Schedule D

Draft Concession Agreement – HAM Component

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1. SPECIFICATION – DESIGN

1.1. GENERAL

If there is a discrepancy between the requirements below and the requirements of the specified design standards the most onerous requirement shall be incorporated in the design.

1.2. FUNCTIONAL REQUIREMENT

Two breakwaters viz Northern Breakwater of about 2000m and Southern Breakwater of about 3650m is to be constructed as indicated in the drawings. Offshore reclamation area is required for storage of containers, in-port rail yard and port operations. The area is reclaimed to the level as indicated in the drawings.

- Reclamation must be carried out by allowing long passage for the material to settle down and reduce the spillage to minimum.
- The Reclamation Bunds are required to contain land reclamation and fill, maintain the design levels, and protect the reclamation fill from wave loadings, currents, propeller wash and flooding.
- The breakwaters and reclamation bunds shall be designed to control wave overtopping against the extreme (design) environmental and marine conditions.
- The breakwaters and reclamation bunds shall be designed using the alignment shown on the Reference Drawings. It shall be a rubble mound structure and armoured with either rock armour or a single layer concrete armour unit system as per design requirement.

1.3. DESIGN CRITERIA – BREAKWATERS AND RECLAMATION BUNDS

1.3.1. Design Life

The design life is the period for which the Works are to be used for their intended purposes with routine maintenance, but without major repair and/or replacement being necessary. At the end of the design life the Works shall comply with the design ultimate and serviceability limit states. Due regard shall be given in design to any deterioration during the design life. Design life for the Works is defined in the table below.

Table 1.1 Design life of the Breakwaters and Reclamation Bunds

Element	Design Life (Years)	Minimum Inspection Interval (Years)	Types of Routine Inspection by Authority	Requirements for Repair and Maintenance
Reclamation platform including ground improvement	50	50	None	Treatment of settlement in excess of the specified limits.
Breakwaters / Reclamation bund	100	10	Routine inspection and replacement of minor slope damage, rock / concrete armour damage.	Replacement or re-positioning of slope protection, rock/concrete armour involving damage exceeding 5% of area Repair of slumping. Treatment of settlement and/ or scouring in excess of the specified limits.
Concrete (reinforced or otherwise)	50	50	None	Cutting out/replacement of defective/spalled concrete and corroded reinforcement.

1.3.2. Durability of Materials

The Concessionaire shall adopt the following material densities for design and construction of the breakwaters and reclamation bunds:

- **Armour Rock:** Rock densities shall be not less than 2,650 kg/m^3 for all layers except the core which shall have a density of not less than 2,400 kg/m^3.
- **Concrete for Crown Wall:** A minimum concrete density of 2,400 kg/m^3 shall be adopted for the construction of the crown walls.
- **Concrete for Armour Units:** A minimum concrete density of 2,400 kg/m^3 shall be adopted for the construction of the concrete armour units.

1.3.3. Platform Level

The platform level of the reclaimed land at the time of taking over of the works for development of the Project shall be a minimum of +3.8 m CD and +4.3 m CD in the areas as indicated in the Reference Drawings. The level at the berthing revetment and other areas shall be as indicated in the Reference Drawings.

1.3.4. Hydraulic Stability for Armour Layer

1.3.4.1. Rock armour Layer

The rock armour shall be sized following the guidance from CIRIA C683, The Rock Manual. In particular, the Van der Meer formula shall be used.

To reduce the regular maintenance required for the breakwaters and reclamation bunds an “initial damage” level shall be adopted. The initial damage level allows between 0% and 5% of the primary rock armour layer on average to be displaced during the design event. This requires the adoption of a Damage Parameter, S=2 when using the Van der Meer formula. The maximum allowable damage under overload conditions (1.20Hs). The slope of all the rock armour layers shall be between 1:1.5 to 1:3.

Notwithstanding the above, rock armour shall not be less than shown on the Reference Drawings.

1.3.5. Concrete Armour Layer

Where concrete armour units are required, the initial sizing shall be based on the Hudson formula as per CIRIA C683, The Rock Manual and guidance from the developer of the concrete units shall be followed.

The weight of the underlayer rock shall be determined according to the filter rules set up for Armour layers in The Rock Manual.

For the adopted damage level, the design damage parameter Nod for concrete Armour units shall be:

Nod = 0 for single layer concrete Armour units under extreme 100 years design conditions

The details provided in the Drawings are for reference purpose only. The Concessionaire is free to select any type of Armour units and arrangement of layers suiting the code requirements and specifications. However, the Concessionaire shall undertake hydraulic model laboratory test and site-specific information prior to using these units in the construction of the shore protection bund. The size of Armour units shall be confirmed using 2D and 3D physical modelling. The Concessionaire is solely responsible for ascertaining the

patent status of the Armour unit proposed by him and bearing but not limited to royalty in this regard during execution and maintenance period.

1.3.6. Hydraulic Stability for Toe Beam

The toe armour design shall be undertaken following the guidance provided in CIRIA C683 The Rock Manual and will use the LAT +0m CD as design extreme low water level.

The type of toe shall be selected to suit the ground conditions so that it provides effective support to the slope armour. Where the breakwaters and reclamation bunds is founded on the underlying rock this will require the toe to be placed in a shallow trench or to be reinforced with heavier armour. Where the toe is founded on mobile sediments scour protection will be required to prevent the erosion of the seabed and undermining of the toe.

The acceptable damage number Nod for the stability of the toe berm along the breakwaters and reclamation bunds is 0.5 under extreme conditions. This Nod of 0.5 means start of damage or minor movement in the toe.

1.3.7. Overtopping Limits

The design of the crest of the breakwater and reclamation bunds shall control wave overtopping and limit wave transmission. The assessment of overtopping shall also take into consideration long term geotechnical settlement so that the overtopping limits are not exceeded throughout the design life of the breakwaters and reclamation bunds.

Overtopping limits under prevailing and extreme conditions have been set to protect the operations equipment on the crest of the breakwaters and reclamation bunds, operational in the lee of the wave wall and limit damage to building/equipment under extreme conditions. These limits shall comply with the guidance set in Eurotop 2018 and overtopping rates shall be calculated according to this guidance.

The Concessionaire shall set acceptable overtopping limits for each of the structures. As a minimum, the overtopping limits at the rear of the vertical face of the wave wall of the breakwaters and reclamation bunds shall be:

- 1 Year condition: <1 litre/m/s
- 100 Year condition: <10 litre/m/s(for protection with reclamation on leeside)
- 100 Year condition: <50 litre/m/s(for protection with no reclamation on leeside)

The overtopping performance of the most exposed breakwaters and reclamation bunds shall be confirmed using physical modelling.

Notwithstanding the above criteria the elevation of the crown wall, and crest armour berm shall not be less than shown on the Reference Drawings.

1.3.8. Wave Wall Stability

The breakwaters shall be designed with a concrete crown wall which incorporates a roadway.

The wave wall shall be designed using fibre-reinforced concrete (i.e., no steel reinforcement). The Concessionaire shall design the crown wall to withstand the load imposed by the design waves during the design storm. An appropriate method to obtain the wave loads shall be applied and the wave wall shall be designed to be robust and require minimal maintenance. Wave loading used for design shall be validated using physical modelling.

A minimum safety factor against sliding and overturning of 1.5 shall be used in the design of the wave wall.

The crown wall shall incorporate a 7.5m wide roadway and is adequate for vehicle and plant use for inspection and maintenance. The roadway shall be drained by applying a slope of 1:50 so that water runs off to the Lee side.

The proposed crown wall on the breakwater serves as a roadway for the vehicular movement. The wall shall be able to provide safe movement of mobile cranes and IRC Class 70R vehicles during its design life span i.e. vehicular load of 100 T has been considered.

The crown wall shall be unreinforced mass concrete. The crown wall will be founded on a blinding layer which will serve to cover the voids of the quarry run and to provide a suitable working surface for the mass concrete.

1.3.9. Physical Model Tests

The performance of the most exposed lengths of breakwaters and reclamation bunds shall be confirmed using scale physical modelling studies commissioned by the Concessionaire.

The modelling shall be undertaken at an internationally recognized laboratory and shall include 2D (flume) and 3D (basin) tests to confirm slope and toe armour stability, wave overtopping performance and pressures/loads on the wave wall. The structures shall be tested up to the 100-year design conditions and also under 20% overload conditions.

1.3.10. Geotechnical Stability of Breakwaters and Reclamation Bund

Appropriate stability analyses shall be undertaken to demonstrate the stability of the breakwaters and reclamation bunds. Slope stability shall be checked in accordance with BS EN 1997-1 and BS EN 1998-5, using the partial factors given in latest editions of BS 6349-2. The potential for circular as well as non-circular failure planes shall be assessed and potential strength degradation due to seismic loading shall be taken into account.

The Concessionaire's design shall allow for the long-term settlement of the breakwaters and reclamation bunds so that the design and functional requirements (e.g. overtopping) are still met at the end of the 100-year design life for these structures. The Concessionaire's design shall demonstrate that the factors of safety on overall stability will be achieved.

The geotechnical design of the breakwaters and reclamation also shall meet the following requirements:

- Factor of safety for non-seismic conditions: 1.3
- Factor of safety for seismic conditions: 1.0
- Factor of safety for construction stage conditions: 1.0

1.3.11. Erosion Control

Erosion control (e.g., geotextiles or granular filters) shall be designed for and installed on the full surface of all breakwaters and reclamation bunds providing separation and filtration and preventing the erosion of reclamation fill material. Design of geotextiles shall be in accordance with BS EN 13253:2016.

1.4. DESIGN CRITERIA – RECLAMATION

1.4.1. Design loads

The reclamation area will be designed to withstand the operational loads and to comply with the settlement criteria defined in section.

Ground treatment shall be undertaken to allow for the general operational loadings **indicated in**

Table 1-2 and considering the general settlement criteria and other specific settlement requirements as defined herein.

Table 1-2: Terminal Area loads

S. No.	Area Description	Design Load, [kN/m2]	
		Static Condition	Seismic
1.	Container Yard	50	25
2.	Rail Area	30	15
3.	Access Road and Gate	30	15
4.	Buildings and Car Park	20	10

1.4.2. Slope Stability

Slope stability analyses shall be carried out to examine all possibilities including circular, non-circular and sliding failures using methods of analyses in accordance with the recommendations of BS 6031.

Table **1.3** depicts the minimum FOS and loading that will be adopted.

Table 1.3: Loading and FOS for Slope Stability Analyses

Loading Case	Loading	FOS
Temporary	At different stages of loading and with 10 kPa construction equipment loading on top	1.3
Permanent Static	As in Table **1-2**	1.5

Permanent Seismic	As in Table **1-2**	1.1

Reference to the construction loading is made to Table 5.11 of CIRIA 580. HA loading for Normal Traffic prescribed in this Table for loading for all combination of vehicles that occur on highways, is considered. This is prescribed as equivalent to a surcharge loading of 10 kPa. Seismic design check is not necessary during the construction stage.

Water Levels

For slope stability assessments during construction, the groundwater table shall be taken at surface level, taking into account that due to height differences along boundaries, locally excess pore water pressures may occur in the fill material. Slope stability assessment shall be carried out for the static and seismic case considering the drawdown condition. Phreatic line should be developed considering storm surge and pore-water pressure build-up.

1.4.3. Settlement Criteria

Overall Ground Settlement

The allowable levels of overall ground settlement across the Site, measured at the formed surface of the reclamation and excluding the effects from a maximum considered earthquake (as defined in Indian Standards 1893 Part IV for Zone II).

Differential Settlement

The slope between any two points on the final surface of the reclamation shall not deviate from more than 0.5% of the distance between any points.

All works for development of the Project shall be constructed to achieve the required tolerances and differential settlement requirements.

Earthquake Settlement

The maximum vertical and lateral deflections will be assessed in accordance with Indian Standards 1893 Part IV for Zone II.

1.4.4. Safety against liquefaction

Concessionaire shall perform liquefaction assessments to determine the safety against liquefaction for the following saturated fills:

a. The fill in sand keys;
b. The reclamation fill; and
c. The fill forming the reclamation edge structures.

The peak ground acceleration and magnitude shall as per Indian Standards 1893 Part IV for Zone II be used in all liquefaction assessments.

1.5. DESIGN CONDITIONS

1.5.1. Data Collection and Modelling

Existing data available to the Authority has been provided to the Concessionaire with the Tender documents. To supplement and verify the data provided by the Authority, the Concessionaire shall organise and perform whatever additional data collection deemed necessary to fully understand and take ownership of the existing data and to enable execution of his obligations under the Agreement. Such additional data shall be analysed by the Concessionaire for use in the execution of the design and construction of the works for development of the Project and the results reported to the Authority.

Existing modelling available to the Authority has been provided to the Concessionaire with the Tender documents. To supplement and verify the modelling provided by the Authority the Concessionaire shall organise and perform such modelling as is required to enable execution of the design and construction of the works for development of the Project.

1.5.2. Design Soil Parameters

The Concessionaire shall be deemed to have satisfied himself as to the conditions expected to be encountered in constructing the works for development of the Project, whether from the information provided in Site Data or from his own investigations.

The Concessionaire shall make his own judgement on the geology and geotechnical conditions at and beneath the Site, including all interpretations. The Concessionaire is solely responsible for data and carrying out his own interpretations and/or ground investigation; notwithstanding any data, statements, recommendations or conclusions made in the ground investigation reports which are provided in Site Data.

The Concessionaire shall be responsible for seeking any additional data, which may be available, and for undertaking any additional surveys, geotechnical or other investigations which may be necessary for the works for development of the Project.

1.5.2.1. Geology conditions

The stratigraphy in the Tuticorin area can be described in general by the following sequence:

1) poorly graded sand with rock fragments layer,
2) moderately week to moderately strong weathered rock.

These two lithologic units are interbedded and deposited in sequential order.

1.5.3. Environmental Data

The design conditions provided in this section are for information only and were used for the preparation of the reference design.

The Concessionaire shall undertake detailed numerical wave and hydrodynamic modelling studies to establish conditions to be used for the detailed design of the breakwaters. Notwithstanding the results of these studies the adopted design conditions shall not be less onerous than those provided in this section.

1.5.3.1. Tide Levels

Tide levels in the VOC Port region are summarised below.

Table 1.4: Tide levels at VOC Port

Description	Abbreviation	Tide Levels (m CD)
Lowest Low Water Level	LLWL	+ 0.11 m
Mean Lower Low Water Springs	MLLWS	+ 0.25 m
Mean Low Water Springs	MLWS	+ 0.29 m
Mean Low Water Neaps	MLWN	+ 0.55 m
Mean Sea Level	MSL	+ 0.64 m
Mean High Water Neaps	MHWN	+ 0.71 m
Mean High Water Springs	MHWS	+ 0.99 m

1.5.3.2. Storm Surge

Storm surge = 0.64 m under 100-year return period.

1.5.3.3. Sea Level Rise (SLR)s

Sea level rise = 0.48m over the 50 years design life of the breakwaters and reclamation bunds.

1.5.3.4. Design Water Levels

High Wáter

- Maximum Design water level (Extreme condition – 1 in 100 yrs.) = 0.99+0.64+0.48 = (+) 2.11 m CD
- Maximum Design water level (Operating condition – 1 in 1 yrs.) = 0.99+0.48 = (+) 1.47 m CD

Low Wáter

- Design low water level (Extreme condition – 1 in 100 yrs.) = (+) 0.00m CD

1.5.3.5. Current Speeds

Current speeds:
For the design of breakwater, the minimum design flow conditions along the breakwaters shall be 1.0 m/s.

1.5.3.6. Water density

Water density = 10.25kN/m3.

1.5.3.7. Design Nearshore Wave Conditions

The extreme wave conditions are shown in Table 1.5.

Table 1.5: Extreme Wave Condition at Project Site

Structure (seabed level in m CD)	100-year Return Period	
	Hs (m)	Tp (s)
Northern Breakwater	6.5	12
Southern Breakwater) (-)10m CD	6.5	12
Sea-side Reclamation Bund (South	6.5	12
South Breakwater and Reclamation Bund (South) at less than (-)10m CD seabed level	(Significant Breaking wave height)	12
Retaining Bund (inside harbour)	2.0	12

Design low water wave conditions shall be derived by the Concessionaire and shall be used in conjunction with the design low water levels given in Section 1.5.3.4. .

The operational conditions within the port and at the breakwaters shall be derived by the Concessionaire.

1.5.3.8. Wind data

The Concessionaire shall determine the appropriate wind speeds to be used in analysis. For the design wind condition shall be derived for both operating and extreme design situation.

1.5.3.9. Rainfall

The rainfall values given in this section shall be confirmed by Concessionaire by analysis of all available data.

Average annual rainfall in Tuticorin is 790.2 mm. Consideration to concentrated seasonal periods of rainfall shall be given by Concessionaire.

1.5.3.10. Seismic Zone

Tuticorin falls under Zone II as per the seismic map of India shown in IS 1893- 2016. However, seismic zone II shall be considered for the design. Importance factor for the breakwaters is to be taken as 1.0.

1.5.3.11. Scour

A minimum local scour depth of 1.5 times the pile diameter will be considered where piles installed through existing seabed.

1.5.3.12. Relative Humidity

Maximum (in May & June) = 100%
Minimum (in May) = 34%

1.5.4. Site investigations

Site investigations have been performed at the Site consisting of bathymetric survey, geotechnical investigation and geophysical investigation. The factual reports are provided in the Site Data.

2. GENERAL

The construction of dredging Works shall comply with the requirements of the relevant standards, including all up-to-date amendments, and particularly the requirements of this section of the Specification. The relevant standards include:

- IS2720: Methods for testing of Soils
- BS 6349-5:2016 [Maritime structures — Part 5: Code of practice for dredging and land reclamation]
- PIANC Report No.100:2009 [Dredging Management Practices for the Environment]
- CIRIA 2012, Hydraulic Fill Manual.

2.1. SCOPE OF WORK

The works for development of the Project covered in this section shall include dredging for:

Permanent Works

- Dredging a trench for sloped breakwater reclamation bund foundation.
- Dredging in all type of seabed strata in the areas of the approach channel, berth pockets, harbour basin to the lines, and levels as specified in the Drawings.
- Dumping of unsuitable material at designated dumping site.
- Dumping of suitable material at the reclamation site.
- Removal of any other unsuitable material from Site to allow completion of the works for development of the Project.

