5 Rubbing Strip

Galvanised iron rubbing strip complete in all respects shall be provided in all the berths suitably. Painting of the same shall be done.

5.20.6 Edge Angles

Galvanised iron edge angles shall be provided at the edges as necessary for all the jetties and painting of the same shall be done.

5.20.7 Drain Holes

For Jetties and Approach, 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.

5.20.8 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 supplied with the mooring rings for fixing to the berth face.

5.20.9 Expansion Joints

Expansion Joint shall be provided wherever necessary to the satisfaction of the Employer.

6.0 SPECIFICATION – EQUIPMENT

6.1 Mobile Harbour Crane

Mobile harbour cranes (MHC) on quay are required as a ship-to-shore handling facility. 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 cranes shall be equipped with automatic spreader for handling containers from the design vessels. The proposed technical specifications are given in **Table 6.1** and **Table 6.2** and typical details of MHCs are shown in **Figure 6.1** and **Figure 6.2**. Mobile harbour crane LHM 425 is suggested at Sittwe jetties and LHM 180 is proposed at Paletwa IWT jetty. However, the Contractor can supply alternative model and make of mobile harbour cranes confirming to the Employer's requirements and specifications.

Table 6.1 Technical Specification for MHC at IWT Jetty Paletwa

S.No	Description	Requirement
1.	Crane Capacity	30.8 T @ 21 m Outreach (Container Operation)
2.	Min. to max. outreach	9 m - 35 m
3.	Above quay at minimum radius	42 m
4.	Above quay at maximum radius	19 m
5.	Below level quay	12 m
6.	Uniformly distributed load	Maximum 1.36 T/m ²
7.	Max. load per tyre	Maximum 5.2 T
8.	Height of boom fulcrum	12.5 m
9.	Tower cabin height (eye level)	17.6 m
10.	Hoisting / lowering	0 - 90 m/min
11.	Slewing	0 - 1.6 rpm
12.	Luffing	0 - 83 m/min
13.	Travelling	0 - 5.4 km/h

Table 6.2 Technical Specification for MHC at Sittwe

S.No	Description	Requirement
1.	Crane Capacity	31.3 T @ 42 m Outreach (Container Operation)
2.	Min. to max. outreach	10.5 m - 48 m
3.	Above quay at minimum radius	44 m
4.	Above quay at maximum radius	29 m
5.	Below level quay	approx. 14 m
6.	Uniformly distributed load	Maximum 1.4 T/m ² (Container)
7.	Max. load per tyre	5.8 t
8.	Height of boom fulcrum	17.8 m
9.	Tower cabin height (eye level)	23.8 m
10.	Hoisting / lowering	0 - 120 m/min
11.	Slewing	0 - 1.6 rpm
12.	Luffing	0 - 85 m/min
13.	Travelling	0 - 5 km/h

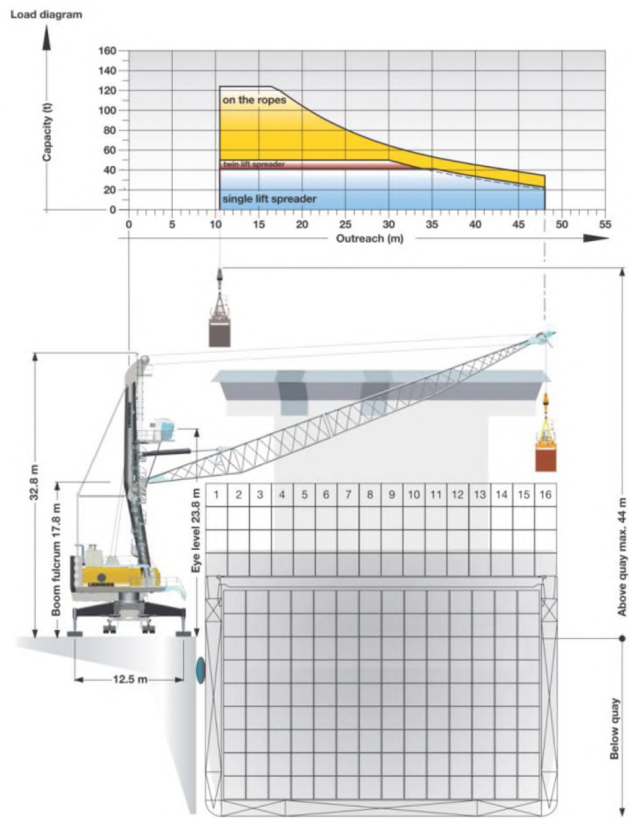


Figure 6.1 Typical details of MHCs (LHM 425, 84T, C-version)

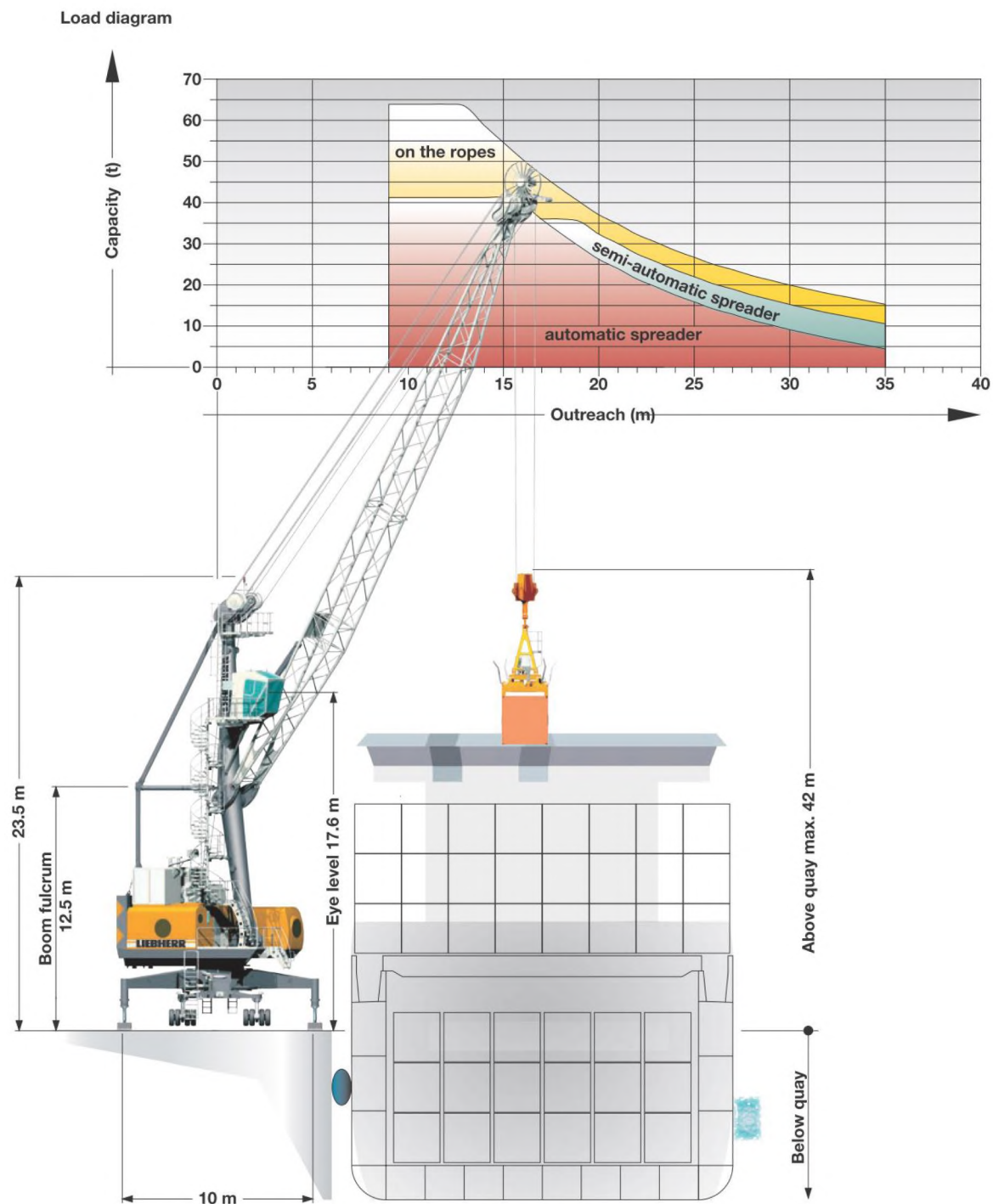


Figure 6.2 Typical details of MHCs (LHM 180, 42T, 4 rope, S-version)

6.1.1 General

The equipment specified herein shall be designed and built for Container Handling on a regular basis, at Jetties at Sittwe and Paletwa, Myanmar.

The Scope of Work is for the engineering, design, manufacture, delivery to site, installation, testing and commissioning up to handing over of the mobile harbour cranes with initial fill of fuel, lubricants and other necessary consumables.