Temporary Works

- Any other Temporary Works as defined by the Concessionaire.

Included in the works for development of the Project is material testing, either within the works for development of the Project or at an approved material source location.

Dredging of Permanent Works shall be carried out to achieve the lines and levels shown on the Drawings. Dredging of an Access Channel shall be within the boundaries as given on the Drawings.

The Concessionaire shall be responsible for:

- The design and formation of stable underwater slopes, whether temporary or as part of the Permanent Works, where the dredged level is not coincident with the existing bed level.
- Disposal to a licenced disposal site for material to be removed as part of the works for development of the Project or Concessionaire's temporary works.

- All suitable material produced by the dredging shall be used for the reclamation.
- Obtaining all approvals, permissions, licenses, and consents which are required to undertake the works for development of the Project, including disposal of unsuitable materials, and are additional to any consents that the Authority obtained prior to the award of the Agreement.
- Payment of all costs related to dredging and disposal, including but not limited to the mining, transport, disposal, including but not limited to all fees, levies, taxes, etc.

The Concessionaire shall comply with any regulatory requirements including environmental monitoring in respect of his dredging and disposal operations. The Concessionaire shall comply with any mitigation and monitoring proposals defined in any EIA or EC, or any other requirements imposed as conditions of consents.

The dredging and disposal work for development of the Project includes undertaking all surveys necessary to control, monitor and verify the dredging and disposal has been undertaken in accordance with the Agreement.

2.2. PARTICULAR SPECIFICATIONS

2.2.1. Definition Dimensions and Layout

The extent of dredging to provide navigable areas and the extent of the reclaimed areas are defined on the Drawings.

- Dredging of the navigation area i.e., in the access channel leading to the harbour basin to the final dredge profile, harbour basin, berth pockets and the area between the basin and the Approach Channel to the final dredge profile, dredged to the level which level varies as shown on the Drawings.
- The access channel, when required by Concessionaire, including its maintenance is part of Concessionaire's Works.
- Temporary dredging profiles (if applicable) shall be determined by the Concessionaire in order to achieve temporary dredged levels. The Concessionaire shall be responsible for designing and excavating all temporary dredged slopes in such way that no instability of the temporary slopes occurs.
- For the navigable areas, the dredging profile is the surface defined by the lines, levels and slopes shown on the Drawings above which all seabed material regardless of type or nature is to be removed by dredging under the Agreement.
- Material needed for the reclamation shall be obtained from other dredge areas selected by the Authority.
- The Final Surface of any work is the surface defined by the lines and levels shown on the Drawings to which, following any settlement which occurs before expiry of the

Maintenance Period for the Works or the relevant Section of the Works, the works under the Agreement are to be finished.

2.2.2. Dredging Requirements

Any proposed dredging for a Concessionaire's Access Channel shall be within the coordinates as given in the Drawings. The Authority has obtained permission for the dredging of such an access channel from the relevant authority, although it is not explicitly required for the Project and does not form part of the Works.

Dredging shall be carried out in such a manner and sequence that semi-fluid material or disturbed seabed material or fine material from run-off water will not accumulate in dredged areas. The Concessionaire is permitted to over-weir, however the water quality requirements as specified in the EIA and EC shall not be exceeded.

2.2.3. Line and Levels

The Concessionaire shall dredge the dredging area footprint to the lines and levels as specified in the Agreement and the Drawings.

2.2.4. Side Slopes

Where side slopes have to be formed as part of the dredging works, they shall be executed to the lines and levels shown on the drawings and tolerances based on BS: 6349-5. The Concessionaire shall be fully responsible for ensuring that his method of forming the slopes does not result in any instability either in the short or long term. The Concessionaire shall submit his proposals for forming the side slopes to the Engineer for approval.

2.2.5. Over Dredging and Dredging Tolerance

Tolerances are measured perpendicular to the design dredging profile. At slope transitions, the horizontal tolerance line shall be projected or trimmed to the intersection with the inclined tolerance line.

The dredging tolerances shall be based on BS: 6349-5, to be taken into account in the designing of the access channel / harbour basin area (exposed/ sheltered water).

Stable side slopes shall be formed for all dredge areas within the Site. Care shall be taken when dredging side slopes to avoid slumping and disturbance of the seabed.

Where the final surface of dredging is found to be outside the specified tolerances, re-dredging or filling with approved material as approved by the Independent Engineer shall be carried out at the Concessionaire's own expense unless specifically directed otherwise.

The tolerances are only applicable for the technical acceptance of the work for development of the Project and shall not be considered for payment.

2.2.6. Disposal of Material

Disposal of unsuitable dredged material shall be at an off-Site disposal area selected by the Authority.

The Concessionaire shall comply with all requirements of the relevant authorities for the dumping area, including surveys of the dumping area and adherence to water quality monitoring, and shall provide a copy of all documentation to the Independent Engineer.

For offshore disposal, the Concessionaire shall conduct a pre-dumping survey, interim surveys (if required by the relevant authority) and post-dumping survey to verify the disposal levels.

For offshore disposal, the Concessionaire shall take water quality samples, a minimum of one sampling set shall be carried out per month, consisting of 4 samples, with all water quality tests as listed in the MoEF & CC guidelines, samples shall be taken from mid depth of the water column in a zone 200 m beyond the boundary of dumping. This testing is in addition to any specific testing required by the relevant authorities.

The Concessionaire shall comply with all environmental legislation, regulations, and requirements with respect to overflowing (Trailing Suction Hopper / Cutter Suction Dredgers and loading of barges) and acceptable turbidity and suspended sediment levels in the water, including at the disposal site. If it becomes clear that the environmental requirements are not being met, immediate measures shall be taken to correct the situation, or dredging/disposal operations will be stopped, with all delays to the Concessionaire's account.

2.2.7. Materials to be dredged

The Concessionaire shall make his own assessment of the quality and nature of the materials to be dredged and provide the most suitable plant to achieve the required dredged profiles.

The Concessionaire shall satisfy himself as to the nature of the material to be dredged by examination of any Site information provided by the Authority and during the course of the Agreement the Concessionaire shall carry out any further investigation necessary for him to optimize the delivery of suitable fill materials and limit unsuitable materials.

The Concessionaire shall make his own interpretation of any information provided, which is given for information only and without prejudice.

2.2.8. Reuse of Dredged material within the works for development of the Project

Dredged materials suitable for inclusion in the works for development of the Project are defined in the reclamation specification. The Concessionaire shall take into account in assessing the suitability of dredged granular materials the petrographic composition of the material and the amount of wear that may result on any pipelines and dredging pumps. Any accumulation of soft/silty and clay materials shall be dredged/removed prior to the placement of any granular reclamation materials.

2.2.9. Dredging in Hard Material

Dredging may be necessary in hard material. The Concessionaire's attention is drawn to the nature of materials indicated on the Geotechnical Investigation reports and that he will be entirely responsible for choosing and providing suitable plant and equipment for the proper execution of the dredging operations.

2.2.10. Ordnance and Munitions

The survey conducted by the Authority does not provide any guarantee that sunken objects, ordnance and munitions have been identified. Notwithstanding the foregoing, the Concessionaire shall make full allowance for the possibility of encountering ordnance and munitions and shall take suitable precautions. Ordnance and munitions may include weapons, bombs, shells, grenades, rockets, depth charges, mines, torpedoes, and the like.

2.2.11. Presence of Gasses in Subsoil

The Concessionaire shall take all measures to make sure that the release of gasses (if any) released during dredging activities do not affect the Health and Safety of its personnel and any other person. The Concessionaire shall also make sure that interfere with the dredging activities will not be delayed and / or stopped due to the presence of these gasses.

2.2.12. Survey

2.2.12.1. Frequency

Interim surveys shall be completed at least weekly.

2.2.13. Reporting

2.2.13.1. Dredging activities

In addition to any other progress reporting requirements, the Concessionaire shall maintain a comprehensive daily updated database of the progress of all dredging, movement, filling,

compaction and productivity data throughout all dredging, filling and compaction operations which shall include but not be limited to the following information:

a. Dredging / filling / disposal activity type;
b. Dredger name and fleet number;
c. Time periods for all dredge related activities including dredging, sailing, coupling, pumping, decoupling and delays for position shifts, maintenance, down time due to shipping movements, breakdowns, etc.;
d. Summary of production rates for dredging and filling activities;
e. Dredge location;
f. Fill location;
g. Estimated daily production of dredging and sand supply activities;
h. Lengths and diameter of all pipelines (floating / sinker / shore);
i. Presence or otherwise of booster pump or pumps with pump fleet number and position;
j. Compaction equipment name and fleet number;
k. All compaction related data, including position, compaction depth, compaction times, power consumption records, etc.

2.2.13.2. Installation reports

An installation report shall be provided for each tide gauge, benchmark, settlement marker or other (semi) permanent survey point. The report shall include, but not be limited to, the installation methodology, instrument type and antiquation, any corrections and transformations, accuracy and location, including photographic record.

2.2.13.3. Survey database

The Concessionaire shall maintain a comprehensive daily updated database of all survey activities and results which shall be used as a basis for all progress reporting. The database shall include information but not be limited to:

a. Date / time;
b. Survey vessel;
c. Survey type;
d. Survey equipment;
e. Surface covered;
f. Weather conditions; and
g. (hyper) link to surveyed data (raw and processed).

2.2.13.4. Weekly progress reports

The Concessionaire shall provide input into the weekly progress report which shall include but not be limited to:

a. Description of the survey activities.

b. Equipment and calibration results; and
c. Progress drawings.

2.2.13.5. Monthly reports

The Concessionaire shall provide input for the monthly report with all survey results. The report shall include but not be limited to:

a. A statement on the purpose and rationale of the investigations.
b. Description of survey plan and equipment.
c. Survey operations including data acquisition and processing.
d. Geodetic and navigation parameters.
e. Calibration results and analysis.
f. Analysis of the accuracy, data density, and reliability of the data presented.
g. Digital (ASCII or Excel) tabulated time series data of water level height; and
h. Progress drawings.

2.2.14. Information Models and drawings

The survey data shall be used as input into Information Models.

2.3. CONSTRUCTION REQUIREMENTS

2.3.1. Definitions

Dredging is the removal of material from areas of seabed, including adjoining areas, to defined levels and slope profiles and the disposal of the material to offshore deposit sites or to reclamation sites as directed on the drawings and this specification within the limits stated in the Agreement.

Level surfaces defined by a level Dredge Profile shall have a level tolerance of plus 0mm and -300mm unless modified in the Particular Requirements.

Dredging Profile is the surface, defined by the lines, levels, and slopes on the Drawings, above which all seabed material, regardless of type or nature, is to be removed by dredging under the Agreement.

The ***Final Surface*** of any work is the surface defined by the lines and levels shown on the Drawings to which the works under the Agreement are to be finished.

Marine Structures are seawalls, breakwaters, breakwaters, jetties, quay walls, dolphins, docks, slipways, beacons, lighthouses, landing steps for berthing of vessels and other similar structures.

2.3.2. Concessionaire's Responsibility

The Concessionaire shall be responsible for inter alia as detailed out in section 2.3.

2.3.3. Site Information

All information relating to the Site provided under the Agreement are believed to be correct and shall be treated strictly as general information which the Authority or the Authority's Representative shall not be held liable for whatsoever.

This information shall not relieve the Concessionaire from making his own investigations to confirm the accuracy of such information provided and shall be solely responsible for any wrong interpretation of such information.

2.3.4. Sequence of Dredging Works

The Concessionaire is free to vary the sequence of the dredging works for development of the Project provided that in all the areas the specified quality of fill compaction and/or density requirements are met, and that the completion of the specified Sections of the works for development of the Project is completed within the time. The Concessionaire shall programme his working methods and rate of operations to comply with the specified requirements.

The dredging activity can be carried out parallel to breakwater construction by taking necessary precautions.

2.3.5. Method of Working

The Concessionaire shall submit a document describing his proposed methods for undertaking the dredging works that shall include the following particulars which shall be submitted to the Independent Engineer for approval.

A schedule listing all conditions or restrictions imposed by relevant environmental protection authorities relating to the dredging and disposal of materials, including copies of applications, marine dumping permits and correspondence,

a. The type and capacity of dredgers,
b. Methods of anchorage and positioning of dredgers,
c. The sequence and rate of working including the sampling and monitoring of the dredging works,
d. Details of silt curtain (if used) for dredging, including manufacturer's literature
e. Arrangements for the transportation and disposal of dredged material,
f. Arrangements for monitoring the fines content of spill water and seabed plumes including the extent of the plumes during dredging operations.

g. Means of dredging adjacent to marine structures which will demonstrate how the Concessionaire will avoid dredging below the over-dredge allowance given in the Dredging Requirements.

Detailed particulars of each area to be dredged shall be submitted to the Independent Engineer at least 14 days before commencement of any Dredging works for development of the Project.

The Concessionaire shall maintain on all vessels used in the dredging operations a record of the times of loading and deposition of dredged material, fuel consumption, and a note, with timing, of any occurrence or eventuality which has a bearing on the progress of the Agreement that occurs during dredging operations. These records shall be available for inspection by the Independent Engineer at all times and, when requested by the Independent Engineer, copies of specified parts of these records shall be provided within two hours of receipt of the request.

Records of the volume of material dredged based on survey data, plant used, water velocity through the suction pipes and material content, working hours, fuel consumption, production and non-production hours shall be recorded daily and submitted to the Independent Engineer on a weekly basis. These records shall include daily plots from track plotting equipment and identify the site where material was deposited or disposed of.

2.3.6. Safety of Navigation

The Concessionaire shall ensure that the dredging and reclamation operations are carried out in such a manner as to comply with the details in 2.3.

2.3.7. Concessionaire's Dredging Plant

The Concessionaire shall provide all necessary types of dredging plant and ancillary equipment suitable for the execution of the works for development of the Project. The Concessionaire shall provide full details of the principal items of plant proposed in the Schedule of Plant explaining how the equipment would be utilised.

If at any time during the currency of the Agreement the Concessionaire should be unable to provide the dredger named in the Schedule of Plant, the Concessionaire shall without delay and with the approval of the Independent Engineer provide another dredger to undertake the work. The replacement dredger must not, in the opinion of the Independent Engineer, be inferior to the named dredger in either size, capacity, robustness, condition of repair or horsepower.

Any delay to the completion of the Agreement caused by a delay in the Concessionaire providing replacement dredging plant to the approval of the Independent Engineer will not be considered to constitute a cause of delay or a special circumstance so as to entitle the Concessionaire to additional costs or an extension of time under the Agreement.

The Concessionaire shall at all times allow the Independent Engineer to have access to all dredging plant and ancillary equipment, including all records of the Concessionaire's dredging operations, for the purpose of carrying out inspections and verifying the Concessionaire's operations comply with the Agreement. The verification records shall include the total quantities and production rates of dredged materials of each type of dredging plant.

All dredging and material transporting equipment shall be fitted with an approved real time track plotting or other recording device, capable of providing the location and plots of the vessels position during dredging and disposal/reclamation cycles. Each piece of dredging plant shall also be fitted with equipment for remotely receiving tide gauge readings.

Dredgers shall also be fitted with electrical equipment for receiving continuous tide gauge readings.

2.3.8. Maintenance of Hopper Vessels

The Concessionaire shall ensure that the closing faces of all split barges/dredgers and the doors and chains of hopper barges used to convey dredged material, are in good repair and that such closing faces and doors do not permit leakage when closed and are kept closed when the barges/dredgers are in the dredging area or are conveying such material to the disposal site.

2.3.9. Spillage and Siltation

The Concessionaire shall strictly abide by all consent conditions defined in any Authorisation granted for the construction and operation of the development/project. All operations shall be conducted so as to minimise spillage and loss of fines, and to ensure that siltation of areas in adjacent navigable waters or areas of the site where the dredging has been completed and handed over, does not occur, nor the recycling of materials during dredging and reclamation operations.

Should siltation of navigable waters or areas adjacent to the Site occur during the currency of the Agreement, as a result of dredging operations, the Concessionaire shall change his method of operations to prevent further siltation to these areas. The Concessionaire shall also remove any such siltation from these areas as soon as possible, such that normal vessel movements are not restricted/affected and previous dredge depths are restored. The

Concessionaire shall also carry out additional surveys as required by the Independent Engineer to confirm whether or not siltation is occurring. Any expense to which these requirements may give rise shall be deemed to be included in the Agreement Price.

Where reclamation material is to be deposited the Concessionaire shall remove any soft material on the seabed just prior to the placement of the reclamation. The placement pattern of reclamation material shall be agreed and co-ordinated to prevent soft and silty material from being trapped in pockets or lenses under or within the reclamation.

Notwithstanding the general requirements of this Sub-clause, the Concessionaire shall carry out a bathymetric survey of the following areas after the completion of the dredging works:

- Berth pockets
- Inner channel, Harbour Basin and Approach Channel

Any siltation which has occurred in these areas since the initial survey shall be deemed to be caused by the Concessionaire and shall be removed and disposed of offsite by the Concessionaire at his own cost and to the approval of the Independent Engineer. Surveys of these areas may be instructed by the Independent Engineer at intermediate times during the course of the Agreement if it appears that siltation is occurring. The cost of the initial, intermediate and final surveys shall be deemed to be included in the Concessionaire's tendered rates and prices.

2.3.10. Navigational Requirements

The Concessionaire shall observe all national shipping and navigation codes and regulations.

The Concessionaire's dredging vessels shall not cause any damage or disruption to the services on the seabed or laid across/ in the vicinity of the navigable channels and they shall abide by all regulations and conditions imposed by the services agencies. Any damage or claim shall be settled by the Concessionaire through his Third-Party Liability Insurance.

The Concessionaire shall conduct his operations so as not to obstruct the marine traffic in the area. He shall keep the Coast Guard and local Authorities informed about all planned and on-going activities, and he shall comply with the general requirements of the Coast Guard and local Authorities regarding traffic in the area.

Part of the Works comprises the reclamation of nearshore areas. The Concessionaire shall arrange his sequence and programme to utilise the suitable dredged material and to avoid any delay and shall be deemed to have included all associated costs in the contract price.

Floating plant shall display appropriate day and night signals, and the Concessionaire shall ensure that a look-out is kept at all times.

2.3.11. Anchors and Moorings

All anchors and moorings used by the Concessionaire shall be to the approval of the Independent Engineer and the Authority as appropriate. The Concessionaire shall use floating buoys to mark the position of the anchors. All location markers shall be visible day and night. The Concessionaire's anchor wires and floating pipelines shall not obstruct navigable channels.

The Concessionaire shall prepare a safety schedule to show how the position of anchors and moorings are co-ordinated with other construction floating plant operating at the same time on the site. The safety schedule shall also record where anchors and moorings cross into any operational harbour/ navigation channels and how the lowering of anchors will be accomplished safely to allow third party vessels to pass.

2.3.12. Abatement of Pollution and Nuisance

The Concessionaire shall take precautions to minimise nuisance and pollution as detailed out in this section

The Concessionaire shall adopt measures to control marine pollution resulting from his activities, particularly in relation to Site clearance, dredging and reclamation operations, dredger refuelling and in so doing shall comply with all statutory requirements and the requirements of the MoEF&CC, other regulatory authority or the Authority.

2.3.13. Removal of Floating Debris

Floating debris within the Site arising from any source shall be collected and disposed off by the Concessionaire at regular intervals agreed by the Independent Engineer. Floating debris shall be prevented from dispersing outside the Site.

2.4. SURVEYS

2.4.1. Tide and Wave Gauges

The Concessionaire shall establish a tide gauge and confirm the same by survey prior to in- or out-surveying.

The tide gauge shall also transmit tidal data to the Concessionaire's dredging equipment. Electronic records of wave and tidal data shall be provided to the Independent Engineer and the Concessionaire shall provide a copy of the program the Concessionaire uses for

determining the tide and wave data. Temporary tide gauges shall be installed around the site as work proceeds. Temporary tide gauges shall be mounted vertically and firmly on rigid supports at locations agreed by the Independent Engineer at all times during execution of the marine works and shall be calibrated, levelled and fixed to give tidal readings within an accuracy of 20 mm. These gauges shall be levelled and calibrated back to the automatic tide gauge.

During the Agreement, the Concessionaire shall operate a real time tide and wave gauge. The gauge shall be deployed in a seabed mounted frame at a location agreed with the Independent Engineer which will not be affected by the operations of other parties. The Concessionaire shall log the tide and wave gauge continually throughout the Agreement at a rate agreed with the Independent Engineer.

The tide and wave gauge shall be a ADCP wave monitor or similar approved. The gauge shall be capable of monitoring water depth to an accuracy of ± 5 mm and temperature to an accuracy of ± 0.1deg C, it shall be programmable to acquire data in burst durations ranging from 1 minute to 72 hours. The gauge shall be capable of being interrogated or reprogrammed remotely, either through the use of a seabed cable or by telemetry and to transmit the tide readings to facilitate real time reduction of surveys. Readings from the tide and wave gauge shall be submitted to the Independent Engineer on a weekly basis to a format agreed with the Independent Engineer.

In addition, up to 3 temporary tide gauges shall be installed at strategic locations around the Site. The temporary tide gauges shall be installed to give immediate visual measurements of sea level. They shall be constructed vertically and firmly fixed on rigid supports at locations agreed by the Independent Engineer and shall be levelled and fixed to give tidal readings within an accuracy of 20 mm.

Temporary tide gauges shall be made of 50 mm thick hardwood and shall be at least 250 mm wide and established with 0.0 m at the Chart Datum. The gauges shall be painted on the marked faces with alternate 100 mm stripes in red and white and shall be marked and numbered in black at 0.5 m intervals over the tidal range from 0.0 m to +3.0 m CD. The painting applied shall consist of one primary coat, two undercoats and one finishing coat.

2.4.2. Survey Equipment

Soundings for in- and out-survey purposes shall be carried out by means of a multibeam system. These surveys shall cover at least the entire works for development of the Project area of the Site, including a 150 m strip beyond the boundary of the dredged areas specified on the Drawings.

The coverage of the bottom with the multibeam survey shall be 120% (i.e., the spacing of the survey lines shall be at least 20% less than the width covered by the multibeam echosounder for each survey line/area).

Sounding for interim surveys shall be carried out by means of a recording dual-frequency trace echo sounder with sufficient sensitivity to permit an accurate measurement of seabed levels and any loose material that might be present above bed level.
For the avoidance of doubt, In /Out survey frequencies of 33kHz and 200-220 kHz shall be recorded but the 200-220 kHz frequency shall be used for verifying level compliance with the Authority's Requirements.

Survey equipment should be equipped with a heave compensation device, to allow for proper surveying when waves are in excess of 0.2 m.

Details of survey equipment (user manuals) shall be available for reference on request of the Independent Engineer.

2.4.3. Calibration

Before commencing any surveys of surfaces below water, the Concessionaire shall conduct trials of the equipment and methods to be used, including calibration procedures, in the presence of the Independent Engineer. Calibration bar checks shall be carried out at the beginning and end of each day's surveying over the full range of anticipated depths. All surveys shall include bar checks and the trace produced by the echo sounder shall be spot-checked at random using a sounding chain with base plate or by other approved means.

2.4.4. Position fixing

The Concessionaire shall provide, install, operate and maintain an approved DGPS which shall fully cover the site of the works for development of the Project and be constantly in operation during the dredging and survey works. All floating equipment is to be located in position using this DGPS system with the location to be entered into an on-board computer and printer and suitable navigation software.

The system shall be installed and tested and set to work for continuous operation with the specified accuracy for the entire period of dredging. The system shall be fully operational from 7 days before the commencement of the pre-dredge survey operation until the last post-dredge survey drawings have been signed and handing over and the Independent Engineer has issued an accepted certificate. No dredging work shall be undertaken while the position fixing system is non-operational or when the positioning system is outside the specified accuracy.

Horizontal and vertical control shall be established by means of RTK-DGPS across the whole of the Site and shall at all times maintain a repeatable accuracy in the vertical plane should be within plus or minus 0.05 m.

Before the start of the works for development of the Project, the Concessionaire shall demonstrate that the repeatable accuracy of the DGPS is within the specifications stated. The Concessionaire shall record and display the coordinates of the fixed point in the survey spheroid and datum and projection as well as in the required chart datum in RTK-DGPS. To this end, the Concessionaire shall input the correct geodetic parameters.

The Concessionaire shall inform the Independent Engineer forthwith of any breakdown, irregularities or otherwise, affecting the positioning of his vessels or other equipment. Delays incurred in the implementation of the Works as a result of non-functioning of the DGPS shall not be reimbursed under the Agreement and will not entitle the Concessionaire to an extension of the Time for Completion.

2.4.5. Setting Out of Surveys

The Concessionaire shall be responsible for setting up his own position-fixing system for setting out and survey control together with position fixing of his floating plant.

The spacing between adjacent parallel survey lines shall not be greater than 20 m. Where the echo sounding traces indicate slopes steeper than 1 in 4 and/or a vertical step in excess of 0.5 m additional survey lines shall be recorded to run at 90° across the feature to obtain a continuous trace of the feature. Main survey lines shall also be run at 90° to the berthing line and berth pocket when these form part of the works to the satisfaction of the Independent Engineer.

Sounding along lines at 90° to the main survey lines shall be carried out at intervals of 50 m and shall include lines coincident with the ends of the main survey lines.

2.4.5.1. Survey Area

The survey area shall generally extend over all areas to be dredged or filled/reclaimed over and where appropriate up to proposed quay faces for the in-survey, and 150 m beyond any dredge area.

2.4.6. Surveys

The Concessionaire shall submit the following surveys to the Independent Engineer. The following types of survey shall be considered as a minimum survey requirement:

a) IN Survey

The IN-survey shall be carried out prior to the start of dredging, as soon as possible after the award of Agreement, but not more than 30 days before commencement of dredging or as per direction of the Authority.

The IN-survey shall extend at least 100m beyond the areas to be dredged in all directions horizontally or toe lines where physically practicable for the survey vessel to access. The pre-dredging survey shall also cover an area of the navigable channel(s) to the site, to be agreed in advance with the Authority. Care shall be taken with the overlap between surveys and any anomalies arising there from shall be resolved to the satisfaction of Authority.

Before commencing dredging, the electronic positioning equipment shall be calibrated before and after each survey as directed by the Independent Engineer. The level of the seabed shall be recorded by means of echo sounding equipment using frequencies 30 KHZ and 210 KHZ simultaneously. Soundings shall be taken to nearest 100 mm. The equipment shall be calibrated in the presence of the Independent Engineer before and after carrying out soundings. All the levels shall be carefully reduced to Chart Datum. On completion of the surveys the soundings shall be mutually verified and agreed between the Independent Engineer and Concessionaire and the Concessionaire shall prepare record drawings to a scale of 1 : 500 or as approved by the Independent Engineer, to show the pre-dredging surface levels of the sea bed. Four copies of these drawings shall be signed and dated by the Concessionaire and appointed independent surveyor (if any) and the Independent Engineer.

At the beginning and at the end of each day's soundings, a bar check shall be taken on the echo-sounding machine. If the results of these checks are not to the satisfaction of the Independent Engineer or his Representative, the soundings will be rejected and a fresh survey carried out. This stipulation applies to all soundings taken under this Agreement.

The echo sounder’s high frequency transducer data shall be that used for the Pre-dredge Survey. Notwithstanding the foregoing, Pre-dredge Surveys shall be run with data logging from both the echo sounder’s high and low frequency transducer and archived for future reference purposes.

The Pre-dredge Survey as accepted and approved by both the Independent Engineer and Concessionaire shall form the basis for all volume calculations throughout the execution of the Works.

The in-survey shall be plotted on plan sheets at a scale not less than that stated in the Dredging Requirements and shall be signed by the Concessionaire as representing the seabed level of the dredge area at commencement of dredging.

b) Interim Surveys

Interim surveys intended to support applications for interim payments or else in support of design assessments shall be undertaken in accordance with the same requirements for in- and out-surveys.

Progress Surveys shall be carried out with a maximum line spacing of 20 metres.

Progress Surveys shall be carried out using the echo sounder's high frequency transducer but with both high and low frequency transducer data being logged.

Depths on charts are to be displayed in decimetres rounded off to the nearest decimetre.

Volumes are to be calculated as the difference between the Pre-dredge Survey and the dredged surface.
For the purpose of volume calculations, average soundings shall be used.

Should weather conditions be such that the Concessionaire deems that the acquisition of good survey data is not possible then the survey shall be delayed until conditions have improved.

c) OUT Surveys

The OUT-survey shall be carried out within 28 days of the completion of the Agreement. The OUT-surveys may be used as a part of the final surveys if they are carried out within the above stated periods.

Not more than 14 days before the date on which the Authority is requested to issue a Taking-Over Certificate for the completed dredged area and/ or 28 days prior to the end of the last Agreement Completion Area for the whole of the works for development of the Project, undertake an out-survey of the dredged area, including a multibeam survey and physical sweep by plough, shall be carried out by the Concessionaire, to confirm that the area is to the Agreement level and no maintenance dredging is required to achieve the dredge level specified on the design drawings.

The Concessionaire shall give the Independent Engineer and the Authority not less than 7 days' notice of his intention to undertake the out-survey and shall make arrangements for personnel from the.se organisations to be present during the survey, should they so require.

The OUT-survey shall be carried out by the Concessionaire over the same area as the IN-survey with closer spacing.

Post-dredging Survey line spacing shall be such so as to give 100% bottom coverage and 100% overlap. Long lines shall also be run along the toe lines in addition to cross lines.

The post-dredging survey shall be carried out to confirm that the Dredging Profiles have been achieved. The post-dredging survey shall cover the same areas as the pre-dredging survey. The post-dredging survey shall be carried out within 14 days of the completion of dredging in any area.

A joint sounding survey shall be carried out by the Concessionaire and the Independent Engineer over the dredged area on a 5m-by-5m grid to check the final dredged levels. The levels obtained by the soundings shall be mutually verified and agreed upon between the Concessionaire and the Independent Engineer and shall be recorded on drawings prepared by the Concessionaire to the same scale as used for plotting original seabed levels. Four copies of these drawings shall be signed and dated by the Concessionaire, appointed independent surveyor (if any) and the Independent Engineer. The other requirements of "Survey before Dredging" shall also apply to this survey.

The above procedure shall be applicable also for interim surveys required for progress verification or for interim payments. Any or all interim surveys shall be carried out at the Concessionaire's cost.

At the end of the Agreement, a composite survey plan showing the results of all surveys except where over-surveyed, shall be provided to the Authority by the Concessionaire.

The Concessionaire shall, in conjunction with the completed out-surveys, demonstrate that no part of the dredged area is above the required dredged level, by carrying out a multi-beam survey. All out surveys are to be witnessed and approved by the Independent Engineer and/or the Authority, should they so require.

If the out-survey do not prove that no part of the dredged area is above the required dredged level, the Concessionaire shall be responsible for the further dredging/removal of material, debris and further survey sweeps, as necessary, to prove that no part of the dredged area is above the required level.

The out-survey shall be plotted on plain sheets at a scale not less than that stated in the Dredging Requirements and shall be signed by the Concessionaire as verification that the area on completion of dredging satisfies the Agreement requirements.

2.4.7. Survey Presentation

The Independent Engineer shall be provided with three prints and a digital copy (in AutoCAD format at the version stated in the Authority's Requirements) of each survey drawing plotted

to a scale not less than that stated in the Dredging Requirements, related to the Project Grid, as soon as possible after completion of each survey. Echo sounder data, reduced to Chart Datum, shall also be provided to the Independent Engineer on CD [electronic format] in X-Y-Z format.

3. STANDARD SPECIFICATIONS

The construction of reclamation Works shall generally comply with the requirements of the relevant standards, including all up-to-date amendments, and in particular the requirements of this section of the Specification. The Works shall comply with the relevant standards which shall include:

- BS 6349-5:2016 [Maritime structures — Part 5: Code of practice for dredging and land reclamation]
- PIANC Report No.100:2009 [Dredging Management Practices for the Environment]
- CIRIA 2012, Hydraulic Fill Manual.

3.1. SCOPE OF WORK

The Works covered by this Section shall include reclamation for:

- Offshore reclamation area with sand fill

Included in the works for development of the Project is material testing, either within the works for development of the Project or at an approved material source location.

The Concessionaire shall be responsible for:

The design and formation of stable underwater slopes, as part of the works for development of the Project.

Payment of all costs related to sand extraction and supply, including but not limited to the mining, transport, disposal, including but not limited to all fees, levies, taxes, etc.

The Concessionaire shall comply with any regulatory requirements for environmental monitoring in respect of his reclamation operations. The Concessionaire shall comply with any mitigation and monitoring proposals defined in any EMP or EC, or any other requirements imposed as a condition of consents.

The Reclamation Works includes undertaking all surveys necessary to control, monitor and verify the dredging and disposal has been undertaken in accordance with the Agreement.

3.2. RECLAMATION - PARTICULAR REQUIREMENTS

This section of the reclamation specification contains particular requirements for the reclamation works to be undertaken under the Agreement. This reclamation requirements take precedence over the general reclamation specification.

3.2.1. Description of the Reclamation works for development of the Project

. In addition, the Concessionaire shall be responsible for providing ground treatment to the reclamation material to achieve the minimum QC values specified in the specification. The

Concessionaire shall allow for reclamation losses, compaction losses and settlement losses during the construction period. This document should be read in conjunction with other Specifications.

The Reclamation Works to be undertaken comprise the following:

a) General Reclamation Fill for the offshore area: For the area that needs to be reclaimed, the Concessionaire shall use granular material from an offshore source. The material as placed shall achieve a minimum representative φ'max of 32.5 degrees, (as defined in BS8002: 1994), an as placed saturated density of 21 kN/m3 (dry density of 18 kN/ m3) and compaction requirements in accordance with this Specification and the Specification for Ground Improvement.
b) Any other fill: Any other fill not specifically listed in this Specification, but shown in the Drawings, is deemed to be inclusive in the work for development of the Project. Characteristics similar as under a. General Reclamation Fill for the offshore area.

3.2.2. Reclamation Tolerances

The Final Surface of deposition and compaction of Fill Material, shall be within the tolerance stated below:

a) + 200 mm to the specified surface level on the Drawings;
b) 0 mm to the specified surface level on the Drawings

A '+' represents a level above design level and an '-' represents a level below design level.

The Concessionaire is allowed to leave excess surcharge material above design level on the area at locations where vibro-compaction are shown in the Drawings, or at another location approved by the Independent Engineer.

The reclamation shall be constructed in such a way that no ponds will be formed, and that rainwater will drain towards the perimeter of the reclaimed area. There shall be no abrupt change in level or gradient of the finished reclamation surfaces unless explicitly stated in the Agreement.

3.2.3. Confinement of Reclamation Works

Reclamation shall be in a confined area within the areas or parcels. On the perimeter of the reclamation area, a reclamation bund will be required to form the confined area.

The Concessionaire is required to minimize the impact of the Reclamation Works on the local marine habitat, including those during the construction of any external bunds. In the event that the discharge of losses of suspended sediments approach the specified levels or such indicated in the EIA or EC, the Concessionaire shall immediately notify the

Independent Engineer and the Concessionaire shall increase monitoring until such time as the suspended sediment levels reduce to within acceptable levels.

Should the concentrations continue to exceed the specified levels for a period of 12 hours, within the subsequent 12 hours the Concessionaire shall prepare proposals for reducing the concentrations to below the specified levels and shall submit these proposals to the Independent Engineer for approval. Such proposals may include a requirement for the Concessionaire to change his reclamation methods or temporarily cease his dredging and reclamation operations. Any damage to external bunds must be repaired immediately and if reclamation material is seen to escape, the Independent Engineer will require the Concessionaire to stop or change his reclamation works until the breach has been repaired.