- 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 meet the operational requirement.
- All works incidental to the above including additions, substitutions and modifications, if any are also covered in Scope.
- Tenders based on International sources shall have due consideration for maximizing components, which have service / support in Myanmar. Tenderers shall list out the availability of such facilities and the details of such arrangements in the event of award.
- Being standard equipment the actual features may contradict in specific cases with these specifications. The Tenderer may indicate such contradictions in the List of Deviations with brief explanation note against each deviation.
- 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.
- Supply of all engineer and labour for design, manufacture, delivery, installation, testing and commissioning of equipment, including transportation, as required, housing, security, temporary sanitation and safety requirements, up to handing-over of equipment.
- All consumable materials including filters, lubricants, hydraulic fluids, battery fluids, electrical fuse, temporary loads up to equipment handing-over.
- Proper safe storage of all equipment and materials delivered at site, in areas designated by the Engineer / Employer in line with customs regulations, if applicable.
- Manuals for installation, operation, maintenance spares, along with drawings/ sketches and schematics as required.
- Training of Employer's personnel on operation and maintenance.
- Supply of spare parts as required up to commissioning and load test and recommended spares for two years operation after commissioning.

6.1.2 Stability and Safety

The equipment shall be stable in all conditions, free on wheels (while not handling) and / or pads (while handling).

The slewing superstructure consisting of boom, counterweight, connecting structural elements shall comprise a completely stable self-supporting structure seated on the undercarriage.

The equipment design shall ensure stability for all conditions including when the boom rests horizontal, or by failure of the luffing motion or any other circumstances when standing on stabilising pads.

6.1.3 Operating Safety

Guards or shrouds shall be designed to prevent injury to persons and shall be provided to every dangerous part of the equipment normally accessible to personnel. They shall be designed to form part of the equipment and shall not in themselves create hazards.

Guards or shrouds shall be provided to prevent accidental contact by persons or parts of clothing being caught in equipment.

It shall be possible to inspect brakes for adjustments, lining wear, etc., without prior removal of break guards being necessary.

Name plates, warning signs or other data affixed to drive components shall not be obliterated or covered by parts of the guards/shrouds.

Since the equipment is a standard crane, safety criteria, if different from the specification, shall be spelt out in the offer as deviation.

6.1.4 Design Features for Maintenance

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 relative to one another.

All walkway and stairways shall be minimum 750mm clear width unless otherwise specified.

All structural steel surfaces intended for access shall be treated with proprietary approved non-slip surface.

Stairways shall be of uniform slope and stair treads shall be hot dip galvanized grating with floor plate nosings.

Hand railing shall preferably be of tubular section with all joints seal welded.

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. Travelling truck wheels, 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 shall be provided for personnel carrying out inspection and maintenance. All replaceable components shall be accessible either to a maintenance hoist provided on board or to mobile cranes from ground level.

Means shall be provided to facilitate the replacement of pivot, wire ropes, slewing assembly, etc. and provision shall be made for anchorage and fixing of the boom and other assemblies for the purpose of hoisting and/or jacking when removing pivot pins, slewing assembly etc. and carrying out other maintenance operations.

6.1.5 Erection and Installation

Erection at site as far as possible shall be limited to minimum. Reeving of wire rope, fixing of small items and in case of bigger crane, basic counterweight with super structure engine to be installed may be installed at site.

All other items are expected to arrive at site in fully assembled condition.

6.1.6 Surface Treatment and Protective Coatings

6.1.6.1 General

All structural steel components need to be protected permanently and effectively against any formation of rust thus avoiding weakening of the cross-sections. Protection against corrosion shall be achieved by painting. The paint coating is effective only if it adheres completely and permanently to the steel surfaces and if the paint resists quick wear.

6.1.6.2 Preparation of Surfaces for Painting

All surfaces of components to be painted 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 or shot. Use of scraper wire brush and pig hammer is acceptable wherever blasting with sand is not possible due to lack of access.

The thoroughly cleaned surfaces shall receive the paint within 6 hours following the removal of rust. If this period of 6 hours is not observed, due to any reasons whatsoever, the surfaces intended to be painted shall have to receive a new cleaning by sand blasting before the coat of paint is applied.

Any removal of rust adherent to steel surfaces by means of chemical solvent is prohibited.

Subsequent to the removal of rust, oil and grease deposits shall be removed with chemical solvents. Wet surfaces shall be dried and painting shall generally be done immediately after cleaning.

Welding areas shall not be painted until after the completion of welding operations.

However, wherever welding has to be carried out after erection at site, the shop coat of paint shall be removed thoroughly unless specifically permitted because of use of appropriate electrodes and paints, before welding and the adjoining steel surface including welding area shall be repainted after proper cleaning as specified herein.

In case of interrupted welding seams, the front points shall be thoroughly cleaned from rust.

The surfaces intended to be painted shall be inspected and approved by the Employer prior to painting.

6.1.6.3 Specifications of Painting

Two coats of epoxy base zinc rich primer (92% zinc on dry film) shall be applied by airless spray. The dry film thickness of two coats shall be 60 microns minimum.

Internal surfaces of box girders shall also be painted with two coats of zinc rich primer (two coats of 60 micron total film thickness).

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 by airless spray to establish an enduring 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.

Total dry film thickness for the system to be 260 microns minimum.

For steel work intended to be painted only at site, a primary coat of Red Oxide Zinc Chromate shall be given at the shop before despatch as a temporary protection.

6.2 Reach Stackers

Reach stackers are required for the handling of containers at yard area. These shall be equipped with a diesel engine as a prime mover for operation and travelling. Two numbers of reach stackers are required at both Sittwe and Paletwa terminals for handling the anticipated traffic. The proposed technical specifications are given in **Table 6.3** and typical details are shown in **Figure 6.3**. Reach stackers LRS 545-31 is suggested. However, the Contractor can supply alternative model and make of reach stackers confirming to the Employer's requirements and specifications.