3.2.4. Reclamation Fill Properties

Reclamation Fill Material shall be free draining and free from organic material. The material shall comply with Table 3.1 and

Table 3.2 when tested in accordance with BS 1377: Part 2 unless stated otherwise:

Table 3.1: Reclamation Fill Material properties

Aspect	Requirement
Grading	d50: between 0.2 and 2.0 mm
Maximum percentage of fines	15% by mass (particles passing 0.063 mm sieve)
Plasticity Index	< 10%
Soluble Sulphate content	< 1.5 g/L
Total Sulphate content	< 0.3% by mass
Uniformity coefficient	≥ 2.5
Effective friction angle of compacted material	≥ 32.5°
Maximum silt content dispersed in the granular material (Material passing a 63-micron sieve)	15% by mass
Magnesium Sulphate Soundness (BS 812 – 121)	<30%
Particle Density (BS 812-2)	>2.3 Mg/m3
Particle Size Distribution (PSD)	See Table 3.2

Table 3.2: Reclamation Fill Material Particle Size Distribution

Particle size [mm]	Fraction (by weight) finer than [%]	
	Upper boundary	Lower boundary
5.0	100	90
3.35	100	75
2.0	100	50
1.18	97	25
0.60	90	15
0.425	80	10
0.300	60	8
0.212	40	5
0.150	30	3
0.063	15	0

Reclamation fill material shall not be material of clay origin and shall not contain clay balls.

It shall be noted that sand shall preferably be silica, however, calcareous or other non-standard sands are allowed. When calcareous or other non-standard sands are used the geotechnical properties (in particular φ′c,, λ, plastic hardening modulus as well as the cyclic resistance to liquefaction, CRR) shall be measured in the laboratory and the effect on the design shall be confirmed by numerical analysis.

Samples of the Reclamation Fill Material shall be tested in large shear box tests to BS 1377: Part 7 or 8 as appropriate to confirm the Fill Material can achieve the minimum specified angle of internal friction when first placed and when compacted, when tested at densities to reflect the as placed and post compacted densities. The compaction characteristics of the reclamation material shall be determined in accordance with BS 1377: Part 4.

The soluble sulphate content of Fill Material placed within 500 mm of concrete, cement bound material or cementitious material shall not exceed 1.9 grams of sulphate, expressed as SO_3, per litre. The total sulphate content, expressed as SO_3, of Fill Material placed within 500 mm of metalwork shall not exceed 0.5% by mass.

From each source of material at least 5 sets of tests shall initially be undertaken in accordance with Table 3.3 to confirm that the material properties conform to the specification requirements prior to placement. If the material source is not consistent another set of five tests shall be undertaken to verify that the material complies with the specification requirements.

Table 3.3: Tests on fill material

Initial Tests on Fill Material of Different Types	
Test	Minimum no. of tests
Plasticity Index	5 (if appropriate)
Grading (PSD)	5
Aggregate Impact Value	5 (see Note 1 below)
Magnesium Sulphate Soundness	5 (see Note 2 below)
Sulphate content	5
Water Absorption	5
Organic matter	5
Carbonate content	5
Angularity	5
Hardness	5
Maximum / minimum density	5
Large Shear Box test undertaken at the anticipated untreated as placed density and post compacted density	5
Particle Density	5
Compaction Tests including max and min density, optimum moisture content relationship and CBR tests	5 of each

Once it has been demonstrated that the source material(s) meet the specification requirements, further routine testing of Fill Material shall be undertaken in accordance with Table 3.4 prior to placement.

Table 3.4: Routine testing of Fill Material

Routine Testing on Fill Material in addition to initial tests	
Test	Minimum Frequency – One Test per

Routine Testing on Fill Material in addition to initial tests	
Plasticity Index	7,500 m3 (if appropriate)
Grading (PSD)	7,500 m3
Aggregate Impact Value	20,000 m3 (see Note 1 below)
Magnesium Sulphate Soundness	20,000 m3 (see Note 2 below)
Sulphate content	20,000 m3 (see Note 3 below)
Water Absorption	20,000 m3 (see Note 3 below)
Organic matter	20,000 m3 (see Note 3 below)
Carbonate content	20,000 m3 (see Note 3 below)
Angularity	20,000 m3 (see Note 3 below)
Hardness	20,000 m3 (see Note 3 below)
Maximum / minimum density	20,000 m3 (see Note 3 below)
Large Shear Box test undertaken at the anticipated untreated as placed density and post compacted density	20,000 m3 (see Note 3 and 4 below)
Particle Density	20,000 m3 (see Note 3 below)
Compaction Tests including max and min density, optimum moisture content relationship and CBR tests	20,000 m3

- Note 1: The Aggregate Impact Value Test will only be undertaken for fill materials with ≥ 20% of particles by mass retained on the 10mm sieve.
- Note 2: Magnesium Sulphate Soundness tests are not required for General Reclamation Fill.
- Note 3: The frequency of routine testing may be reduced for these tests if good consistency is demonstrated by the test data and/or the material properties are consistently better than required by the specification.
- Note 4: The minimum frequency of shear box testing shall not be reduced for the Reclamation Fill material adjacent to Quay Walls.

3.2.5. Fill Placed Density / Compaction Requirements

All Reclamation Fill Material which requires compaction as shown on the Drawings shall be compacted to obtain a Relative compaction of at least 95% of the maximum dry density

according to the modified Proctor test above mean sea level and a Relative Density to meet the compaction requirements for liquefaction below mean sea level.

3.2.6. Hydraulic or other methods of placement of fill

The Concessionaire shall take into account in the execution of the Works the following:

a) The Concessionaire shall use all necessary measures to contain the material within the boundaries of Concessionaire's design;
b) The Concessionaire shall control the deposition or placement of material to obtain a homogenous reclamation fill, avoid concentrations of fine or shell material in localised areas or the formation of compressible areas of fill and shall conduct regular monitoring of materials, in-situ testing, sampling particle size distribution tests and other materials laboratory test to ensure the appropriate acceptability criteria for placed fill are being met.
c) The existing seabed layer consists of sand and weekly to moderately weathered rocks underlying the moderately rocky strata, the placement of fill shall be done in such a way so as to prevent instability of the sub-soil and by methods approved by the Independent Engineer.
d) The Concessionaire shall propose a working method in the Method Statement and describe in detail;
    a. what will be the thickness of the underwater fill layers;
    b. how the situ soil mixing with the reclamation fill will be prevented, and
    c. how the mud waves formed will be prevented.
e) The Concessionaire shall place the material underwater in uniform sub-layers. Underwater fill shall be placed strictly following Concessionaire's design for maximum layer thicknesses to minimise the risk of local instability of the subsoil.
f) The Concessionaire shall prepare strict protocols to be adhered to for the placement of fill. The protocols shall include operational rules for handling breakdowns;
g) The Concessionaire shall make sure that the Independent Engineer can witness sand placement;
h) The Concessionaire shall deposit fill material evenly over the area being filled. The overall slope of an advancing face of the fill shall be such as to avoid failure of the fill or underlying material;
i) An advancing face shall generally proceed in a direction away from the fill in such a way that any material displaced by the filling is not pushed into the fill area;
j) Trenches shall be filled to existing seabed level before placing fill over adjacent soft material. The Temporary Works design shall determine the minimum required distance from any filling to any unfilled trench;
k) The stability of the reclamation layering shall be proven through Concessionaire's design. Prior to placement of a new layer of fill the Concessionaire shall verify the inside profiles and prove through design that additional layers can be placed without affecting the homogenous nature of the reclamation fill and it's stability;

l) During land-based pumping, the Concessionaire shall pump through multiple pipe branches in order to reduce flow it a single location which could result in erosion pits and disturbance of the underlying soil;
m) During land-based pumping the Concessionaire shall fit all pipes with a spray hood to prevent the development of an erosion pit and disturbance of the underlying soil

The methods used shall be such as to prevent shear failure of the underlying materials. If, nevertheless, shear failure occurs of the marine deposits or other seabed material causing 'mud waves' or other gross displacement of the seabed or reclamation, the Concessionaire shall immediately suspend the deposition of fill in that area and shall raise a Non-Conformance Report detailing the remedial action he shall take in order to comply with the Specifications.

3.2.7. Protection from the sea

During construction erosion of fill material along unprotected sides of the reclamation due to forces from the sea shall be anticipated. Concessionaire shall protect the slopes as soon as possible to reduce the loss of sand. The loss of material or slopes due to reclamation slopes being exposed to the action of currents and waves shall be the responsibility of the Concessionaire . The Concessionaire shall allow for the costs associated with the quantity losses and/or provide temporary slope protection. Any sand deposited by Concessionaire or forces from nature outside the Site boundaries shall not be eligible for payment.

3.2.8. Protection from Water and Weather

Surfaces after filling or excavation shall be protected from damage due to water or from exposure to weather conditions. Surfaces shall shed water and prevent ponding. Water levels in excavations for structures, pits and trenches shall be lowered and maintained by appropriate measures sufficient to enable the structures to be constructed safely.

3.2.9. Fill Material allowed to become unsuitable or to deteriorate

Fill Material which has been used or is required for use in the permanent work and which has become unsuitable such that it no longer meets the specification shall be replaced or otherwise dealt with to make the material compliant. If the Concessionaire chooses to deal with the material, he shall submit his proposals for how he intends to carry out the works.

Material to be replaced shall be disposed of by the Concessionaire.

3.2.10. Removal of Fill Material for Reclamation Works

Fill Material which is required for use in the Permanent Works shall not be removed from the Site unless permitted in writing by the Authority.

3.2.11. Compaction Trials

The Concessionaire shall carry out trial(s) to demonstrate the adequacy of the proposed placing and compaction methods to achieve the requirements of the design, and to examine the sequence of operations.

Each trial shall be carried out over an area of not less than 40m x 20m and shall be undertaken “in the dry”. Each trial shall comprise at least four (4) layers of fill.

Trial(s) shall comprise filling the areas using the plant, methods and sequence of construction proposed by the Concessionaire. Following placing and compaction of a layer of fill, the Concessionaire shall undertake four in-situ density tests (sand replacement method or water replacement method, as appropriate to BS 1377:Part 9:1990), together with four associated laboratory compaction tests conducted on material taken from around the in-situ density test, as appropriate, to BS 1377: Part 4: 1990, to demonstrate the attainment of the relative compaction required as defined in Clause 3.2.5. . The in-situ density test shall be conducted in the lower half of the compacted layer. Where the percentage relative compaction is not achieved as required in Clause 3.2.5. the Concessionaire’s methods and plant shall be adjusted such that the compaction requirements are achieved.

If the material properties for the fill vary significantly during the progress of the Works, additional trial(s) will be required.

A minimum of 3 samples of the Fill Material from different areas of the trial shall be tested in large shear box apparatus to BS 1377: Part 7 to determine the Fill Material angle of shearing resistance. The test shall be undertaken at the same relative compaction density as that achieved in the compaction trial. Where the minimum/maximum material properties are not achieved as required in Clause 3.2.1. the Concessionaire’s methods and plant shall be adjusted such that the requirements are achieved.

Separate compaction trials relating to specific ground improvement methods are covered in Section 3.4. Ground Improvement.

3.2.12. Ground Treatment/Improvement

Reclamation Fill Material will be subjected to densification to prevent liquefaction, limit settlements and to increase the fill shear strength. This work will also include settlement transition zones between areas where differential settlement is likely to occur. The Specification for the ground improvement is covered in Section 3.4. Ground Improvement.

3.2.13. Reporting

3.2.13.1. Frequency

Pre and post filling surveys shall be carried out prior to and after execution of the works for development of the Project. Interim surveys shall be completed at least weekly during execution of the works for development of the Project.

3.2.13.2. Reclamation activities

In addition to any other progress reporting requirements, the Concessionaire shall maintain a comprehensive daily updated database of the progress of all dredging, movement, filling, compaction and productivity data throughout all dredging, filling and compaction operations which shall include but not be limited to the following information:

a) Dredging/filling activity type;
b) Dredger name and fleet number;
c) Time periods for all dredge related activities including dredging, sailing, coupling, pumping, decoupling and delays for position shifts, maintenance, down time due to shipping movements, breakdowns, etc.;
d) Summary of production rates for dredging and filling activities;
e) Dredge location;
f) Fill location;
g) Estimated daily production of dredging and sand supply activities;
h) Lengths and diameter of all pipelines (floating / sinker / shore);
i) Presence or otherwise of booster pump or pumps with pump fleet number and position;
j) Compaction equipment name and fleet number;
k) All compaction related data, including position, compaction depth, compaction times, power consumption records, etc.

3.2.13.3. Installation reports

An installation report shall be provided for each tide gauge, benchmark or other (semi) permanent survey point. The report shall include, but not be limited to, the installation methodology, instrument type and antiquation, any corrections and transformations, accuracy and location, including photographic record.

3.2.13.4. Survey database

The Concessionaire shall maintain a comprehensive daily updated database of all survey activities and results which shall be used as a basis for all progress reporting. The database shall include information but not be limited to:

a) Date/time;
b) Survey vessel;
c) Survey type;
d) Survey equipment;
e) Surface covered;
f) Weather conditions; and
g) (hyper)link to surveyed data (raw and processed).

3.2.13.5. Weekly progress reports

The Concessionaire shall provide input into the weekly progress report which shall include but not be limited to:

a) Description of the survey activities;
b) Equipment and calibration results; and
c) Progress drawings.

3.2.13.6. Monthly reports

The Concessionaire shall provide input for the monthly report with all survey results. The report shall include but not be limited to:

a) A statement on the purpose and rationale of the investigations;
b) Description of survey plan and equipment;
c) Survey operations including data acquisition and processing;
d) Geodetic and navigation parameters;
e) Calibration results and analysis;
f) Analysis of the accuracy, data density, and reliability of the data presented;
g) Digital (ASCII or Excel) tabulated time series data of water level height; and
h) Progress drawings.

3.2.13.7. Information Models and drawings

The survey data shall be used as input into Information Models.

3.2.14. Verification to Determine Sand Fill Quantity

Pre and post filling bathymetric and topographic surveys shall be carried out determine reclamation Fill Material quantity.

3.3. RECLAMATION - GENERAL REQUIREMENTS

3.3.1. Definitions

Reclamation is the formation of land over an area offshore seabed, by the deposition of granular Fill Material to the limits stated in the Agreement.

Dredged Profile is the surface, within the specified seabed tolerance, defined by the lines, levels, and slopes on the Drawings, above which all material, regardless of type or nature, is to be removed by dredging under the Agreement.

The **Final Surface** of any work is the surface, within the specified tolerance, defined by the lines and levels shown on the Drawings to which all of the works for development of the Project carried out under the Agreement are to be finished.

Earthworks Final Surface is the surface defined on the Drawings to which all earthworks (including reclamations works) are to be completed.

Areas of Fill are areas within the Site, including areas in embankments, platforms and slopes and in excavations for structures, pits and trenches, in which Fill Material is required to be deposited and compacted as part of the work for development of the Project.

Fill Material may consist of soil, rock, which is on or below the Site at the commencement of the Agreement, or which is imported to the Site, and which meets the requirements of the Specification.

Hydraulically placed Fill Material shall be granular Fill Material placed by hydraulic methods.

Other Fill Material shall be Fill Material placed by a non-hydraulic method.

A **Batch** of Fill Material for Reclamation or Fill material is defined as any quantity of Fill Material which has similar properties throughout.

Formation is that part of the Final Surface on which a pavement, structure or utility, is constructed, or on which the blinding or bedding for a pavement, structure or utility is placed.

Geotechnical Instrumentation is the installation and monitoring of instruments in the ground or structures to provide information on soil and rock parameters for the purposes of construction control and performance monitoring.

Marine Structures are seawalls, revetments, breakwaters, jetties, quay walls, dolphins, beacons, landing steps for berthing of vessels and other similar structures.

Relative Compaction is the percentage ratio of the compacted dry density divided by the maximum dry density. For the purposes of calculating relative compaction only the maximum dry density shall be determined in accordance with BS1377 part 4 using the 4.5kg rammer method.

Relative Density or Density Index is defined in BS1377 part 4. The maximum and minimum densities used to determine the relative density of a compacted material shall be determined in accordance with BS1377, part 4, Section 4.

3.3.2. Site Clearance

Prior to the start of filling operations in any area, the area in which filling is to take place shall be cleared of any rubbish, flotsam, seaweed, and other vegetation and the seabed surface cleaned by the removal of highly compressible fine sediments.

Materials arising from this site clearance shall not be burnt or covered up in any part of the works for development of the Project under any circumstance. All materials arising from this clearance shall be removed from the site and correctly disposed of by the Concessionaire.

3.3.3. Surface Preparation for Fill Material

Surfaces on which Fill Material is to be deposited above sea level shall be prepared after site clearance in accordance with the following requirements:

(a) Topsoil and organic matter shall be removed, where necessary,

(b) Soft spots, boulders and other materials which are unsuitable or unstable shall be removed.

(d) For hydraulic reclamation bunds and/or drainage channels shall be formed to control the return path of the water to the watercourse.

(g) Surfaces other than rock shall be scarified to a depth of 200 mm and compacted to the same standard as the Fill Material which is to be deposited.

3.3.4. Sequence of Reclamation Works

The Concessionaire shall programme his working methods and rate of operations to comply with the required reclamation/dredging sequences along with the progress of the breakwater construction. Reclamation works adjacent to the breakwaters and similar structures must follow the specified sequence and level tolerances in order for the breakwater to be constructed safely and in accordance with the structural design.

3.3.5. Deposition of Fill Material

Fill Material shall be deposited in a manner and sequence as indicated in the drawings such that minimum disturbance of the underlying material will be induced and such that slopes remain stable at all times.

The methods and Constructional Plant used for deposition of Fill Material under water shall be such that segregation of the material does not result. Fill Material shall not be deposited by end-tipping unless it can be demonstrated that the placed Fill Material can meet the Agreement requirements and the stability of slopes demonstrated for the rate of placement of the Fill Material.

Fill Material for blanketing layers and drainage layers shall be deposited uniformly.

If necessary, silt curtains shall be provided before filling activities commence to minimize the impact of the deposition of Fill Material on the surrounding environment.

3.3.6. Overfilling

In areas of fill formed of Fill Material other than Rock Fill Material, and where Reclamation Works Final Surfaces are sloping at a gradient exceeding 1 vertical to 3 horizontal, slopes shall be formed by overfilling and cutting back after compaction. Over-filling shall extend beyond the earthworks final surface by a horizontal distance of 0.5 m or three times the thickness of the compacted layer, whichever is greater.

3.3.7. Deposition of Rock Fill Material Adjacent to Structures and Utilities

Rock Fill Material deposited adjacent to, or above structures, piles or pedestals shall be hand packed or carefully placed by a method which does not cause damage or excessive lateral pressure to the adjacent structure or utility.