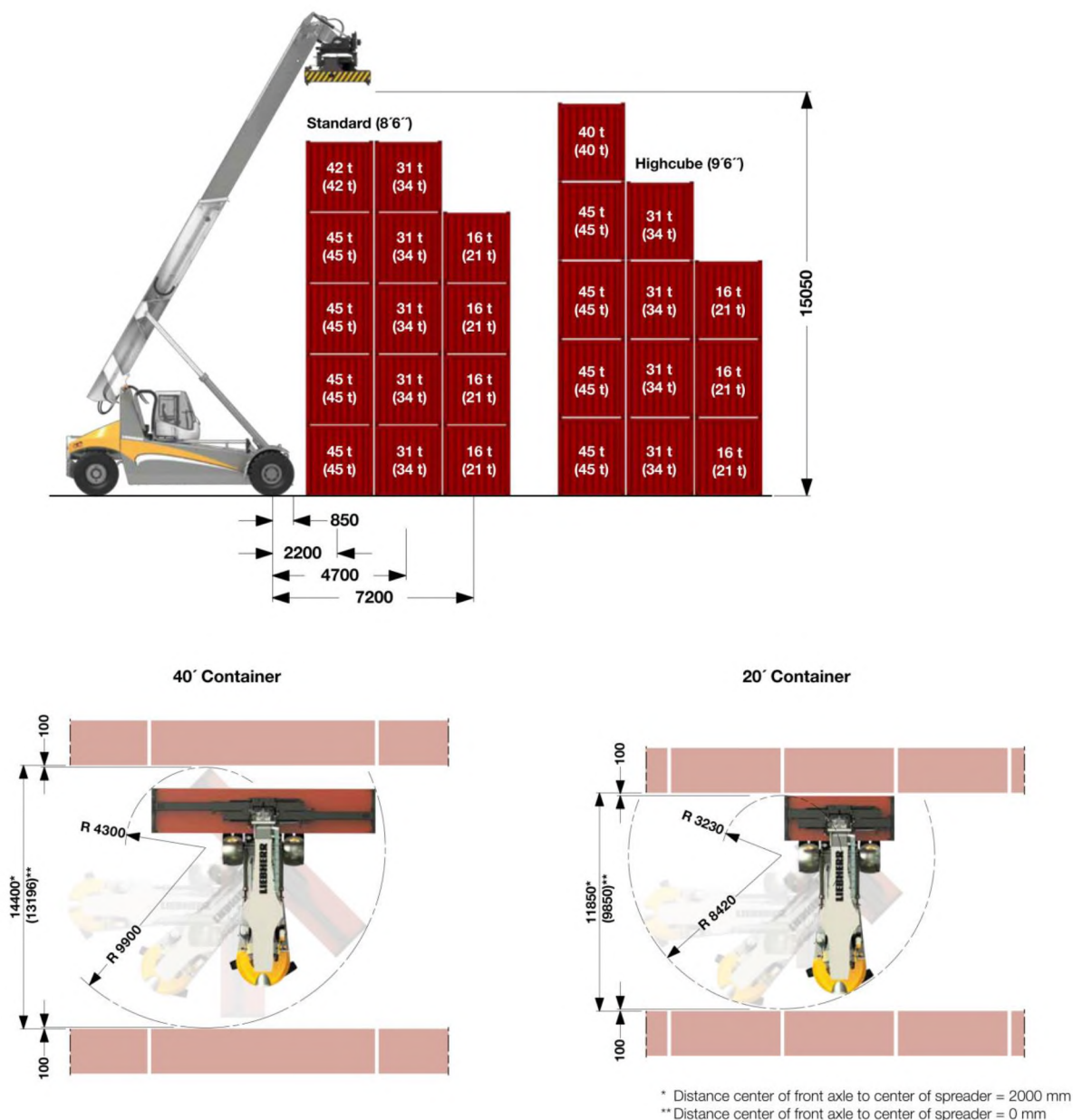


Figure 6.3 LRS 545-31 Lifting and Manoeuvring Capabilities

Table 6.3 LRS 545-31 Toplift Technical Specification

S.No	Description	Requirement
1.	Lifting Capacity (row 1 / 2/ 3)	45 T/ 31 T/ 16 T
2.	Lifting Capacity with supporting plate (row 1 / 2/ 3)	45 T/ 34 T/ 21 T
3.	Stacking height – 8'6" container (row 1 / 2/ 3)	5 / 5 / 4
4.	Stacking height – 9'6" container (row 1 / 2/ 3)	5 / 4 / 3
5.	Max. lifting height under twistlock (row 1 / 2)	15050 mm / 13300 mm
6.	Boom angle (min. / max.)	° 0 / 60.3
7.	Boom height (min. / max.)	4980 mm / 17800 mm
8.	Min. ground clearance	300 mm
9.	Drive speed* (unladen / laden)	25 / 20 (km/h)
10.	Lifting speed (unladen / laden)	0.40 / 0.25 (m/s)
11.	Lowering speed (unladen / laden)	0.40 / 0.40 (m/s)
12.	Spreader type	Toplift
13.	Spreader width (min. / max.)	6050 mm / 12175 mm
14.	Spreader side shift	+/- 800 mm
15.	Spreader rotation	° -105 / +195
16.	Mechanical pile slope (mechanical levelling)	° +/- 3
17.	Turning Radius (20ft/ 40ft)	8420 mm/ 9900 mm

6.3 Internal Transport Vehicles (ITVs)

Internal Transport Vehicles (ITVs) are required for the handling of containers from yard to jetty and vice versa. These shall be equipped with a diesel engine as a prime mover for operation and travelling. Four numbers of ITVs are required at both Sittwe and Paletwa terminals for handling the anticipated traffic. The proposed technical specifications are given in **Table 6.4**.

Table 6.4 Technical Specification of ITVs

Description	Requirement
Length	To accommodate 2 × 20' / 40'
Type	Skeletal
Capacity	50 T
Axles and Wheels	Steering Axle – 6 T (2 wheels) Middle Tandem Axle – 22 T (8 wheels) Rear Tandem Axle – 22 T (8 wheels)
Fuel for Prime mover	Diesel

7.0 SPECIFICATION – ELECTRICAL WORKS

7.1 Electrical Equipment

The scope includes Design, supply, Installation, Testing and Commissioning of Electrical, Communication, CCTV and Access Control system in complete to match the need of the operation requirement as specified in the Tender document. However specification and tentative SLD are furnished herewith for bidding purpose. Hence it is the responsibility of contractor to design the electrical system as per the load list provided by the Employer.

7.1.1 Diesel Generator (DG Set)

7.1.1.1 Scope of Work

The scope includes Design, supply, Installation, Testing and Commissioning of 1 No. of 350 kVA DG set including all accessories like control panels, power outlet panels, radiator etc at both locations. The DG set shall be supplied with separate day tank.

The work also includes supply and installing of stack as per local pollution control Board norms.

Approval from DGMS, other governing agency and approval from Electrical inspector shall be under contractor scope.

Obtaining diesel engine manufacturer approval of the installation with specific emphasis on alignment, exhaust piping and ventilation before commissioning

As built drawing, supplier test certificate, catalogues, data sheets & other detailed engineering document shall be submitted in four sets to consultant and client.

Any related work covering supply of installation materials, consumables etc. whether specified or not, to render the system fully functional and conforming to the best engineering standards.

The Bidder shall arrange for all design and civil construction works for making foundation for DG sets, Diesel tank, making trench in panel room. The design of the foundation shall be approved by the Engineer.

7.1.1.2 Design Basis

Nominal voltage : 415V +/- 10% (without AVR)

Number of Phases : 3+Neutral

Frequency : 50Hz+3%

Neutral Earthing : Solidly earthed

Control supply : 24V, 2 wire DC

7.1.1.3 Codes and Regulations

- BS 5514
- BS649
- IS1000
- IS13364
- IS1962
- ISO 8528 all parts

7.1.1.4 Component Specification

Diesel Engine

- Type : 4 strokes
- No: of Cylinders : 6 Cylinders
- Cooling : Water cooled and turbo charged Diesel Engine
- Capacity : Minimum 600BHP @ 1500 RPM under NTP conditions

Engine designed to run continuously, confirming to BS: 5514/ DIN-6271/IS 10002/ ISO – 3046 with an overload capacity of 10% for one hour in any 12 hours continuous operation.

The engine shall be complete with the following accessories:

- Heat Exchanger
- Corrosion inhibitor coolant
- Paper element filters for fuel, lube oil and by-pass
- Flywheel to single bearing alternator with housing.
- Dry type air cleaners and vacuum indicators
- PT Self Adjusting direct fuel injection system
- Silencer

- Stainless steel exhaust flexible bellows
- Electronic Control panel with digital governor suitable for synchronization.
- Electric Starter
- Battery charging alternator
- Electronic instrument panel (Displaying the following)
 - Battery Voltage
 - Coolant Water Temperature
 - Lubricating Oil Pressure
 - Engine speed
 - Engine running Hours
 - RS 485 MODBUS Communication
- Safety & Control (Trip & Indication for):
 - High Water Temperature
 - Low lube oil pressure
 - Over speed stop
 - Low engine speed
 - Low fuel level
 - High fuel level
 - High lubricating oil temperature
 - Engine jacket water temperature high
 - Engine jacket water pressure low

Air inlet system, Charging system, Control system, Exhaust system

Alternator:

Alternator conforming to BS:5000/ IS:4722 with standard design with IP 23 Protection, suitably rated at 350kVA at 0.8pf, 415 Volts, 3 phase, 4 Wires, 50 Hz., 1500 RPM, self excited (brushless)

excitation)and self regulated, Band of Voltage Regulation +/-1.5% of rated voltage (from no load to full load) and Class “H” Insulation. Alternator should be mounted on a common single base frame and coupled directly to the engine.

Alternator shall be provided with the following items.

- Continuous damper winding
- 6 numbers of RTD and one anti condensation heater wired to a separate terminal box.
- 3 phase sensing AVR with 0.5% voltage regulation
- A neutral CT of adequate ratio and class for REF relay for D.G protection
- Separately mounted adaptor box suitable for cable termination of aluminium XLPE cable of size as per approved SLD

Alternator shall further meet the following specification:

- The alternator shall be suitable for 20% over speed for 2 minutes
- The alternator shall be capable of carrying 50% overload for a duration of 1 minute.
- The alternator shall be capable of carrying 10% overload for one hour in any period of 12hours running.
- The alternator terminal voltage for any load variation should be maintained with +5%
- Both end of each phase winding shall be brought to the terminal box.
- The alternator shall withstand the 3 phase short circuit at the terminals for a period of three seconds.
- The total harmonic distortion shall not exceed 3% and the design shall permit upto 30% unbalance between phases while in operation.

Acoustic Enclosure:

The acoustic enclosure shall be of free standing, floor mounting type integral with the DG set. The enclosure shall be provided with rugged heavy duty structural steel base frame with chequered plate flooring on which DG set is to be mounted. The enclosure shall be prefabricated factory built and modular in construction, so that it can be easily assembled at site around the DG set. The enclosure shall consist of acoustically treated panels housed in rugged steel frames, which shall be bolted together to form the body of the enclosure. The construction features of acoustic enclosures are as follows.

- The acoustic panels shall be filled with a special grade high density mineral wool retained on the inside by perforated GI sheets specially designed for optimum sound attenuation.
- The outer surface of the acoustic panels shall be fabricated of performed 16G corrugated CRCA sheet steel of SAIL make only.
- All materials used for acoustic enclosure shall be fire resistant/fire retardant grade.
- The sheet steel treatment shall consist of degreasing, de rusting and phosphating followed by two coats of zinc chromate primer, followed by two coats of zinpholite surface for superior corrosion resistance and two coats of finish paint.
- Base frame shall be of Sturdy, fabricated/welded construction, made out of high quality Steel section suitable for mounting the engine and alternator. The base frame shall be suitably designed to simplify transportation, handling, slinging. It shall have provision for levelling adjustments, as required during installation.

Noise Level Outside Enclosure:

- 75 dBA at a distance of 1metre under free field condition and adhere to the guide lines of MOEF (Ministry of Environment and Forest) and CPCB (Central Pollution and Control Board) norms.
- Provision to log essential parameters at 1minutes interval shall be provided along with Optional Data logger (**to be quoted separately**)

DG LT Panel:

The panel shall be sheet steel construction and arranged for free standing, cubicle type 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. The panel shall be of dust and vermin proof.

The panel shall accommodate the following:

- Suitable Moulded Case Circuit Breaker,
- Ammeter with Selector switch
- Voltmeter with Selector Switch, 500 Volts
- Frequency Meter
- KWH Meter
- KVAR Meter

- KW Meter
- Current Transformers
- Instrument fuses
- Battery voltmeter
- Power Factor Meter
- Excitation current Ammeter
- Excitation Voltmeter

The following protection Relays shall be provided in the DG LT Panel.

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

The following protection Indication Lamps shall be provided in the DG LT Panel

- DG set on
- Load on DG set
- Start failure
- Generator over current
- Generator high voltage
- Generator low voltage
- Earth fault
- Generator winding temperature high

- High bearing temperature
- Reverse power
- Rotor diode failure

Fuel Tank:

Fuel Tank should be located nearest to the DG set enclosure to ensure free flow of Diesel. The capacity of the Fuel tank shall be **900 Litres**.

Battery:

The Battery shall be of heavy duty, high performance lead acid type of Exide make. Each Battery shall be rated 12V .The number of AH capacity shall be selected to suit the engine requirements.

The Battery shall be suitable for six successive starting attempts each of 10 seconds duration with a gap of 5 seconds between successive starts.

The Battery shall be supplied complete with electrolyte and accessories. The accessories shall include battery stand, Battery leads, with terminal ends acrylic top cover and inter battery connectors.

Lube Oil System:

Complete with cooling system, oil temperature monitor, filtration system up to 20 microns, level indicator and fume disposal system to be provided. Fuel system with primary and secondary fuel filter, fuel pump to be provided

The Supplier should attend to the Breakdowns within 24 hours of reporting the fault and put the DG set back in Operation. The supplier should provide the auto-recording Telephone number and any other contact number available for reporting the breakdown.

Training to the Staff involved in Operation & Maintenance of DG set to be imparted at site.

Painting:

The outside enclosure shall have a factory applied weather proof powder coated finish while all other structure shall have appropriate corrosion proof coating suitable for a coastal climate. Steel structures shall have a coat of zinc chromate primer and a coat of synthetic enamel paint of approved shade. The exhaust pipe/duct and stack shall have appropriate high temperature resistant paint. Any paint or coating damaged during transportation and erection shall be rectified at site to the satisfaction of the Engineer in charge.

Foundation:

The DG set shall be installed on the foundation of suitable height. Successful bidder shall determine the soil bearing capacity for designing the foundation for D.G Set. A PCC of weight 2.5times the operating weight of the Genset with enclosure or as recommended by OEM whichever is higher required to be provided. 300mm of the foundation shall be above the ground level and breadth of foundation should be at least 250mm more on all sides than the size of the enclosure. Generator set shall be mounted on anti vibration mounts inside the enclosure.

All the civil works related to the foundation shall be on contractor scope.

Inspection:

The contractor shall arrange for the inspection of the set by the diesel engine manufacturers authorised representative and obtain his approval before rolling the set.

Guarantee:

The DG set and accessories shall be guaranteed for satisfactory operation for a period of 24 months from the date of commissioning or 5000 running hours from the date of supply, whichever is earlier. Any defects noticed during this period shall be rectified free of cost. The supplier shall indicate the type of record to be maintained so that the warranty claims if any are honoured by the manufacturer.

The design and installation of acoustic treatment shall ensure that the noise level at 1m from the DG set at any point shall not exceed 75 dBA while operating the set at rated load.

Taking Over:

The client will take over the DG set for operation on completion of the following.

1. DG sets are installed, tested and commissioned as per the specification
2. Original Test certificates are furnished for Engine, alternator, acoustic enclosure etc.
3. Load trails are successfully conducted including acoustic enclosure and ventilation fan if any.
4. Necessary approval from Electrical inspectorate, DGMS and any other approvals as required are obtained.
5. 4 set of as built documentation, spare part list, maintenance chart and operation and maintenance manuals are to be submitted.
6. The set shall be handed over with first fill of Lube oil and fuel tanks full of diesel oil along with spares mentioned.
7. Engraved tally indicating the starting, paralleling instruction (if any) etc shall be provided.
8. Training to at least one Engineer and two technicians shall be provided for operation and maintenance of the DG Set.

SPARES:

The DG Set shall be supplied with the following spares.

1. Two sets of renewable part of oil, fuel & air filters.
2. Two number of Fan belts
3. Five numbers of spare fuses of each type & size used.
4. Two spare relays of each type, set of fuel injectors.
5. One number manual gear pump.

Documents:

As part of the equipment supply, the following documents shall be supplied.

1. General arrangement plan of DG set
2. Piping schematic diagram
3. Layout of fuel and exhaust piping
4. Layout and construction detail of acoustic treatment
5. Calculation for ventilation system design
6. Engine wiring Diagram
7. Test certificate for Engine and alternator
8. Installation, operation and maintenance instruction for Diesel Engine and alternator
9. Spare part list
10. Approval from Pollution control Board, DGMS and CEA

Technical Particulars of DG Set:

Details to be furnished by the Tenderer during the bid submission:

SI. No.	Description	Specification
1.	Generator KVA Rating / Model No.	350 KVA /
Engine		
2.	Make	
3.	Model No.	
4.	BHP Output	
5.	Cooling	

SI. No.	Description	Specification
6.	Aspiration	
7.	No. of Cylinders	
8.	RPM	
9.	Compression ratio	
10.	Displacement (ltrs.)	
11.	Fuel oil	
12.	Fuel consumption at no load	
13.	Fuel consumption at 25% load	
14.	Fuel consumption at 50% load	
15.	Fuel consumption at 75% load	
16.	Fuel consumption at full load	
17.	Capacity of fuel tank (litres)	
18.	Governor	
19.	Starting system	
20.	Lube oil specification	
21.	Lube oil sump capacity	
22.	Lube oil consumption (ltrs. per hour)	
23.	Coolant capacity (Engine + Radiator)	
24.	Lube oil change period (hrs.)	
25.	Emission compliance	
26.	Battery rating	
Alternator		
27.	Make and Model No.	
28.	Type	

SI. No.	Description	Specification
29.	Voltage	
30.	Frequency	
31.	Phase	
32.	Rated current	
33.	Power factor	
34.	Enclosure	
35.	Voltage regulation	
36.	Class of Insulation	
Control Panel		
37.	Make	
38.	Type	
39.	Overall dimensions (L x B x H)	
40.	Finish	
41.	Sheet metal size	
42.	Make and type of contactors / circuit breakers	
43.	Make and type of instruments	
44.	Make and type of switch fuse units	
45.	Other facilities incorporated	
Generator set		
46.	Noise level	
47.	Overall dimensions of the DG set	
48.	Overall canopy dimension	
49.	Approx. Total weight (Dry)	
50.	Type of coupling/bearing details	

7.1.2 LT Switchboard

7.1.2.1 Scope of Work:

This specification covers design, manufacture, supply, installation, testing and commissioning of L.T Switch Boards for D.G and LT Panels at Work shop, Buildings and Container Yard.

7.1.2.2 Design:

Voltage: As shown in SLD

Frequency: 50 Hz +/- 3%

Fault Level: As shown in SLD

Ambient Temperature: 50 Deg. C

7.1.2.3 Codes & Regulations:

IS 2516(Part 1) : AC Circuit Breaker requirement , voltages not exceeding 1000 Volts

IS 2516(Part 2) : AC Circuit Breaker tests, voltages not exceeding 1000 Volts

IS 4237 : General requirement for switchgear and control gear for voltages not exceeding 1000 volts.

IS 4047 : Specification for Heavy duty air break switch

IS 2208 : Specification for HRC cartridge fuses links up to 650 volts

IS 2705 : Specification for current Transformer

IS 2067 : Specification for aluminium bus bar

IS 1336 : Recommendation for colour of Push Buttons

IS 1248 : Specification for direct acting electrical instruments

IS 2147 : Degree of protection provided by enclosure for low voltage switch gear

IS 375 : Specification for marking and general arrangement for switch gears, bus bars, main connection and auxiliary wiring.

IS 722 : Specification for AC electricity meters

IS 3231 : Electrical Relays for power system protection

IS 5082 : Wrought Aluminium and aluminium alloy bars, rods, tubes and section for electrical purposes.

IS 2675 : Specification for enclosed distribution fuses board and cut outs for voltage not exceeding 1000volts.

BS3871(Part 1) : Specification for miniature circuit breaker

IEC 309-1 : Plug and socket

7.1.2.4 General Construction

This specification covers the requirements of **D.G LT Panel, Reefer LT Panel, Work shop PDB Panel** complete with all accessories. The switchgear and its components shall be designed for design ambient temperature of 50OC. Switchgear shall be designed for natural air cooling. No forced cooling is acceptable.

Short circuit withstands rating of the switchgear shall be as given in the SLD.

415V normal system shall be solidly grounded.

Bus bar, 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 of the panel 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.

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

LT Switch Boards shall be of sheet metal enclosed, cubicle type 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 following degree of protection.

- D.G LT Panel : IP 54
- Reefer LT Panel : IP 65
- Work shop PDB Panel : IP 54

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 these panels shall be from bottom.

Switchboards shall be divided into distinct vertical sections (Panels), each comprising of the following compartments:

- Main bus bar 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 ACB feeders shall be draw out type and non ACB feeders shall be fixed type. ACB 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.

7.1.2.5 Air Circuit Breakers

Air Circuit breakers shall be (TPN), 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.

7.1.2.6 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 MCCBs shall be manually operated. The operating handle should give a clear trip indication.