Rock Fill Material deposited around utilities, including pipes for submarine outfalls, shall be hand packed or carefully placed by a method which does not cause damage to the adjacent structure or utility and the fill shall be progressively brought up to the specified level by placing equal layers on both sides.

Rock Fill Material deposited directly on geotextile shall be deposited in a manner that complies with the geotextile manufacturer's instructions and that, in particular, the geotextile is not ruptured, and its performance is not impaired.

3.3.8. Spillage, Siltation and Turbidity

The Concessionaire shall provide such silt traps, settling ponds, drains and sluices and other temporary works, including temporary access roads and bridges, as may be necessary for the proper execution of the Work and in fulfilment of his obligations under the Agreement.

All reclamation operations shall be conducted so as to prevent flooding of adjacent areas and to minimise spillage and loss of fines from the Site, and to ensure that siltation of navigable channels, turning areas or adjoining facilities does not occur.

The sequence of filling in any area shall be such as to ensure that a build-up of fine material does not take place in any area of the Site and shall ensure that it is not drained back into the sea with excessive siltation and turbidity. Layers of fine material deposited as part of the reclamation process shall be excavated and removed from the reclamation material.

3.3.9. Formation of Mudwaves

If, during the placement of Fill Material, deep rotational or translational slip failures, mudwaves or large lateral displacements of materials occur, the Concessionaire shall stop filling immediately. The Concessionaire shall identify the cause of the movement and rectify the defect and stabilize the ground prior to the resumption of filling.

3.3.10. Erosion

When placing the Fill Material hydraulically, care shall be taken not to cause erosion or wash out the in-situ soil or previously deposited hydraulic Fill Material.

The Concessionaire shall assess and allow, while in a temporary state, for the risk of erosion of Fill Materials, geotextiles and rock materials, due to reclamation processes or caused by waves and current action prior to the completion of the permanent works.

3.3.11. Adjoining Property, Bunds and Drains

The Concessionaire shall take measures to protect all adjacent properties from adverse effects caused by the Reclamation works. Methods such as the construction of bunds and the installation of drains or temporary erosion protection shall be adopted and care shall be taken to avoid flooding to adjoining property and to ensure that no materials are deposited thereon as a result of the Works.

3.3.12. Survey Requirements

3.3.12.1. General

The details of the survey requirements are covered in Section 3.5. Survey Requirements.

3.3.12.2. Surveys to be carried out

The survey activities to be carried out shall include but are not limited to:

- Pre-construction survey of the Site, any Section or part thereof before commencement of any works for development of the Project;
- Post Construction survey of the Site area, any Section or part thereof on completion of an area of the Works activity and prior to being covered up;
- Daily and monthly intervals to monitor the progress of the Works and ascertain the Works done for assessment of stability, compliance and valuation;

- Any other surveys of the Works as requested by the Independent Engineer to show progress and compliance with the Authority's Requirements and Concessionaire's design.

3.3.13. General Requirements for Filling

All methods used for placing, grading, levelling and compaction of Fill Material shall be documented and submitted to the Independent Engineer at least 14 days prior to undertaking the work for development of the Project.

The Concessionaire shall be fully responsible for carrying out the works for development of the Project in such a manner as to avoid instability of the Fill Material and of underlying strata, and to prevent excessive intermixing of seabed material with overlying Fill Material. Underwater filling against existing slope profiles shall commence at the lowest level and the reclamation shall proceed progressively up the slope to minimise the risk of intermixing of materials or causing slope instability.

3.3.14. Temporary Side Slopes

Unless otherwise defined in the Agreement, the Concessionaire shall design temporary side slopes such that a factor of safety against rotational or translational slip failure of at least 1.3 is maintained at all times. The Concessionaire shall document his proposals for forming each side slope and demonstrate by calculation that the slope is stable. The documentation shall include proposals for the monitoring of pore pressures during slope filling operations.

Should slips, slides or areas of large lateral displacements occur, the Concessionaire shall stop filling in the affected area immediately. The Concessionaire shall do everything necessary to identify the cause of the movement, rectify the defect and stabilize the ground.

3.3.15. Temporary Works for Reclamation

The design of Temporary Works associated with reclamation works, ground improvements, slopes, and breakwaters including temporary slopes, stockpiles and drainage, shall be such that the risk of failure is not more than that which would be adopted if the Temporary Works were to be permanent. Allowance may be made in the design of the Temporary Works for the shorter design life and for the risk to persons and property and the surface water and groundwater conditions which are likely to occur during construction.

3.3.16. Haulage of Fill

Haulage of Fill Material to an area of fill shall proceed only when the compaction plant operating at the area to be filled have previously achieved the specified requirements for relative compaction of the Fill Material.

3.3.17. Handling and Storage of Fill Material

Fill Material shall not be handled or stored in a manner that will result in segregation, deterioration, erosion or instability of the material.

Different types of Fill Material shall be kept separate from each other.

Fill Material shall not be stockpiled on the foreshore or seabed within the Site unless specifically permitted under the Agreement.

Water levels in excavations for structures, pits and trenches shall be lowered and maintained at the lower level by appropriate measures sufficient to enable the Permanent Works to be constructed in the dry unless the drawings note Permanent Works as being constructed underwater.

3.3.18. Fill Material allowed to become unsuitable or to deteriorate

Fill Material which has been used or is required for use in the work and which has become unsuitable such that it no longer meets the Specification shall be replaced or otherwise dealt with to make the material compliant. If the Concessionaire chooses to deal with the material, he shall submit his proposals for how he intends to carry out the works for development of the Project.

Material to be replaced shall be disposed of by the Concessionaire.

3.3.19. Removal of Fill Material for Reclamation Works

Fill Material which is required for use in the works for development of the Project shall not be removed from the Site unless permitted in writing by the Authority.

3.3.20. Site Investigation

The Concessionaire shall carry out geotechnical investigations, upon Instruction by the Independent Engineer, including but not limited to, boreholes, inclusive of sampling, in-situ and laboratory testing, SPTs and CPTu’s in order to verify the Authority's design.

3.4. GROUND IMPROVEMENTS

3.4.1. Standard Specifications

The design and construction of Ground Improvement Works shall generally comply with the requirements of the relevant standards, including all up-to-date amendments, and in particular the requirements of this section of the Specification.

The Works shall comply with the relevant standards based on the type of compaction. All equipment and methodology shall be used on the basis of the manufacturers' recommendations.

For vibro compaction the relevant standards shall include BS EN 14731 [Execution of special geotechnical works. Ground treatment by deep vibration].

3.4.2. Scope of Work

The Ground Improvement Works to be undertaken shall comprise of:

- Pre-treatment soil investigation works including boreholes, electric cone penetration tests (eCPTu), necessary field and laboratory testing which is required for the design of vibro-compaction.
- Conducting initial field trial works by means boreholes, electric cone penetration tests (eCPTu), at the locations specified. Submission of post assessment report along with recommendations for main works for development of the Project.
- Ground improvement and soil densification of reclaimed fill through Compaction by vibro-compaction, and/or other techniques proposed by the Concessionaire and approved by the Independent Engineer.
- Carry out post treatment soil investigation works by means of boreholes, electric cone penetration tests (eCPT's), as advised by Independent Engineer to check the adequacy of improved ground as per design and submission of post assessment report for approval of Independent Engineer.
- Monitoring to ensure stability and achievement of the performance requirements.

All reclaimed material needs to be compacted and at some locations the underlying in-situ soils need to be compacted as well (if required).

Vibro-compaction is to be executed in a design grid with the objective to reach minimum 70 % Relative Density after compaction. Post soil investigation will be executed in the centroid of a compaction grid and also in between compaction point to verify whether the compaction requirements are achieved. In the evaluation, a rolling average of 1 m will be applied to the tip resistances.

It is up to the Ground Improvement Concessionaire to determine the type of probe and other remaining production parameters, required to achieve the compaction requirements defined above.

Ground improvement shall be undertaken in the areas shown on the Drawings and in accordance with this Specification. The items to be foreseen by the Ground Improvement (GI) Concessionaire include the following:

- GI Concessionaire shall set out the vibro-compaction locations on site.
- GI Concessionaire shall provide daily progress reports
- All auxiliary equipment required for vibro-compaction works (i.e., wheel loader, water pumps and storage tanks, generator, site office container, etc.);
- The vibro-compaction equipment must have built-in automatic digital monitoring system for continuous recording of power output and depth of penetration.
- GI Concessionaire shall provide its own fuel supply.

Design concept and calculations for the ground improvement works shall be approved by the Independent Engineer prior to commencement of work at site.

3.4.3. Design Requirements

Concessionaire shall submit complete design of ground improvement works scheme covering size, spacing, depth, diameter, arrangement pattern, replacement ratio, etc.) considering the following factors:

a) The design of ground improvement for the proposed facilities shall be made to achieve mitigation of liquefaction potential and to achieve relative density of 70%.
b) Seismic parameters shall be in accordance with IS: 1893 Part 1 2016 and to be designed for Zone II for liquefaction analysis.
c) Ground water table for analysis: at EGL.

3.4.4. Vibro-Compaction

3.4.4.1. Spacing

The Concessionaire shall determine the spacing between the compaction points to achieve the Concessionaire's design and the Authority's specification. The spacing shall be in the form of an equilateral triangular grid.

3.4.4.2. Depth of treatment

The vibrator tip shall penetrate full depth of reclamation fill. The ground shall be treated up to the depths of treatment specified in Drawing.

3.4.4.3. Locations / Spacing

The ground improvement with vibro-compaction shall be carried out in a design grid and c/c spacing as specified in the drawings the same shall be maintained. This spacing shall be decided based on the compaction on trial area and should ensure relative density of minimum 70%.

Post soil investigation is to be conducted at every 12,000 Sq.m shall be carried out to confirm the improvement density. After ground improvement the achieved relative density of reclaimed ground should not be less than 70%.

3.4.4.4. Finishing of Ground Surface

The finished ground surface of general reclamation fill shall be graded and levelled on completion of the reclamation works. Areas adjacent to structures shall be graded to drain away from structures and prevent ponding.

3.4.4.5. General methodology

Prior to commencing the works for development of the Project, the Concessionaire shall have placed sufficient reclamation sand fill above the finish level to allow for filling of depressions and settlement due to vibro-compaction.

Vibro-compaction shall be carried out by lowering the vibro probe vertically into the ground under its own weight assisted by flushing jets. Water required for the penetration and compaction process is to be obtained directly pumping from nearby water source.

The vibro probe shall be maintained at depths throughout the reclamation fill height until the compaction criteria is achieved.

The procedure shall be repeated over a grid pattern to be determined from the field trial results to ensure that the zones of influence overlap sufficiently to achieve the required compaction requirements throughout the area and depth to be treated.

All depressions created by vibro-compaction process shall be back-filled with suitable fill material and the post-treated ground shall be compacted and levelled to the final level.

In situations where reclamation sand fill has been placed on top of very soft, soft and firm cohesive deposits, the Concessionaire shall devise methods whereby the full thickness of the sand fill can be compacted without causing a mixing of the sand fill and the cohesive deposits.

Concessionaire shall also submit detailed construction methodology of installation of ground improvement works to the Independent Engineer in charge and shall obtain the approval at least one week prior to the commencement of works. Suggestions, if any, made by the Independent Engineer on the construction methods shall also be implemented by the Concessionaire.

3.4.4.6. Obstructions

In the event of obstructions being encountered that prevent the penetration of the vibro-probe, the Concessionaire shall carry out one of the following options:

a) Remove the obstruction and backfill the void with suitable fill material;
b) Re-position the treatment points and/or modify the layout for vibro-compaction works;
c) Additional probe locations around the obstruction;
d) Carry out other ground improvement measures to achieve the Authority's Requirements.
e) The Concessionaire may also be required to carry out additional boreholes to investigate the nature of the obstruction.

3.4.4.7. Reporting

In addition to any other progress reporting requirements, the Concessionaire shall maintain a comprehensive daily updated database of the progress of vibro-compaction works which shall include but not be limited to the following information:

a) Commencement level;
b) Probe number and location;
c) Depth of penetration;
d) Rate of penetration, lift heights, elapsed times, backfilling sequence;
e) Power consumption of the vibrator with depth during penetration and compaction;
f) Time for penetration, flushing, compaction and overcoming obstructions;
g) Details of obstructions, delays and unusual ground;
h) Volume of backfill consumed;
i) Weather report; and
j) Any other information as may be required by the Independent Engineer.

3.4.5. Trails and Monitoring

3.4.5.1. Field trial

Prior to any ground improvement works the Concessionaire shall carry out initial field trials to demonstrate the adequacy of the proposed improvement methods to achieve the performance requirements and to examine the sequence of operations.

The trials shall take place at a location as specified in the drawing and pre and post treatment testing as agreed by the Independent Engineer. The results obtained from the trials shall be used to assess the acceptability of the initial design.

All design parameters adopted during the field trials shall be duly recorded. These include (as a minimum) the details of vibro probe, power consumption, spacing and grid of compaction points, amount of washing required to create hole of sufficient diameter, volumetric change and/or sand consumption, number of passes required to achieve the specific improvement and average enforced settlement.

The Concessionaire shall submit detailed report of trial test for approval of Independent Engineer. Based on trial tests, if any variation in spacing of Vibro-compaction is required then Concessionaire shall suggest the required spacing to meet the requirement of the specifications.

3.4.5.2. Assessment of Ground Improvement

Areas of reclamation fill after ground improvement, any existing fill and in-situ soil, shall be tested by undertaking Cone Penetration Test (eCPT) with pore pressure measurement and boreholes with SPT record at a rate of at least two full depth profile of tests per 12,000 m² of area, to demonstrate compliance with both the Authority's Requirements and Concessionaire's design requirements.

CPTs shall be carried out in accordance with latest Indian Standards IS 4968 (part 1, 2 &3) and SPT as per IS 2131.

3.4.6. Installation

3.4.6.1. General

The work shall include installation as per the latest codal practice and using soil parameters indicated in the site investigation report as part of Volume VI prior to commencement of works for development of the Project. Concessionaire shall incorporate the technical suggestions, if any, given by the Independent Engineer in the design and shall revise the drawings accordingly prior to commencement of works for development of the Project.

3.4.6.2. Installation Procedure

Vibro-compaction shall be performed after site stripping and grubbing as per above mentioned clause.

a) The vibrator is located at the probe location and then lowered to the design depth with water jets operating.
b) A front-end loader then introduces granular backfill at the ground surface around the vibrator so that the backfill is allowed to fall down the annulus around the probe.
c) The Vibrator is then raised several feet to allow the backfill to fall below the vibrators tip.
d) The vibrator is then lowered to within at least 60cm of the initial penetration as amperage increase is monitored. This parameter is indicative and is to be re-established during initial field trial works.
e) The process is then repeated with the vibrator raised and lowered such that on each re-penetration, the tip of the Vibrator advances to within 60cm of the previous penetration depth, or refusal, whichever occurs first. The Vibrator will not be raised more than 120cm at any time unless the backfill stops flowing to the bottom of the vibrator.

f) Vibrator probe shall be capable of compacting the soils with a minimum centrifugal force ≥290KN.

3.4.7. Tolerances

The vibro-probe shall be kept as near to vertical as possible within the tolerance of 1 in 20 and shall be located within 150 mm of the planned positions in any direction.

3.4.7.1. Setting out

Concessionaire should construct and maintain Temporary Benchmarks (TBM) with concrete structure and level marked with paint inside the site throughout the construction period as required and as directed by the Independent Engineer. The MSL from the nearby permanent benchmarks should be transferred to the TBM and the levels of the TBM shall be rechecked periodically as directed by the Independent Engineer.

Setting out shall be carried out from reference lines and points shown in the drawings. The Concessionaire shall provide and maintain benchmarks at the area throughout the duration of works. Immediately before installation, the ground improvement point positions shall be marked with suitable identifiable pegs and markers.

3.4.7.2. Depth and spacing

The depth and spacing of the ground improvement points shall be as shown in the approved drawings and neither the depth nor the spacing shall be varied without prior agreement with the Independent Engineer. Any variations in depth of treatment due to site conditions not anticipated in the design shall be reported immediately to the Independent Engineer for information and any further action.

3.4.7.3. Position

The vibro-probe shall be kept as near to vertical as possible within the tolerance of 1 in 20 and shall be located within 150 mm of the planned positions in any direction.

3.4.8. POST TESTING

3.4.8.1. Post Soil investigation

After completion of vibro-compaction works, routine tests by means of borehole with recording SPT N value and eCPT up to the treatment depth should be conducted. The test method, frequency of testing and criteria for acceptance shall be agreed prior to the commencement of the treatment. The post soil investigation should be carried out near to pre soil investigation points and the average results of all the post test results shall be plotted based on the factual data and shall be presented in the post assessment reports.

Analytical interpretation for the conclusion of the test results shall be done based on achievement of the required criteria for the minimum of 90% of the depth treated / tested (on cumulative basis).

Post compaction eCPT's (or SPT's) will be undertaken 14 days after completion of the compaction in the tested area. Post SI cannot be undertaken while compaction is in progress within the area, as vibration and water/air jetting in the vicinity of SI may affect the SI results. In case the first pair of SI (first chance) doesn't comply with the specifications, a second pair of SI (second chance) shall be performed at 14 days after first testing. The results of the second chance post SI shall overrule the first results. The principle of first and second chance post SI is regularly applied in ground improvement projects by vibro-compaction, as the soil parameters may increase with time as a consequence of aging.

If the reclaimed soil comprises of calcareous material, the measurement of the soil resistance will be affected as crushing occurs due to the high loads applied by the test. When comparing cone resistance values in sand, at the same relative density and at the same stress level, but one in silica material and the other one in crushable carbonate material, a clear difference is found. Hence shell or Carbonate correction factor shall be applied to eCPT or SPT resistance whenever required.

3.4.9. Quality Control Systems

A comprehensive quality control system shall be implemented to ensure a high standard of work. The system shall include schematic online recording of each ground improvement point construction essential parameters (time, depth, energy, etc) are to be monitored using computerized recording systems / online (real time) recording. Post construction routine testing data should be maintained and submitted to Independent Engineer on periodic basis.

3.4.10. Surface Compaction

Post vibro-compaction works, before handing over of the treated area the Concessionaire should do surface compaction using vibro-rollers. Minimum 90% MDD needs to be reached after compaction.