7.1.2.7 Control and Selector Switches

Control and selector switches shall be of rotary type, with name plates clearly marked to show the function and positions. Circuit breaker control switches shall have three positions and shall be spring return to "NEUTRAL" from "CLOSE" and "TRIP" positions and shall have pistol grip handles. Circuit breaker selector switches shall have three stay put positions marked 'Test', 'Local' and 'Remote', respectively. They shall have black spade handles. Selector switches for starter modules shall have 'Test', 'Local', 'Remote' positions as specified. Ammeter and voltmeter selector switches shall have four stay put positions with adequate number of contacts for 3-phase 4-wire system. These shall have oval handles. Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondary.

7.1.2.8 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.

7.1.2.9 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.

7.1.2.10 Indicating Instruments

All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm. square size with 240 degree linear scales, and shall have an accuracy class of 1.0. All instruments shall have white dials with black numerals & lettering. Black knife edge pointer shall be

provided for meters. Ammeters provided for motor feeders shall have a compressed scale at the upper current region to cover the starting current up to eight (8) times the CT current. No direct reading type ammeters shall be used. All such meters shall be fed through suitable Current transformers for motors rated 10kW & above. All analog type meters shall be of Moving Coil type. All Multifunction meters shall have digital display and communication port with true rms measurement facility with minimum 1% accuracy level.

7.1.2.11 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 6A at 110 V AC and 1A (inductive) at 110 V DC. 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 annunciation functions, overloads reset and miscellaneous commands.

7.1.2.12 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

7.1.2.13 Control Supply and Space Heater Supply

D.G LT Panel, Reefer LT Panel, Work shop PDB Panel shall have control transformers tapped from incoming side of the each incomer. The control circuit of the panel designed on 230V AC. 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. `

Each module the panel shall derive 230V 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.

Necessary switch and MCB to isolate and distribute the supply to each panel shall be provided. Each panel shall be equipped with the following as required:

- Thermostatically controlled space heater(s).
- Illumination lamp with door switch
- 5A 3pin socket with MCB protection.

7.1.2.14 Wiring

All switchboards shall be supplied completely wired internally up to 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 moulding. 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.

7.1.2.15 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 solder less crimping ring type conforming to IS:8309. All lugs shall be insulated / sleeved.

7.1.2.16 Nameplates and Labels

LT Switch Boards 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 stencilled 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.

7.1.2.17 Bus bars and Insulators

Each Switch Board shall be provided with three phase and neutral bus bars. All bus bars and jumper connections shall be of high conductivity aluminium/copper of adequate size. The cross-section of the bus bars shall be uniform throughout the length of switchboard. All bus bars 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 bus bar 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 bus bars shall have HR PVC 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 bus bars shall be same as that of the incomer breaker, and bus bar 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 bus bar joints shall be covered by insulating shrouds.

7.1.2.18 Earthing

A copper 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 be less than 2.5 sq.mm

7.1.2.19 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.

7.1.2.20 PAINTING:

All paint shall be applied on clean , dry surfaces under suitable atmospheric and other condition in accordance with the paint manufacturers instruction. All paints used shall be compatible with each other and capable of performance for five year in the environment specified with out any need for maintenance. The minimum standards acceptable are.

1. Cleaning by shot blasting to grade as 2.5 OF ISO 8501-1
2. All sheet steel surface shall be degreased, pickled and phosphate in accordance with IS 6005 "Code of practice for phosphating of iron and steel"
3. Immediately following phosphating the surfaces shall be painted with two coats of high quality zinc chromium primer.
4. All surfaces of coating shall be filled with approved two pack filler and rubbed down to a smooth finish.
5. Interior surfaces of terminal boxes, after preparation, cleaning and priming shall be painted with one coat of zinc chromate primer, one coat of phenolic based undercoating, followed by a final coat of phenolic based finishing paint to white colour followed by final coat of anti condensation white paint of a type an make to the approval of the project manager.A minimum over all paint thickness of 150 micron shall be maintained throughout.The first coat of primer applied on the same day, preferably within two hours of shot blasting.
6. Exterior steel surfaces and metal work after preparation and priming shall be painted with one coat of zinc chromate primer, one coat of phenolic based undercoating and two coats of iron oxide paint, then painted with a final coat of phenolic based hard glass finishing paint of the light grey shade no.631 of IS 5 to provide an overall minimum paint thickness of 200 microns.

7.1.2.21 Erection and Commissioning:

All switch gear panels shall be installed on finished surfaces. The correct level shall be ascertained before final grouting. The contractor should take at most care in delicate equipments, instruments and relays. Dragging shall be avoided as far as possible. Whenever the instruments and relays are supplied separately, they shall be mounted only after the associated control panel have been erected and aligned.

7.1.2.22 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.

7.1.2.23 Spares List

The following spares shall be supplied with each LT switch Board. The price quoted by the bidders for equipment shall include the spares listed below and no separate payment shall be made for them.

- MCBs : 2 of each rating
- MCCBs : 1 of each rating
- Indication Lights : 5 of each colour
- Cable end termination : 10 of each size being used in the panel
- ASS/VSS : 1 of each rating
- Ammeter : 1 of each rating
- Voltmeter : 1 of each rating
- CT/VT : 1 of each rating
- Panel door handle : 1 of each type
- ACB racking handle : 1 of each type
- Auxiliary relays : 1 of each type
- Auxiliary contactor : 1 of each type
- ACB Spring charge motor : 1 of each rating

7.1.2.24 Drawing and Documents

The following drawings and documents shall be furnished.

1. General arrangement drawing of the panel showing
 - Overall dimensions
 - Terminal locations
 - Total Weight
 - Foundation details
 - Section details
 - Bill of Material with make and quantity
2. Single line diagram and wiring diagram including control circuit diagram with terminal block details.
3. Technical data sheet of ACB, MCCB, Relays, Contactor, meters and other associated equipments.
4. Calculation sheet for sizing of bus bar

7.1.3 Reefer Gantry Panels

7.1.3.1 Scope

Scope shall include design, supply, installation, testing and commissioning of three number of Reefer Gantry Panels at each terminal as per the specification described below.

7.1.3.2 Description

There will be total 3 number of reefer gantry panels. The Reefer Gantry panels shall be located one at each level of Reefer Gantry. Each Reefer Gantry panel shall feed to 6 numbers of plug & socket at each level.

The successful bidder shall be responsible for the design, supply, installation, testing and commissioning of all reefer gantry panels.

The reefer gantry panel shall be provided with ingress protection in accordance with IEC 60529 Cat IP65 (minimum). The enclosure of the panel shall be manufactured from marine grade steel.

Each reefer gantry panel shall receive 3 phase, 415V, 125A Power supply from the LT panel near DG set. The reefer gantry panel shall have 125A MCCB as incomer.

Each reefer gantry panel shall have the following features. One 415V, 125A 4P MCCB Incoming switch and 8 numbers of 415V, 32A, TP MCB as shown in the drawing

The general construction and bus bar arrangement of the reefer gantry panel shall be as follows.

- The cubicle shall be sheet metal enclosed type suitable for wall mounting. It shall be totally enclosed, completely dust proof and vermin proof.
- The cubicle enclosure shall be provided with a degree of protection not less than IP65.
- The enclosure shall be suitable for use in highly saline environment.
- MCCB incomer feeder shall be 4pole thermal magnetic type release with adjustable overload and fixed short circuit setting.
- The bus bar shall be high conductivity electrolytic copper, free from sharp edges and burs.
- The sheet steel work shall be of excellent quality and shall be free from burs.
- The sheet steel used for the panel construction shall be at least 1.6mm thick.
- Phase barriers and insulating sheets shall be provided in the panel as per the general practise.
- The doors shall have gaskets made of non-ageing material to make the module dust tight. Each door shall be provided with counter sunk screws. All components hinges, gaskets used shall be suitable for the saline environment.
- Adequate space shall be available in the panel for the termination of incoming aluminium armoured cable.
- The switches, fuses etc shall be mounted on the rear plate of the module. Only switch drive, push buttons, indicating lamps, meters shall be mounted on the module door with the switch in the closed position.
- The paint thickness shall be 150microns and shall be marine grade type.
- The cable entry to the panel shall be from bottom.
- The Gland plate shall be 3mm thick
- The external paint shade shall be 631.

7.1.4 Reefer Plug & Sockets

7.1.4.1 Scope

Scope shall include design, supply, installation, testing and commissioning of Eighteen(18) number of Reefer Plug & Socket as per the specification described below.

7.1.4.2 DESCRIPTION

Plug and sockets shall be provided as per the ratings shown in the drawings. Plug and sockets shall conform to IEC 60309-1. It shall contain

- Silver tipped spring loaded contacts and temperature rise as per the above IEC.
- Metal clad/Polycarbonate type of construction
- Plug & Socket arrangement shall be push pull type
- Outdoor type with IP67
- Safety lid cover for the socket
- Safety shutter shall be provided with the socket for avoidance of insertion of wire without plug
- Earth pin should make first and break last
- Mechanical interlocking on plug insertion

Six numbers of plug and socket shall be provided in each level of Reefer Gantry. Hence totally 18 numbers of Plug and socket shall be provided. The location of plug and socket for each reefer container shall be co-ordinated with the position of the containers on the side of the reefer gantry serving the container to minimise the potential tripping Hazard of cable across the walk way.

The Plug and sockets shall be of the polycarbonate construction 415V, 32A 3P+E industrial pattern sockets (Mennekes make/Equivalent) in accordance with IEC60309. The Plug & Socket arrangement shall be wall mounting type. Each of this arrangement shall be fitted with suitably rated RCBO with 100MA leakage sensitivity. Sockets shall provide ingress protection to IEC 60529 Cat.IP67 (minimum) regardless of whether a plug is inserted.

7.1.5 Automatic Power Factor Control Panels

7.1.5.1 Scope

Scope shall include design, supply, installation, testing and commissioning of automatic power factor control panel along with 415V shunt capacitor banks as required in this specification and in Single Line diagram.

7.1.5.2 Design

Voltage: 415V

Frequency: 50 Hz +/- 3%

Fault level: 50kA

7.1.5.3 Codes & Regulations:

- IS 2834
- IS 13340-1993
- IS13341-1992
- IEC 60831-1+2

7.1.5.4 Construction

- 415 V Automatic Power Factor Control Panels shall comprise of MCCB / Switch Fuse, 1.1KV Air Break Contactor, PF Meter, Automatic PF Correction Relay with Capacitor Banks of suitable rating as indicated in the attached Single Line Diagram.
- Rating shown in the SLDs is 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 5 kVAR power step minimum. The capacitor banks ratings shall be finally selected to provide a power factor of 0.95 lag on the bus. Zero steps shall also be provided. Capacitor bank shall be double layer construction (film + paper + foil) gas impregnated type.
- The sheet steel enclosure shall be of minimum 14SWG thick CRCA sheet.
- APFC panel shall be of IP42, Indoor application.
- Free Standing Floor Mounting Non-Compartmentalized. The APFC enclosure should be compact in size for indoor application
- Provision for manual and auto mode to be provided.
- Power factor indication, digital or analog to indicate the actual system power factor.
- Power factor setting dial calibrated from 0.8 lag to 0.8 lead to be provided.
- APFC relay shall be 6 Stage Microprocessor based digital with the following features a.)APFC relay Controller should sense the KVAR required achieving preset target PF by automatically switching ON / OFF the capacitor unit or stage.

- An emergency stop type mushroom head push buttons, "Emergency OFF" shall be available to de-energise all the contactors and also switch OFF the incoming MCCB/ACB both in auto and manual mode.
- Control supply for the capacitor bank shall be tapped from the incoming side of incomer breaker.
- APFC panel shall have the following features.
 - Two tone hooter
 - Fault indication lamp
 - APFC out of circuit indication lamp.

7.1.5.5 Painting:

All paint shall be applied on clean , dry surfaces under suitable atmospheric and other condition in accordance with the paint manufacturers instruction. All paints used shall be compatible with each other and capable of performance for five year in the environment specified with out any need for maintenance. The minimum standards acceptable are.

- Cleaning by shot blasting to grade as 2.5 OF ISO 8501-1
- All sheet steel surface shall be degreased, pickled and phosphate in accordance with IS 6005 "Code of practice for phosphating of iron and steel"
- Immediately following phosphating the surfaces shall be painted with two coats of high quality zinc chromium primer.
- All surfaces of coating shall be filled with approved two pack filler and rubbed down to a smooth finish.
- Interior surfaces of terminal boxes, after preparation, cleaning and priming shall be painted with one coat of zinc chromate primer, one coat of phenolic based undercoating, followed by a final coat of phenolic based finishing paint to white colour followed by final coat of anti condensation white paint of a type an make to the approval of the project manager. A minimum over all paint thickness of 150 micron shall be maintained throughout. The first coat of primer applied on the same day, preferably within two hours of shot blasting.
- Exterior steel surfaces and metal work after preparation and priming shall be painted with one coat of zinc chromate primer, one coat of phenolic based undercoating and two coats of iron oxide paint, then painted with a final coat of phenolic based hard glass finishing paint of the light grey shade no.631 of IS 5 to provide an overall minimum paint thickness of 200 microns.

7.1.5.6 Drawing and Documents

The following drawings drawing and documents shall be submitted in two sets for consultant approval.

- Guaranteed Technical particulars
- Type Test certificates.
- General arrangement drawing of the panel showing
 1. Overall dimensions
 2. Terminal locations
 3. Total Weight
 4. Foundation details
 5. Section details
 6. Bill of Material with make and quantity
 7. Single line diagram and wiring diagram including control circuit diagram with terminal block details.
 8. Technical data sheet of ACB, MCCB, Relays, Contactor, meters and other associated equipments.
 9. Calculation sheet for sizing of bus bar

7.1.6 Lighting System

7.1.6.1 Scope

Scope shall include indoor and outdoor lighting design, supply, installation, testing and commissioning of lighting system in complete to match the required illumination level as indicated in the specification. Building lighting design and area lighting design shall be done by the contactor and submitted for Engineers approval.

7.1.6.2 Standards

The design, manufacture, erection, testing and commissioning shall comply with the latest issue of the following standards and rules.

- | | |
|---------|--|
| IS 9537 | : Specification for Rigid PVC conduit for electrical wiring |
| IS 694 | : PVC insulated cables with copper conductor for voltage up to and including 1100V |
| IS 732 | : Code of practice for electrical wiring and installation |
| IS 1646 | : General code of practice for fire safety of building electrical installation |
| IS 3043 | : Code of Practice for earthing |

IS3646	: Code of Practice for internal illumination
IS 4615	: Switch socket outlets
IS 3854	: Switches for domestic and similar purposes
IS 5133	: Boxes for enclosure of electrical accessories
IS 1644	: Code of practice for personal Hazard for safety of building
CIE 129:1998	: Technical Report, Guide for lighting of Exterior work area

7.1.6.3 Lighting System Specification

This specification covers the requirements of Illumination system.

The lighting system includes

- 100% Normal AC lighting
- 20% High Mast Lighting and other Lightings 100% on DG set
- Emergency lighting through battery backed PL lamps in selected areas of the plant during plant emergency conditions.

Normal AC Lighting shall be energised from 3-phase, 4-wire, 415 V main DG LT Panel. D.G LT Panel feeds to Lighting Panel-1 and Lighting Panel-2. These lighting panels' further feeds to Lighting Distribution Boards (LDB) for each individual area. Emergency lighting shall be provided in specific areas such as D.G Room, Work shop Building, Areas near local panels, staircases and other strategic areas during AC supply failure. Emergency lighting shall normally be "off," and upon loss of normal AC supply, emergency lights shall be turned "on" in auto mode. Emergency lighting units with integral batteries shall be used. Emergency lighting unit shall provide light for four hours when the normal power source is lost. Each emergency light unit shall be provided with battery, battery charger and two numbers 10 watt fluorescent lamps. Exit light fixtures shall be compact fluorescent and shall be provided in all the Building at exit doors.

HPSV/HPMV/Fluorescent/ Incandescent lamps shall be used as light sources in the lighting system. Fixtures considered shall be energy efficient type with low loss ballast & low harmonics with higher lumen / watt.

Emergency lighting luminaries shall be supplied to ensure a safe exit in the case of power failure. Enclosure shall be of weather & dust-proof construction and consist of cast aluminium body with polycarbonate diffuser, 1x13 W fluorescent tubes, integral transistorized control gear, charger and 24V battery. Each shall be connected to the 230 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 1.5 hours.

All fluorescent fixtures shall have Triphosphorous fluorescent lamps. All GLS & HPSV/HPMV lamps shall be screw type.

All fittings shall be weatherproof and 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% .

HPSV/HPMV/Fluorescent lighting fixtures shall be provided with Power factor correction capacitor to achieve high power factor.

Lighting level design shall include a Maintenance factor as follows to account for lamp lumen depreciation, luminaries' surface dirt and room surface dirt, etc.

- Air conditioned areas : 0.8
- Non-Air conditioned areas : 0.7
- Dust prone outdoor Areas : 0.6

Suitable number of 63 ampere, 3 phase, 415 volt AC welding receptacles shall be provided. Welding receptacles shall be placed near all major equipment and at an average of 30 meters in each building.

20A, 240V, Single phase convenience receptacle with switch shall be provided in all the rooms. The convenience outlets shall be spaced to provide access to any point with a 15 meter extension cord. Receptacles shall be served from an earth leakage circuit breaker (ELCB).

Welding sockets shall be fed from PDB. Number of receptacles per circuit shall be not 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.

7.1.6.4 Lighting Panel -1 & Lighting Panel-2

Lighting Panel-1 & 2 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-65 for outdoor installation.

AC distribution board (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.

7.1.6.5 Lighting/Power Distribution Boards

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.

7.1.6.6 Receptacles

3 phase Industrial type welding receptacles shall be rated for 415V, 63 Amps with interlocked switches, scrapping earth connection, male and female units and cover. Protection class shall be IP-65.

1 phase Industrial type receptacles shall be rated for 240V, 20A Amps with interlocked switches, scrapping earth connection, male and female units and cover. Protection class shall be IP-65. 1 phase receptacles with switches shall be provided at each emergency portable lamp fittings.

All receptacles shall be provided with matching plug-tops. All hardwares shall be of Stainless steel type only including the mesh of well glass luminaries, nut, bolts, washers, etc.

7.1.7 High Mast Lighting System

7.1.7.1 General

The 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.

7.1.7.2 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.