3.4.11. Workmanship

The Concessionaire shall state the type and number of rigs used for the work and shall satisfy the Independent Engineer regarding the suitability, efficiency and adequacy of the equipment to be employed. On completion of each area of ground treatment the Concessionaire shall grade muck and surplus materials arising from the ground treatment to leave a reasonable firm and level working surface at no extra cost.

The Concessionaire shall inform the Independent Engineer, at regular mutually agreed intervals, of the forward program of ground treatment.

The Concessionaire shall submit to the Independent Engineer on the first day of each week, or at such longer periods as the Independent Engineer may from time to time direct, a progress report showing the current rate of progress and progress during the previous period on all important items of each section of the works for development of the Project.

On completion of the ground treatment works to the satisfaction of the Independent Engineer, the Concessionaire shall remove all plants and unwanted material from the site.

3.4.12. Submission

The Concessionaire shall submit approved design report confirming the design, including as-built layout, installation records, etc. and shall include the following minimum information but not limited to below documents:

a) Factual pre-treatment soil investigation report
b) Particular directives associated with design and execution which are relevant to subsequent use of the treated ground.
c) The source, type and quality of materials to be used for ground improvement works.
d) Quality control plan and inspection test plan (ITP).
e) Ground improvement records (includes power consumption, depth of penetration, method of treatment, presence of heave, date-time, obstruction/delays, any unforeseen conditions encountered, etc.).
f) Post treatment assessment reports.
g) Any other document.

3.5. SURVEY WORKS

3.5.1. Scope

The Concessionaire shall execute hydrographic and topographic surveys and measurements. The surveys and measurements shall form the basis for checking compliance with the specifications and Concessionaire's design, progress remuneration, progress assessment and assessment of completion for the different work parts.

3.5.2. Standards

The survey works shall comply with the relevant standards which shall include:

- Special Publication S44 Level 1a for hydrographic survey;
- IHO C-13 Manual on Hydrography;
- FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors & Nautical Cartographers (IBSC) and documented in IHO publication S-5 (Standards of Competence for Hydrographic Surveyors).

3.5.3. Control

3.5.3.1. Benchmarks

Concessionaire shall use the coordinates and level of the benchmark provided in the Authority's Requirements – Drawings to set out the works for development of the Project.

The Concessionaire shall, before construction commences, establish an adequate system of "third order" accuracy control points and benchmarks, which shall be clearly marked, adequately referenced and properly recorded. These benchmarks shall be maintained for

the duration of the Agreement and replaced or relocated as necessary. Benchmark accuracy shall be verified periodically to check for movement due to settlement, land subsidence or any other disturbance.

3.5.3.2. Horizontal and vertical control

Horizontal and vertical control shall be established by means of RTK-DGPS across the whole of the Site. Tide readings obtained from the tide gauge will be logged and checked against data logged with the RTK system.

3.5.3.3. Water levels

At least one tide gauge pressure sensor shall be installed at a location to be agreed with the Independent Engineer and shall record continuous water level measurements, collected at least every ten minutes, for the duration of the Agreement. The pressure sensor shall be accurately levelled to allow the measured data to be reduced to vertical datum. Periodic rechecking of the positioning shall be carried out.

3.5.4. Accuracy

3.5.4.1. Water level records

The sensor shall have a minimum accuracy of 0.05 m.

3.5.4.2. Hydrographic surveys

Vertical accuracy: The sum of the verified and or certified accuracy of all survey instruments used for determining the depth measured by hydrographic surveys shall be less than or equal to 0.10 m at a 95% Confidence Level.

Horizontal accuracy: The sum of the verified and or certified accuracy of all survey instruments used for determining the horizontal position of depths measured by hydrographic surveys shall be less than or equal to 1.0 m at a 95% Confidence Level.

The Concessionaire shall demonstrate a willingness to augment the accuracy of survey work by working to optimise the time advantageous sea state, weather and tidal conditions available.

3.5.4.3. Topographic surveys

The accuracy of topographic surveys in the horizontal plane and vertical plane shall be 0.03 metres.

3.5.5. Survey Requirements

3.5.5.1. Hydrographic Survey

Hydrographic survey shall be used to produce a digital elevation model (DEM) of the seabed, surrounding features and the works for development of the Project below the waterline. Swath bathymetry shall be carried out using a multi beam echo sounder (MBES) with additional single beam echo sounder for data validation and for use within shallow

areas. Both the MBES and the single beam shall operate at frequency of 200-220 kHz. The MBES shall be aligned with RTK-DGPS to provide accurate positioning throughout the survey works. In shallow water areas hand sounding methods may be used applying 10 m line spacing and sounding points along the line every 2 metre.

The Concessionaire shall undertake all hydrographic surveys using:

1. the same survey equipment;
2. the same frequency;
3. the same sailing speed; and
4. the same settings.

The area to be surveyed shall cover at least 100 m of the original seabed beyond the Site boundaries.

3.5.5.2. Topographic Survey

Topographic survey shall be used in order to produce a DEM of the works for development of the Project above the waterline. Where topographic survey is to be combined with bathymetric survey, i.e., at the edges of the reclamation area, the topographic survey shall extend into the water to provide an overlap in data of minimum 5m.

Cross sections of the reclamation bund structures shall be taken at 10m intervals along the line of the edge and shall record a point at each significant change in line and level of the slope with a maximum distance between survey points of 1m.

Topographic surveys over the reclamation shall be carried out over a 50m x 50m square grid, have data points along the gridlines at a distance of maximum 5 m and cover all features.

Topographic readings on ground level shall be taken avoiding pushing the receiver pole into the ground, so as to establish true ground level. Measurements on rock structures shall be carried out following the recommendations of CIRIA C683 The Rock Manual.

3.5.5.3. Calibration requirements

The Concessionaire shall provide certified copies of all calibration reports and test results before the survey equipment is deployed to the Site. The Concessionaire shall carry out ongoing calibration of all equipment in accordance with the supplier's recommendations and industry standards.

3.5.6. Setting Out and Surveys for Reclamation Works

The Concessionaire shall be responsible for the accuracy and setting out of all surveys which shall include a checking procedure and undertaking surveys as specified.

Each dredger and survey launch utilised in hydraulic reclamation works shall be equipped with and shall use DGPS electronic position fixing device capable of providing onboard a

continuously updating position from remote shore stations. The Concessionaire shall demonstrate that the type of position fixing equipment satisfies the Agreement requirements.

The Concessionaire shall carry out accurate pre-reclamation and post-reclamation surveys as described below, together with all necessary interim surveys.

The Concessionaire shall provide all necessary surveying equipment launches, electronic position fixing equipment, echo sounders, heave compensation, recording devices and trained personnel meeting with the requirements of the Specification to carry out surveys. Bar checks and position fixing checks shall be carried out at the start and finish of each period of surveying.

The surveys shall be as follows:-

a) Pre-Reclamation Survey

The pre-reclamation survey shall be carried out prior to the start of reclamation, as soon as possible after the award of Agreement, but not more than 28 days before commencement of reclamation. It shall comprise both a land survey and a hydrographic survey.

The land survey shall be sufficient to define all features of the site and shall include spot levels.

The pre-reclamation survey shall extend over the area to be reclaimed plus 150 m beyond the area and to ensure an overlap between any offshore and onshore surveys. Particular care shall be taken with the overlap between surveys and any anomalies arising there from shall be resolved.

b) Initial Survey

The initial survey for deposition of Fill Material shall be taken as being the pre-reclamation survey or the final dredging survey may be used if the construction programme has the reclamation commencing within 28 days of the completion of the dredging.

c) Interim Surveys

The Concessionaire shall carry out interim surveys as necessary during the execution of the Works. The interim surveys shall adequately cover the particular areas of interest to enable the weekly and monthly progress to be determined. The interim surveys shall be carried out using hydrographic and land survey techniques as appropriate.

d) Post-Reclamation Survey

The post-reclamation survey shall be carried out to confirm that the reclamation final surfaces have been achieved. The post-reclamation survey shall cover the same areas as the pre-reclamation survey. The post-reclamation survey shall be carried out within 28 days of completion of the area. Should any part of the area required to be reclaimed be found to be outside the tolerances specified, the Concessionaire shall increase or reduce the level to achieve the specified levels and re-survey the area. The Concessionaire shall provide

sufficient additional reclamation material to make up any settlement losses that occur during the construction period.

Survey base lines shall be as for the pre-reclamation survey.

e) Final Surveys

Where the reclamation defines a Final Surface the final survey for the reclamation works shall be carried out within 28 days of completion of all dredging and reclamation works for the phase completion or the completion of all the works.

The final survey shall comprise a land survey of the Site and a hydrographic survey of all below water filled areas, and a hydrographic survey of the entire dredged area as detailed in the Specification.

Survey base lines shall be as for the pre-reclamation survey.

At the end of the Agreement a composite survey plan showing the results of all surveys shall be provided to the Authority by the Concessionaire.

Survey plans shall be plotted to appropriate scales (however in no case shall they be greater than 1:500) and related to the Project Grid. The Authority shall be provided with three prints and a digital copy (in an approved AutoCAD format) as soon as possible after completion of the survey.

3.5.7. Reporting

Refer the details covered in section 3.2.13. .

3.6. FILL MATERIAL

3.6.1. Source of Fill

The Concessionaire shall provide sufficient information by means of testing to assess that the material is suitable fill material in accordance with the Specifications and Concessionaire's design.

3.6.2. Material

3.6.2.1. Fill Material

Fill Material shall consist of naturally occurring or processed material which at the time of deposition satisfies the soil design parameters or is capable of being compacted in accordance with the specified requirements to form stable areas of fill which meet the soil design parameters.

Fill Material, shall not contain any of the following:

a) Material susceptible to volume change, including marine mud, soil with a liquid limit exceeding 65% or a plasticity index exceeding 35%, swelling clays and collapsible soils,
b) peat, vegetation, timber, organic, soluble or perishable material

c) dangerous or toxic material or material susceptible to combustion, and
d) metal, rubber, plastic or synthetic material.

Fill Material used for Reclamation shall be inert granular material as specified in the Agreement. Fill Material shall have the particle size distribution within the ranges stated in the Agreement.

Underwater Fill Material shall consist of natural granular material extracted from the seabed with a uniformity coefficient greater than 3 unless otherwise specified in the particular requirements.

Engineered Fill Material may be placed above or below water and shall consist of pieces of hard, durable rock, which are free from cracks, veins, discoloration, and other evidence of decomposition, with a uniformity coefficient of greater than 6.

The soluble sulphate content of Fill Material shall not exceed 1.9 grams of sulphate, expressed as SO3, per litre.

The total sulphate content, expressed as SO3, of Fill Material shall not exceed 0.5% by mass.

3.6.2.2. Granular Filter Material

Granular filter material, when required, shall consist of durable, natural material, free of clay, organic material and other impurities. Granular filter material shall have the particle size distribution stated in the particular requirements.

The following particulars of the proposed filter materials and methods of construction for granular filters shall be documented and submitted to the Independent Engineer to demonstrate conformity with the Agreement:

a) Whether granular filter material is to be supplied ready mixed or is to be mixed on the Site,
b) Source of supply, including name of supplier of ready mixed material,
c) Quantity of each constituent if the material is to be mixed on the Site,
d) Constructional Plant and methods of mixing for material mixed on the Site,
e) Method of storage and location of storage areas on the Site,
f) Methods of deposition and compaction of material including method of verifying placement tolerances are achieved,
g) Results of three tests for particle size distribution of the Fill Material against which the granular filter is to be placed.
h) Details of filter design including calculations and grading envelopes.

The particulars shall be documented and verified at least 14 days before deposition of granular filter material starts.

Granular filter material shall be thoroughly mixed. Material that has been stockpiled shall be remixed before deposition.

Granular filter material shall be deposited in a manner which will not result in segregation or contamination of the material. The placed layer thickness of the filter shall be not less than the thickness shown on the drawings.

Granular filter material shall be deposited in such a manner that a continuous free draining zone is formed. The surface of each layer shall be cleaned and scarified before the next layer is deposited.

3.6.3. Geotextiles

Geotextile filter shall be of a type, manufacture and have the properties stated in the Specification for Geotextiles and laid in accordance with the manufacturer's recommendations. The manufacturers recommendations for laps shall be considered to be minimum requirements.

3.7. SUBMISSIONS

Description of Reclamation works for development of the Project

The following descriptions of the proposed materials and methods of deposition of Fill Material shall be documented prior to the mobilisation of reclamation equipment:

a) details of reclamation equipment/plant,
b) sources and properties of each type of Fill Material,
c) details of silt curtains or other methods of controlling turbidity as required by the Agreement including all relevant manufacturers' literature,
d) methods of deposition and compaction of Fill Material,
e) methods of controlling moisture content of Fill Material, and
f) sequence and rate of working.

The following additional particulars shall also be submitted if the proposed method involves the deposition of hydraulically placed Fill Material:

a) A drawing plan showing the delivery pipeline alignments and positions of the discharge points which demonstrates the proposed sequence of work,
b) Calculations of the rate and duration of discharge,
c) Monitoring of pore pressures to ensure slope stability during reclamation operations and identifying actions to be taken if pore pressure trigger levels are exceeded,
d) Details of containment bunds and tailwater drainage systems together with the monitoring of sediment quantities in the discharge water.

3.7.1. Compaction Trials

Fourteen (14) Days prior to the commencement of any compaction trials the following details shall be submitted:

a) Full details of the objectives and methodology of the trials;
b) Source of Fill Material;
c) Method of fill placement and the specification of plant to be used;
d) Method of monitoring layer thickness;
e) Compaction procedures and the specification of plant to be used;
f) Details of the tests to be conducted on the compacted fill to demonstrate compliance with the Authority's Requirements and Concessionaire's design requirements.
g) On completion of each compaction trial a report or reports covering the scope and outcome of the trials in respect of the following aspects shall be submitted:
h) Location and date of trial;
i) Full material description with associated laboratory testing;
j) Layer thickness variation;
k) Compaction equipment specification;
l) Efforts used to compact per layer;
m) Results of all tests conducted during the trial;
n) Full documentation of Site activities;
o) Weather records;
p) Interpretations of the data from the trial in graphical form, comparisons of test data with the required fill properties and supporting text;
q) Conclusions and recommendations;
r) Relevant Standards or Codes of Practice used in the trials shall be referenced as appropriate.

Schedule D

Draft Concession Agreement – HAM Component

4. BERTHING STRUCTURE

4.1. DESIGN BASIS

The design Basis furnished by Employer is only a guideline data and is the responsibility of the EPC Contractor to check-up all the data for its adequacy for design of the structures.

4.2. GEOMETRY & STRUCTURAL SYSTEM

The berth structure will be a conventional piled structure with bored cast in-situ piles supporting an RCC deck. In this configuration:

- The piled platform serves as the berth deck.
- A rock bund will be provided on the landside, acting as a retaining structure to contain the earth fill behind it.
- The base of the bund will be at the existing rock level, i.e., -11.5 m CD for the berths.
- The width of the piled deck must be designed such that:
- The slope of the rock bund is stable relative to the berthing area.
- The required dredge depth is maintained at the berth.

The rock bund will extend up to +2.5 m CD, and a retaining wall will be provided at the berth edge to ensure the back-up area is level with the deck structure.

Considering a future dredge depth of (-) 22.00 m CD, a piled deck width of 35.5 m will safely accommodate the construction of the rock bund without interfering with the berthing area.

The Scope of work involves construction of container berths in 2 phases.

- PHASE I – Berth Length of 1000m
- PHASE II – Berth Length of 1000m

4.3. MATERIAL PROPERTIES

Cement

For all structural elements, OPC grade-53 cement mixed with GGBS (Maximum 50 %) conforming to IS: 12269 shall be used.

Grade of Concrete & Steel

Table BERTHING STRUCTURE.2: Grade of concrete and steel

Structure	Material	
	Concrete	Steel
Sub Structure	M40	Fe500D
Super Structure	M40	Fe500D

M40 grade is proposed for sub structure and super structure of berths with Fe500D steel.

Maximum water cement ratio of 0.45 and minimum cement content of 400 kg/m3 of concrete shall be used (Clause 8.3.3 of IS: 4651 Part IV).

4.4. ENVIRONMENTAL DATA

4.4.1. Tidal data

The tide range at Tuticorin relative to the Chart Datum (CD) is as follows:

- Lowest Low Water Level(LLWL) + 0.11 m
- Mean Lower Low Water Springs (MLLWS) + 0.25 m
- Mean Low Water Springs (MLWS) + 0.29 m
- Mean Low Water Neaps (MLWN) + 0.55 m
- Mean Sea Level (MSL) + 0.64 m
- Mean High Water Neaps (MHWN) + 0.71 m
- Mean High Water Springs (MHWS) + 0.99 m
- Highest High Water Level (HHWL) + 1.26 m

4.4.2. Wave & Current

The Wave heights to be considered for operating and extreme conditions are as follows:

Condition	Wave height (m)	Time period (s)	Return period (years)
Operating	0.55	7 to 10	1

Current loads on piles are calculated based on the current velocity of 1knots.

4.4.3. Wind

The Wind loads on structure shall be considered as per IS 875 : Part 3.

The Basic wind speed under operating condition : 20 m/s

The Basic wind speed under cyclonic storm : 39/s.

Design wind pressure can be obtained as per IS 875 Part 3-2015:

Design wind speed, pd = $KdKaKcpz$

where,

The wind pressure at any height, pz = 0.6Vz2

The design wind speed, Vz = $k1k2k3k4Vb$

Kd – Wind Directionality Factor = 1.00

Ka – Area Averaging Factor = 1.00

Kc – Combination Factor = 1.00

k1 – Risk Coefficient = 1.06

k2 – Terrain Roughness and Height Factor = 1.05

k3 – Topography Factor = 1.00

k4 – Importance factor for Cyclonic Region = 1.00

4.4.4. Temperature & Shrinkage

The maximum and minimum air shade temperatures are interpreted from available nearest contours in IRC-6 and are as follows.

- Maximum temperature: (+) 40 deg C
- Minimum Temperature: (+) 10 deg C
- For the effects of shrinkage on structure, a shrinkage strain of 0.0002 shall be considered as per IRC-6:2017.
- The coefficient of Thermal Expansion for reinforced concrete shall be 11.7x10-6/oC

Note:

It is assumed that superstructure concreting will be done in 2 stages and stage 2 concreting will be done with some time gap after stage 1 concreting. Since half the total shrinkage of concrete takes place within this period after concreting, the residual shrinkage value which is half of the total shrinkage shall only be considered in design.