7.1.7.3 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.

7.1.7.4 Light Switching Philosophy

Each High Mast shall have two 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.

7.1.7.5 Location of High Masts

High Mast locations shall be finalised by the contractor to match the lux level indicated in the specification. However tentative locations of the High mast are shown in the Drawing attached with these specifications only for tender purpose.

7.1.7.6 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.

7.1.7.7 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 for the lowering and raising of the head frame. 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.

7.1.7.8 Mechanical Arrangement – Lowering and Raising Head frame (Ring) System

For installation and maintenance purpose, it is required that the head frame (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 head frame 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.

7.1.7.9 Top Pulley Assembly – Lowering and Raising Head frame (Ring) System

The pulleys for the lowering and raising of the head frame 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 multi core 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 head frame. 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 head frame 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.

7.1.7.10 Winches – Lowering and Raising Head frame 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.

7.1.7.11 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.

7.1.7.12 Openings

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

7.1.7.13 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, the High Mast structures shall have adequate strength to resist fabrication, handling and erection loads without becoming overstressed or deflecting excessively.

7.1.7.14 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 base plate 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 head frames shall be hot dipped galvanized both internally and externally to a minimum thickness of 100 microns.

7.1.7.15 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.

7.1.7.16 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.

7.1.7.17 Materials

All materials shall comply to 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.

7.1.7.18 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 luminaries shall be tested as per Indian Standard and shall be suitable for installation on high mast.

7.1.7.19 Aviation Light

GLS/LED type aviation light shall be provided at each mast.

7.1.7.20 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.

7.1.7.21 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.

7.1.7.22 Wiring

Wiring shall be complete in all respects so as to ensure proper functioning of control, protection and interlocking schemes. Control wiring shall be of 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 will 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.

7.1.7.23 Component Specification of HMSB

a) 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 230 V +10%, 50 +3% Hz, AC supply. The contactors in general shall not drop out at voltage on and above 65% rated control supply voltage.

b) Photo Electric Switch

A photo electric cell/switch operating on 230 Volt AC shall be provided for automatic group control switching operation based on solar radiation levels.

c) 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.

d) 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.

e) 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.

7.1.7.24 Installation of Light Fittings

Mounting height of centre 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. Fluorescent 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.

7.1.7.25 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.

7.1.7.26 Spares

10% of the light fittings of various size used shall be supplied as spare.

7.1.8 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.

- Incoming cables to 415 V Panels (Breaker operated) : 50 kA for 1 sec.
- Incoming cables to 415 V Panels (Breaker operated) : 50 kA for 0.5 sec.
- Incoming cables to 415 V Panels (MCB protected) : Fuse cut-off current for 10 m.sec
- Cables from 415 V Panels to Motors : 50 kA for 0.16 sec ACB operated
- Feeders from DB (MCB protected) : Fuse cut-off current for 10 m.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.

7.1.8.1 Construction

HT Cables:

Cables shall be XLPE insulated, screened, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, compacted 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, compacted aluminium conductor conforming to IS: 7098 Part-I.

Control Cables:

Control cables shall be of 1.1 kV grade, multi core, 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:

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.

7.1.8.2 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.

7.1.8.3 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.

7.1.9 Cabling, Earthing & Lightning Protection System

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. Cable 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 areas. 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.

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

On cable trays all the multi core 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 of galvanized steel. 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 of 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 solder less crimping type conforming to IS 8309.

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:

- Panel sealing method comprising Encasing Panels, Cavity fill material & Sealant
- Mortar sealing method comprising Mixing Mortar curing with water.

7.1.9.1 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.

7.1.9.2 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.

7.1.9.3 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 conform to the requirements of latest editions / amendments of the following:-

Indian Electricity Act and rules framed there under.

- 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 (75 Kg/metre run of each cable tray), 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/stencilled 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/stencilled 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 up to 1.5 metres from respective floor for mechanical protection. The sheet cover shall be of removable type.

7.1.10 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.

7.1.11 Closed Circuit Television

The contractor shall design, supply, installation, testing and commissioning of Closed Circuit Television as per the requirement. The Closed Circuit Television (CCTV) System shall provide video surveillance and recording function for the operators to monitor all the sensitive areas. Two types of cameras shall be provided: (i) Fixed cameras with fixed focal length lens and fixed orientation. (ii) Pan/Tilt/Zoom (PTZ) cameras with variable focal length lens with adjustable orientation in both the vertical and horizontal directions.

7.1.12 Data Network

The contractor shall design, supply, installation, testing and commissioning of data and networking for the plant as per the requirement. Data Network 13.4.1 Ethernet IP network as per IEEE 802.11 including both wire line and wireless component and redundancy for high reliability and availability shall be designed and maintained across the Port for data transmission between different equipment, control centres, administration and gate systems. 13.4.2 Fast Ethernet/Ethernet Network – the characteristics of LAN and WAN cables shall follow ISO/IEC 8802-3.

7.1.13 List of Recommended Spares:

List and item wise prices for recommended spares and special tools for both external and internal illumination, Spares for Panel Boards, HT/LT and control cables, Internal wiring, lightning protection, CCTV, Data network shall be submitted by the contractor. The purchaser shall purchase only those that are considered necessary.

7.1.14 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.

7.1.14.1 D.G Set:

1. Test at Manufacturer Works:

The routine Tests and Full load test on Engine, Alternator shall be carried out at manufacturer works in accordance with applicable Indian and international standards in presence of Engineer/Client Representative.

2. Test at Site:

The following test shall be conducted at site in presence of Client representative before tenderisation. The contractor shall provide all testing equipment, labour and consumable required for the testing.

Testing of DG test shall be strictly in accordance with ISO 8528 all parts.

Checking the alignment by the engine manufacturers representative and obtaining approval.

Insulation resistance on alternator, control panel and cabling/Bus bar trunking

Checking the AMF operation both on auto and manual mode

Checking AVR operation

Checking the engine safety for satisfactory operation

Checking the vibration level

Testing of individual protective device on engine and alternator and ensuring that the wiring is carried out properly.

Full load run test for 8 hours continuously. All the reading shall be logged to evaluate the fuel consumption, lube oil pressure, water and oil temperature vis-a-vis the electrical load.

The noise level at one metre from the enclosure and the temperature rise inside the enclosure shall be measured.

Any deviation from the guaranteed technical particulars shall be made good and these performance parameter shall be measured once again till the required results are achieved.

The DG set deemed to be commissioned after satisfactory performance of all associated equipment.

7.1.14.2 LT Panels:

1. Test at Manufacturer Works:

Type Test:

Bidder shall furnish the copies of type test certificates for the all test indicated below along with bid conducted on switch boards.

Short time current test.

Temperature rise test.

One minute power frequency voltage with stand test.

Routine Test:

Mechanical operation test

Dielectric test

Inspection Test:

The inspection shall consist of following but shall limit to the same.

Appearance and construction

Dimension and mounting details

Feeder arrangement and feeder details

Door alignment and gaskets etc

Alignment of switch drive and handle

Bus bar Resistance: Bus bar joint resistance shall be measured with calibrated joint resistance tester as per relevant IS.

Insulation Resistance: The insulation resistance shall be measured between phases to earth. The insulation resistance shall be measured 1000V megger. The insulation resistance shall not be less than 50 Mega Ohms in any case.

High Voltage Test: The test shall be carried out by applying voltage of 2.5KV for one minute.

- Between all phases and earth
- Between the phases

Operation test:

- ON/OFF operation of switches, contactors, indication lamps, tripping of contactors etc shall be checked.
- Breaker testing and Breaker details: Breaker operation shall consist of but not limited
 - 1. Manual closing/Tripping
 - 2. Electrical closing and tripping
- Breaker tripping through releases.

2. Test at Site: The breaker operation shall be checked in test position as follows.

Manual closing and tripping

Breaker tripping through releases/relays

Interlocks-protective releases/relays and breaker tripping time shall be set as specified.

Emergency trip

ON/OFF Indication

Breaker annunciation and indication

Scheme interlocks checks.

7.1.14.3 APFC Panels:

Inspection Test

The inspection shall consist of following but shall not limit to the same.

- Appearance and construction.
- Dimension and mounting

- Meter ranges and name plates etc.
- Wiring etc.

The following routine test shall be carried out as per IS 2834.

- Test for out put and capacitance
- Voltage test between terminal and container(for capacitor unit).
- Voltage test between terminal and earth(for capacitor bank).
- Insulation resistance test.
- Test for efficiency of discharge device

7.1.14.4 Lighting Power and Distribution Board:

Inspection and Testing

Inspection shall consist of following but shall not limit to the same.

- Appearance and construction.
- Dimension and mounting
- Meter ranges and name plates etc.
- Feeder arrangement and feeder details
- Door alignment and gasket etc.

Test:

The following test shall be carried out.

Insulation Resistance: The insulation resistance shall be measured between phases to earth. The insulation resistance shall be measured 1000V megger. The insulation resistance shall not be less than 5 Mega Ohms in any case.

High Voltage Test: The test shall be carried out by applying voltage of 2.5KV for one minute.

- Between all phases and earth
- Between the phases
- Between phases and neutral
- Routine test as per IS and heat run test(type test) shall be carried out on panel.