4.4.5. Marine Growth

Marine growth of 50mm thick is taken into consideration while assessing Wave and Current forces.

4.4.6. Nominal Cover

Minimum nominal cover to reinforcement shall be 75mm for piles and 50mm for Beam/slabs as per standard codes (IS 456 -2000).

4.4.7. Earthquake Loads

General design to comply with IS 1893 part 1:2016: General provisions and buildings.

The horizontal seismic coefficient is as follows.

Seismic Zone = II

$$Ah = Z\,I\,(Sa/g)/(2R)$$

Where,

Ah	:	Design horizontal seismic coefficient
Z	:	Zone factor = 0.1
I	:	Importance factor = 1.5
R	:	Response reduction factor = 3 (For RCC structures) = 5 (For Steel structures)
Sa/g	:	Average response acceleration coefficient (depends on

Time period of Structure)

Time period of the structure shall be evaluated by STAAD Analysis considering Dead Load + Super Imposed load + 50% Live Load.

4.5. GEOTECHNICAL DATA

The geotechnical report shared with tender document is for reference purpose only. However EPC Contactor shall take responsibility of the sufficiency of data and take all additional surveys/investigations at his own cost.

Load Data

Dead Load

The dead loads are assessed considering following unit weight of materials.

Plain Concrete : 24.00 kN/m3

Reinforced Concrete : 25.00 kN/m3

Structural Steel : 78.50 kN/m3

Sea water : 10.30 kN/m3

Live Load

Quay

The berth structure shall be designed for the following live loads:

Stacking Loads

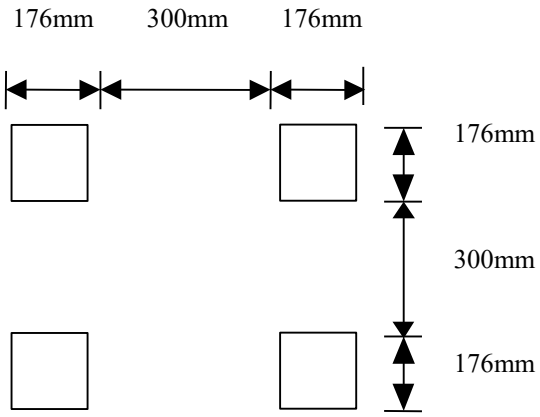
The Deck slab will be designed for:

- UDL of 5t/m2
- Container corner loads given in table below.
- At locations where crane is in rest or operation, Uniform distributed load of 2 t/m2, between rails, along with container crane loads
- Stacked container loads
- Gross weight and self-weight of containers assumed to be
- 20ft container – 24T Gross, 2T SW
- 40ft container – 30.5T Gross, 3T SW

The wharf design can accommodate full containers 20’ or 40’ block stacked up to 4 high and 3 across anywhere on the wharf considering the load table given below for equivalent UDL as well as corner loads:

Container Stack Height	Reduction in Weight	Equivalent UDL T/sq.m	Corner Load T
1	0%	1.35	7.6

2	10%	2.5	13.7
3	20%	3.3	18.3
4	30%	3.8	21.3
5	40%	4.0	22.9



Configuration of Container Corner (Not to Scale)

Container Handling Plant Loads

Front/ Forklift Truck (FLT)

Load under spreader 40T

Lift height full container 5 high

Lift height empty container 7 high

Number of wheels (Fr/Rr) 4/3

Axle load with full container (Fr/Rr) 106/11T

Reach Stacker

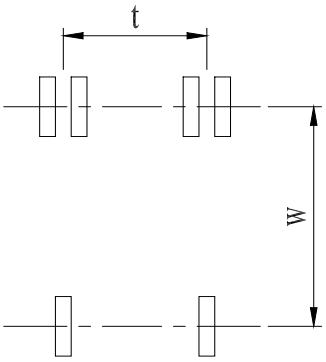
Load under spreader 40T

Lift height full container 5 high

Lift height empty container 7 high

Number of wheels (Fr/Rr) 4/2

Axle load with full container (Fr/Rr) 94/21 T

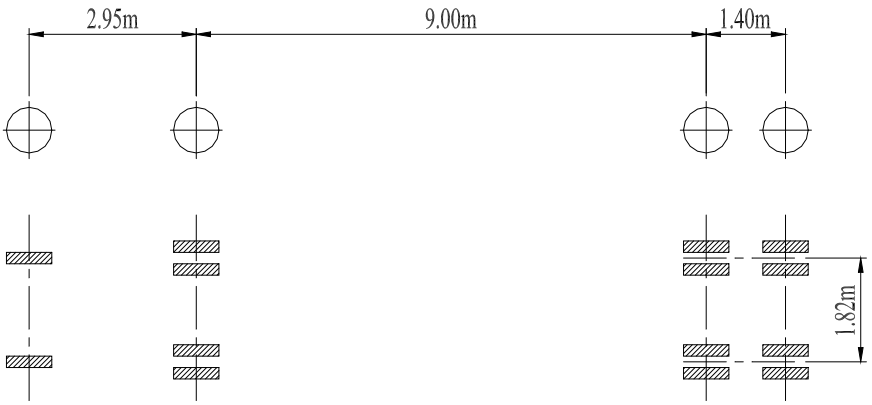


Reach Stacker Wheel Configuration

Tyre Pressure :		1000kPa
Wheel base (w) :	5.5m	
Tread (t) :	2.4m	

Tractor and Roll Trailer

Trailer capacity		40T
Number of wheels, tractor front	:	2
Number of wheels, tractor rear	:	4
Number of wheels, trailer	;	8



Wheel Configuration of Tractor and Trailer

Vehicular Loads

- IRC Loads - IRC Class AA and IRC Class A Loading

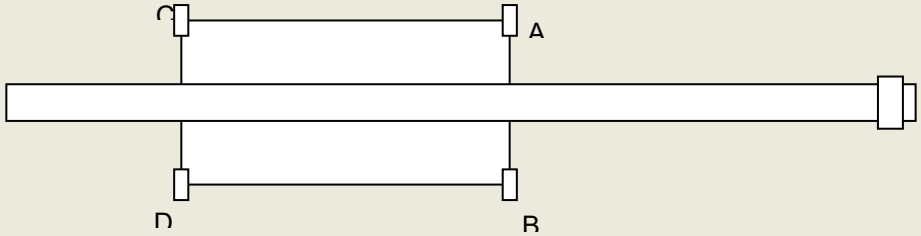
Rail-Mounted Container Quay Crane

Total number of corners	4
Number of wheels/corner	8
c/c distance of the wheel	1.5 m
Outreach	65 m
Backreach	20 m
Distance between c/c of corners of the wheels in longitudinal direction	14.5 m
Distance between corners of the wheels in transverse direction (c/c of rails)	30.48m

Maximum wheel load cases are tabulated below. Wheel diagram detail of Quay crane shall be as follows:

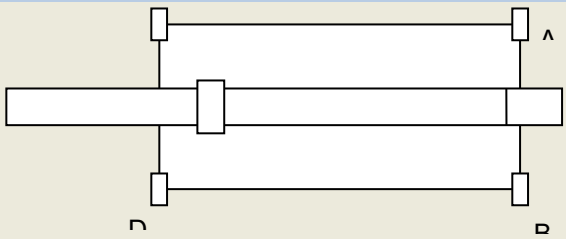
Table BERTHING STRUCTURE.3 : Load details for Rail Mounted Container Quay Crane (RMQC)

Operating condition (Normal)



Trolley position	Wheel load (T/wheel)			
	SEA		LAND	
	A	B	C	D
Trolley at outreach	87.6	67	35	11
Trolley at backreach	54	30	71.2	48

Stowed condition (Storm)



Trolley at stowed position	Wheel load (T/wheel)			
	SEA		LAND	
	A	B	C	D
Wind from landside to seaside at angle	-27	118.3	-42	111.2
Wind from seaside to landside at angle	-49	93	-18.5	131.4

Other crane conditional and accessory loads:

Tie down force : 442 t /corner (landside)

: 200 t /corner (seaside)

Stowage pin force : 200 t /side (landside)

: 178 t /side (seaside)

Stacking Loads

- Same as clause 9.2.1.1

Vehicular Loads

- IRC Loads - IRC Class AA and IRC Class A Loading

Berthing Load

Berthing loads shall be calculated in accordance with IS 4651 (Part III).

Quay

The terminal is expected to handle vessels up to 24,000 TEU. Range of vessels considered for arriving at the governing berthing force is presented in Table BERTHING STRUCTURE.4:

Table BERTHING STRUCTURE.4: Range of vessel

VESSEL SIZE	LoA	Beam	loaded Draft
8,000 TEU	335	42	14.5
10,000 TEU	350	48.2	14.5
12,500 TEU	397	56	14.5
18000 TEU	400	59	16
24000 TEU	400	61.3	16.26

Berthing Energy calculation : As per IS 4651 (Part 3) – Loading

Factor of Safety for Proprietary Type of Fenders* : As per IS 4651 (Part 4) – General Design Considerations

* A Factor of Safety of 2.0 shall be applied over calculated ultimate Berthing Energy.

Mooring Load

As per Table 4 of IS: 4651(Part III).

Design Mooring Force/ bollard : 2000 kN acting at any one point.

Analysis & Design

The various structural elements of the berth are modelled as a 3D structure with appropriate loads and analysed using STAAD Pro software. In the structural idealisation, soil springs / pile-fixity method will be used for the applicable soil strata as mentioned to account for soil-structure (pile) interaction. All the elements will be designed as per Limit State of Collapse and Checked for Limit State of Serviceability.

Limit State of Serviceability

Deflection: Deflection due to all loads including creep and shrinkage should not exceed span/250 as given in Clause 23.2 of IS 456:2000.

Crack width: The allowable Crack width is taken as per IS 4651 (part 4).

Permissible crack width shall be smaller of 0.004 times the clear cover to main bar and the values as per table below:

Zone	Max. Crack width (mm)	
	Sustained load	**Transient Load**
Atmosphere zone	0.2	0.3
Splash zone	0.1	0.2
Immersed zone	0.2	0.3
Below mud line	0.3	0.3

Sustained load: Dead load plus 50% of full uniformly distributed live load + earth pressure

Transient load: Dead load plus berthing or mooring load and full crane load or full live load uniformly distributed + earth pressure

Slope Stability Analysis

Slope stability analysis shall include both circular and non-circular slips. The application of seismic acceleration shall be in accordance with the standard code of practice. Stability of slopes will be checked using Geo-Slope or Plaxis Software.

Pile Foundation

Design shall be carried out considering soil parameters at structure location. The static capacity of the pile is derived based on IS 2911.

Load combinations

Load combinations

Load combination factors for analysis of the structure is considered in accordance with IS: 4651-Part (IV)-2023

Safety Factors

Partial Safety Factors are considered in accordance with IS 4651 –Part (IV) -2023.Load combination factors for analysis are considered in accordance with IS: 4651 Part IV.

Design codes and Standards

All Permanent works will be designed to the latest Indian Codes of Practice, Design Standards, Regulations and/or guidelines appropriate to the element of works considered. When, Indian standards are not available for particular applications, other reputed International codes or widely accepted references are to be referred as per the priority given in brackets (BS, API, PIANC). The following is the list of main codes of practice to be used in the design.

IS: 4651 (Part I – V)Codes of Practice for Planning and Design of Ports and Harbours

IS: 456-2000 Code of Practice for Plain and reinforced Concrete

IS: 800 -1984 Code of Practice for General construction of steel

IS 2911 Code of Practice for Design and Construction of Pile foundations

IS: 1893-2002 Part1 Criteria for Earthquake resistant Design of structures

IS: 9527 Part 3 Code of Practice for Design and Construction of Port and Harbour Structures.

IS: 9556 Code of Practice for Design and Construction of Diaphragm walls

IS: 875 Part3Code of Practice for Design Loads for Building and Structures-Wind Load

IRC -6 Standard specifications and Code of Practice for Road bridges, Section II-Loads and Stresses

Where Indian Standards does not cover a particular design requirement, relevant International Standards shall be referred.

4.6. TECHNICAL SPECIFICATIONS - BERTHS APPURTENANCES

Specifications for Fenders

Maximum of Berthing Energy calculated and adopted for selection of fenders

Berthing Energy calculation : As per IS 4651 (Part 3) – Loading

Factor of Safety for Proprietary Type of Fenders*: As per IS 4651 (Part 4) – General Design Considerations

* A Factor of Safety of 2.0 shall be applied over calculated ultimate Berthing Energy.

- The drawings enclosed with the technical offer shall include
- Levels such as Centreline of fender, frontal pad top & bottom levels, Concrete bottom level, deck level etc.

Dimensions such as through distance, width of frontal pad, size of bolts & nuts etc

Type of Fenders

Suitable type; totally non-corrosive with frontal protective / pressure reduction panel, if required, having low co-efficient of friction and other fixtures, accessories etc. The fixtures like bolts, nuts, chains etc should be of corrosion resistant materials and shall be as follows.

Anchor bolts, Bolts, nuts & Washers	:	SS316 or SUS 316 or its equivalent
U anchors (if any)	:	MS grade 8.8 Galvanised or Equivalent
Stud link Chains (If any)	:	MS Galvanised or Equivalent
Pad	:	Polyethylene (UMHW) Min 40mm thick
Frontal frame	:	MS with suitable epoxy painting or Equivalent

Typical frictional co-efficient (for frontal pads):

In X – Direction: 0.2 (Parallel to berth)

In Z – Direction: 0.2 (vertical direction)

Each Fender point can have single fender to functions as single unit to meet the technical requirements.

Contractor shall submit a programme for supply of fenders with its accessories at site.

Manufacturers of proprietary fenders shall supply the energy absorption, deflection and reaction force characteristics of the specific fenders, along with design calculation to prove suitability of fenders for the conditions given.

Manufacturers shall provide only the standard rubber grades, provided in their catalogue. Intermediate rubber grades shall not be accepted.

Specifications of fenders

a) Rubber

The material used for the fender shall be made from 100% natural or 100% synthetic rubber of high quality without any filler material 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. The rubber used

for fender shall have Tensile Strength, elongation and hardness as per JIS, ASTM or ISO Standards. The design shall comply with the PIANC's Guidelines for Design Of Fender Systems.

b) Accessories

The materials for fender accessories shall generally conform to the following requirements

a) Protector (Frontal) Panels Frame shall be made of rolled steel to ASTM A441 or equivalent
b) 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
c) Shackles and turnbuckles where required shall be galvanized carbon steel to ASTM A 575 Gr. 1025 or equivalent
d) The chain and its components shall be sized to withstand the maximum loads with a minimum factor of safety of three on breaking strength, but with a stock size of not less than 30 mm. Suspension chains shall have provisions for field adjustment. All chains and pad eyes for attaching chains shall be hot dip galvanized carbon steel to ASTM A 575 Gr. 1025 or equivalent subject to approval of the Engineer.
e) U-anchor where required shall be of MS grade 8.8 Galvanised or Equivalent or equivalent
f) The material for resin anchor sleeve shall be made of synthetic resin and proved satisfactory to the following requirements

Physical Properties:	
Tensile Strength (230C)	- Min 300 kg.sq cm ASTM 638
Water absorption	- Max 3%
(weight change)	
Chemical resistance to	- Max 1%
10% NaCl (weight change)	
Elongation (230C)	- 20% ASTM 638

g) The anchor bolt shall be made of stainless steel to AISI 304
h) 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.

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 0.15 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.

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 – 2024

The traditional and widely used Constant Velocity (CV) Method and

Decreasing Velocity (DV) Method

No of test specimen: A minimum of 10 % of the fender order should be randomly selected and tested to ensure compliance with performance requirements.

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.

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.

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 – 2024.

Verification/Quality Assurance Testing

a) 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 – 2024. A minimum of ten percent of the fender order shall be tested for compliance with energy/ reaction requirements.

b) Break in Deflection

Break-in deflection of actual elements should be at least manufacturer rated deflection. At least one cycle should be performed.

c) Other Testing

Effect of contact angle and durability tests should be carried out as per PIANC Guidelines for the Design of Fenders Systems – 2024 recommendations.

d) Dimensions

Fenders shall meet manufacturer's specified dimensional tolerance.

e) 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.

Certification

The fenders shall be certified by independent testing agencies such as IRS, Lloyds or other approved classification society.

Installation

The Contractor shall provide fenders on the Berth as per the vendor specifications. The fenders and bollards shall have to be dispatched from the manufacturer's works to the Site by the Contractor, after written consent from the Employer.

List of Approved Fender manufacturers

All Fenders used for the project shall be sourced from Trelleborg, IRM, HiTech, Sumitomo or Shibata.

Specification for Bollards

The bollards have to withstand sudden jerking effect from ropes connected to vessels and to resist rubbing effect of ropes on its sides.

Standards and Codes

The following latest edition 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.Properties

- Bollards shall be of Cast Steel.
- 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 follows:

Sulphur : 0.05% max.

Phosphorous : 0.5 % max.

Specification for Casting

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.

Casting 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 blow-holes.

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 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.

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 uniform temperature no less than the normalising 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 method of heat treatment and all relevant records shall be furnished.

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 manufacture's initial and trade mark
- The capacity of the bollard in minimum 10cm letter size engraved/ projected.

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.

Testing

Test Sample

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 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 tip and others from as near the bottom of the casting as is practicable.

Samples shall be tested in approved laboratory.

Type of Test

a) 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.

b) 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.

c) Non-destructive Tests

The following non-destructive tests at Cross-sections decided by the Employer shall be carried out.

Ultrasonic flaw detector test as per IS 3664 for checking the thickness of the castings and to detect the defects in the casting.

- Magnetic particle test
- 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 before the manufacture is commenced.

d) 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. A certificate of chemical analysis of such cast shall be supplied when required to do so by the Employer.

e) Testing facilities

The manufacturer 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 manufacturer 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.

f) Re-test

If any of the test pieces 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 manufacturer 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.

Bolts, Nuts and Washers

Bolts and Nuts

All anchor bolts shall be of SS Bolts conforming to IS 1364 shall be used.

Washers

All plain washers shall conform to the requirements of IS 2016.

All bolts, Nuts and Washers shall be galvanised conforming to IS 1367.