7.1.14.5 Lighting Installation:

Testing of Installation:

Before installation is but in toi service, the following test shall be completed

Insulation Resistance: The insulation resistance shall be measured between phases to earth. The insulation resistance shall be measured 1000V megger. The insulation resistance shall not be less than 5 Mega Ohms in any case.

Testing earth continuity path:

The earthing conductor shall be tested for electrical continuity. The electrical resistance of the same along with earthing lead from connection with earth electrode to any point, in earth continuity conductor in the complete installation shall be less than one ohm.

Testing of polarity of single pole switch:

The test shall be made to verify that all single pole switches have been fitted between the phase conductors and light/fan/socket outlet:

7.1.14.6 Cables

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.

Special Tests

The following tests as applicable to FRLS sheathed cables shall be conducted as type tests on each size of each lot.

- Oxygen index test
- Temperature index test
- Acid gas generation during fire
- Smoke generation test under fire
- Swedish chimney test for class F3 as per SS: 4220 14 : 75
- Under fire conditions for bunched cables as per IEEE std. 383 / 74

7.1.14.7 Earthing:

SITE TEST:

The following earth resistance values shall be measured with an approved and calibrated earth tester and recorded.

- Each earth grid, earth mat, earth pit, piles earth

- Earth continuity and bonding conductors
- Earthing system as a whole

7.2 List of Approved Makes

S. No.	Equipment / Component	Preferred Makes
	LT Switchgear	ABB / Siemens / Schneider / L&T
	Distribution Boards	L&T / Siemens / Schneider / ABB / Indo Asian Technocommerce / Milestones / Pyrotech
	HT & LT Power cables	Universal / Nicco / CCI / Fort Gloster
	Copper Wires PVC FRLS	Skytone / Echo Cables / BatraHenlay / National / Finolex / Polycab
	Cable Glands/Lugs	Jainsons / Dowells / Gripwell / SMF
	Cable Trays	Ercon / Indiana / Industrial Perforation / Sintex / MM Engineering / Pilco / Parekh
	LT Capacitor Bank	L&T / Siemens / Epcos / Mehar / ABB / Crompton / Asian / Universal / Madhav
	Battery	Exide / Amco / Amara Raja / Chloride / Standard
	Battery Charger with DCDB	Chhabi Electricals / Caldyne / Mastek / DB Electronics
	Diesel Generator Set	Powerica / Jakson / Kohler / Greaves
	Lighting fixture	Bajaj / Philips / Crompton / GE Lighting / Wipro
	High mast	Bajaj / CGL
	Plate-Switches & Sockets, Boxes	MK / Crabtree (Havells) / Anchor
	GI Conduit with accessories	BEC / AKG / SENCO / Jindal
	MCCB	Siemens / L&T / ABB / Schneider

S. No.	Equipment / Component	Preferred Makes
	MCB / ELCB / RCB / MPCB	Siemens / L & T / MDS / Schneider / Havells
	Fuse/Link	Siemens / L&T / Alstom / Schneider / C&S / Areva
	Switch Fuse Units	Siemens / L&T / Havell's
	Contactors	Siemens / L&T / ABB / Schneider
	Indicating Lamps / Push buttons	Siemens / Schneider / Teknic / Kaycee / L&T / Essen / Vaishnav / BCH / C&S
	Push button stations	Siemens / Schneider / Teknic / Rishabh / L&T / BCH / Control Group
	Meters(digital) MFM	Schneider (Conzerv) / L&T / Secure
	Voltmeter / Ammeter / PF Meter / Frequency Meter/ KWH Meter	AE I/ IMP / MECO / INDCOIL / Enercon / L&T / Rishab / Siemens / Industrial Meters
	Selector Switch	L&T / Siemens / Schneider / Kaycee / Salzer / C&S / Vaishnav
	Auxiliary Contactors/ Relays	L&T / Siemens / BCH
	Overload Relays (Hand Reset Type)	L&T / Siemens / BCH / Telemachanique
	Protective / Auxiliary Relays	Alstom / Schneider / Siemens / EasunReyroll / ABB / Telemachanique / L&T
	Time Delay Relays	BCH/Siemens/L&T/English Electric
	Power Contactor with 2NO+2NC	L&T / Siemens / Telemachanique
	Timer	Siemens / L&T / BCH / Schneider
	Terminal Blocks	Elmex / Connect Well
	Current Transformer/ Potential Transformer	AE / Kappa / L&T / Siemens / Pragati / C&S / Jyoti
	Plugs & Sockets	Havells / Legrand / Hensel

S. No.	Equipment / Component	Preferred Makes
	Welding Sockets	B&C / BCH
	Telephone System	BPL / Siemens / Bharti / Tata Telecom
	PVC Conduit and accessories	BEC / Polypack / Precision /AKG
	Cable Termination Kits & Straight Through Joints	Raychem / M-Seal (3M)

8.0 DRAWINGS

S.No.	Drawing Number	Drawing Title
1	60544930-DRG-T-0000-CS-1001	OVERALL LAYOUT OF SITTWE TERMINAL
2	60544930-DRG-T-0000-CS-1002	OVERALL LAYOUT OF PALETWA TERMINAL
3	60544930-DRG-T-0000-CS-1003	TOPOGRAPHIC SURVEY MAP OF SITTWE TERMINAL
4	60544930-DRG-T-0000-CS-1004	TOPOGRAPHIC SURVEY MAP OF PALETWA TERMINAL
5	60544930-DRG-T-0000-CS-1005	LAYOUT PLAN OF PORT JETTY AND IWT JETTY AT SITTWE
6	60544930-DRG-T-0000-CS-1006	CROSS SECTION OF JETTIES AT SITTWE
7	60544930-DRG-T-0000-CS-1007	LAYOUT PLAN AND SECTION OF IWT JETTY AT PALETWA
8	60544930-DRG-T-0000-CS-1008	CROSS SECTION OF JETTIES AT PALETWA
9	60544930-DRG-T-0000-CS-1009	TYPICAL DETAILS OF JETTY FIXTURES
10	60544930-DRG-T-0000-CS-1010	DETAILS OF CONTAINER YARD PAVEMENT AT SITTWE
11	60544930-DRG-T-0000-CS-1011	DETAILS OF CONTAINER YARD PAVEMENT AT PALETWA
12	60544930-DRG-T-0000-CS-1012	LAYOUT PLAN OF WORKSHOP BUILDING AT SITTWE
13	60544930-DRG-T-0000-CS-1013	SECTION OF WORKSHOP BUILDING AT SITTWE
14	60544930-DRG-T-0000-CS-1014	PLAN AND SECTION OF WORKERS AMENITY ROOM AT SITTWE
15	60544930-DRG-T-0000-CS-1015	GROUND FLOOR PLAN OF WORKSHOP AND WORKERS AMENITY ROOM AT PALETWA
16	60544930-DRG-T-0000-CS-1016	FIRST FLOOR PLAN OF WORKSHOP AND WORKERS AMENITY ROOM AT PALETWA
17	60544930-DRG-T-0000-CS-1017	SECTIONS OF WORKSHOP AND WORKERS AMENITY ROOM AT PALETWA
18	60544930-DRG-T-0000-CS-1018	PLAN AND SECTION OF BOUNDARY WALL AT SITTWE

19	60544930-DRG-T-0000-CS-1019	PLAN AND SECTION OF BOUNDARY WALL AT PALETWA
20	60544930-DRG-T-0000-CS-1020	PLAN AND SECTION OF INTERNAL ROADS AT SITTWE
21	60544930-DRG-T-0000-CS-1021	PLAN AND SECTION OF INTERNAL ROADS AT PALETWA
22	60544930-DRG-T-0000-CS-1022	LAYOUT AND SECTION OF STORM WATER DRAINAGE AT SITTWE
23	60544930-DRG-T-0000-CS-1023	LAYOUT AND SECTION OF STORM WATER DRAINAGE AT PALETWA
24	60544930-DRG-T-0000-CS-1024	PROPOSED DREDGING PLAN AT SITTWE
25	60544930-DRG-T-0000-CS-1025	GENERAL ARRANGEMENT OF REEFER GANTRY
26	60544930-DRG-T-0000-CS-1026	SITTWE TERMINAL D.G POWER DISTRIBUTION SINGLE LINE DIAGRAM (SLD) SHEET 1 OF 3
27	60544930-DRG-T-0000-CS-1027	SITTWE TERMINAL D.G POWER DISTRIBUTION SINGLE LINE DIAGRAM (SLD) SHEET 2 OF 3
28	60544930-DRG-T-0000-CS-1028	SITTWE TERMINAL D.G POWER DISTRIBUTION SINGLE LINE DIAGRAM (SLD) SHEET 3 OF 3
29	60544930-DRG-T-0000-CS-1029	PALETWA TERMINAL D.G POWER DISTRIBUTION SINGLE LINE DIAGRAM (SLD) SHEET 1 OF 3
30	60544930-DRG-T-0000-CS-1030	PALETWA TERMINAL D.G POWER DISTRIBUTION SINGLE LINE DIAGRAM (SLD) SHEET 2 OF 3
31	60544930-DRG-T-0000-CS-1031	PALETWA TERMINAL D.G POWER DISTRIBUTION SINGLE LINE DIAGRAM (SLD) SHEET 3 OF 3