Fixing Details

The manufacturer shall submit the detailed fixing arrangements of the bollard to the deck with full details of the bolts etc. to the Employer for his approval.

The manufacturer 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 wharf.
- All relevant test certificates.

Test Certificate & Acceptance Criteria

- All bollards and accessories shall be certified by competent testing agency such as IRS, Lloyds or other approved classification society.

List of Approved Bollard manufacturers

All Bollards used for the project shall be sourced from Trelleborg, Richard marine, E J Bean, harbour marine or Marine International.

Rubberized Ladders

They are provided on the structure for access from vessel landing wherever required. There shall be not more than 3 meters of climb to nearest landing through a ladder. The ladder should provide hand/foot holds and also have shock absorption and shape restoration characteristic.

Mooring Rings

These rings shall be made from 20mm diameter of Stainless Steel (SS 316 grade) with an outer diameter of 200 mm. Suitable eyebolts of stainless steel (SS 316 grade) to AISI 304 or equivalent shall be provided with the mooring rings for fixing to the berth face.

Rubbing strip

Galvanised iron rubbing strip complete in all respects shall be provided in all the berths suitably at all bollard locations. Painting of the same shall be done. Minimum thickness requirement of Galvanization shall be 250 micron.

Edge angles

Galvanised edge angles shall be provided at the edges of all the berths, crane rail trenches, possible locations of corner cracking etc. Minimum thickness requirement of Galvanization shall be 250 micron.

Drain Holes

For all berths, the contractor shall provide the drain holes in the deck, crane rail trenches, service trenches, pits etc. to drain surface water. Drain holes shall be provided by PVC pipes at suitable locations. These pipes shall of sufficient diameter to drain surface water through the deck and at the approach trestle.

5. TECHNICAL SPECIFICATION – CIVIL CONSTRUCTION WORKS

This section deals with the requirements of materials for use in construction of the berth structure with regard to quality, testing, approval and storage of materials, before they are incorporated in the work.

5.1. STANDARD OF QUALITY

All materials used in the construction work shall be of good quality of their respective kinds obtainable indigenously in each case and shall be procured from manufacturers of repute in order to ensure uniformity of quality and assurance of timely supply. Any material not fully specified herein and for which there is no relevant Indian Standard, shall be the best of their kind and to the approval of the Engineer/ Engineer's Representative.

Approval and Tests

All materials to be used in construction shall be subject to approval of the Engineer / Engineer's Representative. The Contractor shall apply sufficiently in advance with samples of the materials including the supporting test results from the approved laboratory and other documentary evidence from the manufacturer wherever applicable indicating the types of materials and their respective sources. The Engineer/ Engineer's Representative also reserves the right to conduct additional tests in the same or other reputed laboratories at his discretion. The cost of all such tests shall be borne by the Contractor. The delivery of materials at site shall commence only after the approval of the quality, grading and sources of the materials by the Engineer / Engineer's Representative.

The quality of all materials once approved shall be maintained throughout the period of construction and periodical tests shall be carried out to ensure that it is maintained. Such routine tests shall be listed under the different materials and/or as the Engineer / Engineers Representative may order from time to time.

Where a particular "Brand" or "Make" of material is specified in the Schedule of Items or Technical Specifications, such "Brand" or "Make" of material alone shall be used on the work. Should it become necessary for any reason (such as non-availability/ceased to be produced), to use any material other than the specified "Brand" or "Make", the Contractor shall submit sample of the same to the Engineer / Engineer's Representative for approval together with test certificates and other documents necessary for examining and giving approval thereof.

Codes

Unless otherwise specified in the contract the relevant provisions of the appropriate Bureau of Indian Standards shall apply for all materials and workmanship.

The years of publication against various standards, referred in this specification, correspond to the latest standards as on date of preparation of this specification. During the use of this

specification in future, the latest publication as on date shall be referred to. Where Standards are not yet published by the BIS or IRC, relevant British Standards or Standards of the American Society for Testing Materials (ASTM) or other International Standards shall apply. In case of any conflict in meaning between these specifications and those of BIS or IRC, or British / ASTM Standards the provisions of these specifications shall prevail.

Use of Permanent Materials for Temporary Works

Materials to be incorporated in permanent works shall not be used for temporary works unless otherwise approved by the Engineer's Representative. Granting of such permission shall not prejudice the right of the Engineer to reject materials so used, which have become unfit to use in permanent works.

Rejection of Materials

Any material brought to site which, in the opinion of the Engineer / Engineer's Representative is damaged, contaminated, deteriorated or does not comply with the requirement of this specification shall be rejected.

If the routine tests or random site tests show that any of the materials, brought to site, do not comply in any way with the requirements of this specification or of B.I.S. Codes as applicable, then that material shall be rejected.

The Contractor at his own cost shall remove from site any and all such rejected materials within the time specified by the Engineer / Engineer's Representative.

5.1.1. Materials for Concrete

5.1.1.1. Aggregates

Aggregates shall comply with the requirements of IS: 383-2016 "Specification for Coarse and Fine Aggregates for Concrete".

They shall be hard, strong, dense, durable, clean and free from veins and adherent coating, vegetable matter and other deleterious substances; and shall be obtained from approved sources. Aggregates shall not contain any harmful material such as pyrites, coal, lignite, shale or similar laminated material, clay, alkali, soft fragments, seashells and organic impurities in such quantity as to affect the strength or quality or durability of concrete. Aggregates that are chemically reactive with alkalis of cement or might cause corrosion of reinforcement shall not be used. Aggregates that are not sufficiently clean shall be washed in clean fresh water to the satisfaction of the Engineer.

a) Testing

All aggregates shall be subject to inspection and testing. The Contractor shall submit samples of various aggregates from each source of supply for test and approval. While submitting the samples, he may indicate the source of supply, type of aggregate availability and all relevant information. Only the aggregates from the source of supply which pass QC test shall be used in the work.

Sampling and testing shall be carried out in accordance with IS 2386-1963 (Part I to VIII) "Methods of Test for Aggregates for concrete".

b) Grading

The Contractor shall ensure that the full range of aggregate used for making concrete is graded in such a way as to ensure a dense workable mix. The delivery of aggregates will commence only when the Engineer has approved the samples and the quality and grade shall be maintained consistent and equal to the approved sample. Before construction commences, the Contractor shall carry out a series of tests on the aggregates and on the concrete made there from to determine the most suitable grading of the available aggregates. Once the most suitable grading has been found, the grading shall be adopted for the construction of the works and periodic tests shall be carried out to ensure that it is maintained.

c) Size and grading of fine aggregates

The grading of the fine aggregates shall conform to IS: 383-2016 and shall be within the limits of Grading Zone-II. The maximum size of particle shall be 4.75mm and shall be graded down. Sand containing more than 10% of fine grains passing through 150-micron sieve or having the fineness modulus less than 2 shall not be used for concrete work.

d) Size and grading of coarse aggregates

The nominal maximum size of the aggregates for each mark of concrete or for each type of work shall depend upon the description of the particular item in the Schedule of Items and/or according to relevant clauses of IS: 456-2000. The aggregates shall be well graded and the grading shall conform to relevant requirements of IS: 383-2016 depending upon the maximum nominal size as specified or as required.

e) Fine aggregate for mortar and grout

The grading of fine aggregate for mortar and grout shall be within the limits of grading zone III and IV as defined in IS: 383-2016

f) Storage & Stacking

Aggregates shall be stored at the site on clean, well-drained areas, which are not liable for flooding. Care shall be taken in the storage to avoid intrusion of any foreign materials into the aggregates. Where various types of aggregates are stored close to each other, they shall be separated by a wall or plate. In case of stockpiling, care shall be taken to avoid forming pyramids resulting in segregation of different sized materials.

g) Coarse Aggregates Types

The type of coarse aggregate shall preferably be natural aggregates, stone metal and shall be approved by Engineer. Unless otherwise specified, stone metal shall be used as coarse aggregate.

5.1.1.2. Stone metal

It shall be crushed or broken from hard stone obtained from approved quarries of igneous or metamorphic origin. The stone metals shall be hard, strong, dense, durable and angular in shape. It shall be free from soft, friable, thin, flat, elongated or laminated and flaky pieces and free from dirt, clay lumps, and other deleterious materials like coal, lignite's, silt, soft fragments, and other foreign materials which may affect adversely the strength & durability of concrete. The total amount of deleterious/ foreign materials shall not exceed 5% by weight according to relevant clause of IS 383-2016. If the contamination is found to be exceeding the limit, the stone metal shall be screened and washed before use.

5.1.1.3. Fine Aggregates

Natural river sand or Manufactured Sand shall only be used for Fine Aggregates. It shall not contain harmful organic impurities in such form or quantities as to affect adversely the strength and durability of concrete. Sand for reinforced concrete shall not contain any acidic or other impurities which are likely to attack steel reinforcement. The percentage of all deleterious materials including silt, clay etc., shall not exceed 5% by weight and if exceeded sand shall be screened or washed before use to the satisfaction of Engineer / Engineer's Representative.

5.1.1.4. Cement

The cement to be used shall be Ordinary Portland cement, 53 Grade conforming to IS: 12269-2013 or Portland Pozzolona Cement conforming to IS: 1489. Cement shall be procured from reputed manufacturer like Ultratech, Birla, Coromandal, Malabar Cement or Ambuja.

a) Testing of samples

The contractor shall supply a copy of the manufacturer's test certificate for each consignment of cement, brought by him to the Engineer /Engineer's Representative. The Contractor shall conduct necessary tests as per relevant BIS Codes as soon as each consignment is received at site to ensure the strength of cement and the results shall be furnished to the Engineer/Engineer's Representative. In case the required strength is not obtained, the Engineer/Engineer's Representative may reject any cement notwithstanding the manufacturers' certificate or any other suitable action as deemed fit. The sampling of cement for testing shall be according to IS: 3535 -1986. All tests shall be in accordance with the relevant clauses of IS 4031 (Part-I to Part-15) 1988 to 1999 & IS: 4032-1985.

b) Contractor's Responsibility

From the time a consignment of cement is delivered at site and tested and approved by the Engineer / Engineer's Representative until such time as the cement is used on the works, the Contractor shall be responsible for keeping the same in sound and acceptable condition and at his expense and risk. Any cement which deteriorates while in the Contractor's custody

is liable for rejection as unsuitable and it shall be removed from the site at the cost of contractor within two days of ordering such removal. No cement shall be stored for more than 3 months.

c) Stock of Cement

In order to ensure due progress, the Contractor shall at all times maintain on the site at least such stock of cement, which he considers necessary and prudent. Any delay in completing the project for want of cement shall be the responsibility of the contractor.

d) Storage of Cement

The storage of Cement shall meet the requirement of IS 4082.

The cement shall be stored in such a manner as to permit easy access for proper inspection and in a suitable watertight, well-ventilated building to protect it from dampness caused by ingress of moisture from any source. Different Grades / types of cement shall be stored separately. Cement bags shall be stacked at least 15 to 20 cm clear of the floor leaving a space of 60 cm around the exterior walls. The cement shall not be stacked more than 10 bags high.

Each consignment of cement shall be stacked separately to permit easy access for inspection. Cement shall be issued from stores in the order in which it was received on site, commencing with the consignments, which has been in the store for the longest period of time. The age of cement at the time of delivery shall not be more than 2 months and shall be used within 3 months, thereafter.

5.1.1.5. Water

Water used for mixing concrete and mortar and for curing shall be clean and free from injurious amounts of oil, acid, alkali, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. The pH value of water shall be not less than 6. Tests on water samples shall be carried out in accordance with IS: 3025 and shall meet the requirements mentioned in clause 5.4 of I S: 456-2000. Water shall be obtained from an approved source.

Where it is obtained from a source other than a supply main, it shall be tested to establish its suitability. Water for construction purpose shall be stored in proper storage tanks to prevent any organic impurities getting mixed up with it. The Contractor shall make adequate arrangements to have sufficient water at the site at all times.

Seawater shall not be used for concrete or any related works including curing.

5.1.1.6. Sand for filling

Sand for filling shall meet the requirements of IS: 383 and shall be natural sand or Manufactured Sand and shall be hard, strong and free from any organic and deleterious materials. Any sand proposed shall be used only after its approval by the Engineer /

Engineer's Representative. Sand obtained from seashores, creeks or river bank affected by tides shall not be used for filling. The grading shall be not below Gr. Zone III as per IS 383.

5.1.1.7. Admixture for Concrete

Admixtures if approved by the Engineer/ Engineer's Representative shall be used in required quantities as per manufacturer's specification to get the desired workability and strength. The approved admixture to be incorporated in the work shall conform to relevant BS/BIS code and shall be of sulphonate naphthalene formaldehyde condensate shall be compatible with the cement and for steel Bipolar corrosion inhibiting liquid concrete admixture approved by RDSO/IRC to be used in the work and shall produce workable concrete without loss of slump until placed in position thus helping in placing and compaction of concrete. The proportion of admixture to be used in concrete shall be determined by tests. Such tests shall be conducted as per IS 9103 or IS 2645, in any approved laboratory at Contractor's cost and test results submitted to the Engineer / Engineer's Representative at any stage of the work. Other types of admixtures shall not be used without prior approval.

5.1.1.8. Curing Compound

All concrete shall be cured using Self Curing Compound.

Interval of Routine Test

The routine tests of materials, delivered at site, shall be at the following intervals:

Aggregates - Fortnightly or for every 200 m3 for each aggregate whichever is earlier and in other respects generally as per IS: 2386 (Part 1 to 8) -1963.

Cement - Fortnightly or for each consignment, within 4 days of delivery and in other respects generally as per IS: 4031.

Water - Once in two months for each source of supplies and in other respects generally as per IS: 456-2000.

Reinforcement - For each consignment within 4 days of delivery in accordance with IS: 1786-2008, IS: 1599-2012 and IS: 1608-2018.

5.1.1.9. Steel

a) Reinforcement

Reinforcement bars for concrete shall be CRS round steel bars of the following types:

a) High strength deformed steel TMT bars (Fe500D) conforming to IS: 1786-2008 for Concrete Reinforcement.
b) For steel less than 10mm dia. High yield strength deformed steel TMT bars (Fe415D) conforming to I S: 1786-2008 for Concrete Reinforcement.
c) Reinforcement fabrics conforming to IS: 1566-1982 "Hard Drawn Steel Wire Fabric for Concrete Reinforcement"

All reinforcement bars shall be of uniform cross sectional area and be free from loose mill scales, dust, loose rust, coats of paint, oil or other coatings which may destroy or reduce the bond. The reinforcement bars shall be product of reputed companies. Steel shall be procured only from primary steel producers / Integrated Steel Plants from TATA / SAIL / RINL / JSW / JSPL or SHYAM STEEL using iron ore as the basic raw material and having in-house iron making facilities followed by production of liquid steel and crude steel with in-house rolling, adopting BF-BOF route or DRI-EAF technology as per Ministry of Steel guidelines.

No Re-rolled material/secondary steel will be accepted or allowed for any structural works. Every lot of supply shall require to be accompanied by manufacture's test certificate for establishing correlation with TMT/CRS bars supplied. Every lot shall be tested in the independent laboratory to assess whether the properties are conforming to IS: 1786-2008 as directed by the Engineer-in-charge.

b) Testing

The Contractor shall furnish a copy of the manufacturer's test certificate for each consignment of reinforcement bars brought to site and conduct necessary tests as per IS Codes and the results furnished to the Engineer/ Engineer's Representative. In case the strength requirements are not met with, the Engineer / Engineer's Representative shall take appropriate action.

All tests shall be done as per relevant clauses of IS: 1786-2008, IS: 1566-1982, IS: 280-2006, IS: 2062-2011, IS: 1161-2014, ,IS1367, IS: 3063-1994, IS: 1239 (Part 1 and 2)- 2004 and 1992 and IS: 1367-1980.

c) Tests after Delivery

The Engineer / Engineer's Representative may order any additional tests on the structural / reinforcement steel brought by the contractor. The cost of such tests shall be included in the rates and prices. The Engineer / Engineer's Representative may accept / reject the same based on test results.

5.1.1.10. Binding Wire

Binding wire for reinforcement shall be annealed steel wires 20 BWG conforming to IS: 280 -2006 "Specification for Mild Steel Wire".

Light Structural Work and Inserts

Steel for preparation of inserts and embedment into concrete shall conform to IS: 2062-2011- Steel for general structural purposes- Specification.

5.1.1.11. Foundation Bolts

Bolts to be embedded in concrete shall, conform to IS: 5624-2021 "Specification for Foundation Bolts". Material for bolts, shall be SS Bolts conforming to IS 1364 shall be used.

Plain washers shall conform to IS: 2016 -2018 "Specification for Plain Washers and spring washers shall conform to IS: 3063 -1994 "Spring Washers for Bolts, Nuts & Screws".

Threaded Fasteners

Bolts and nuts for fastening shall conform to IS: 1367 (Part 1)-2002 "Technical Supply Conditions for Threaded Fasteners".

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 headbolts, screws & nuts of product grade C	IS:1363
Cold formed light gauge structural steel sections	IS:811
Technical supply conditions for threaded steel fasteners	IS:1367
Plain washers	IS:2016
Steel wire ropes for general engineering purposes	IS:2266
Thimbles for wire ropes	IS:2315
Bulldog grips	IS:2361
Mild Steel Tubes, tubulars and other wrought steel fillings (for Hand rail tubular sections).	IS:1239
Drop forged sockets for wire ropes for general engineering purposes	IS:2485
Steel chequered plates	IS:3502
Hexagonal bolts and nuts (M42 to M150)	IS:3138

a) 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.

b) 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 Engineer for verification.

The reinforcement bars, structural steel sections and other miscellaneous steel material etc., shall be stored in such a way as to avoid and prevent deterioration, corrosion, bending, twisting and warping.

c) Rejection

The Engineer / Engineer's Representative may reject at his discretion 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.

d) PVC Pipes

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

CPVC Pipes shall conform to the requirements of IS: 15778

e) 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.

f) Paint

All paints shall be of approved quality and shall be obtained from the suppliers, authorized by the Manufacturers. Paint shall conform to appropriate Indian standards for ready mixed paints where applicable.

a) Primer coating of any Structural Steel shall conform to IS 2074
b) All paints shall be tested as per requirements of IS 101

All exposed Steel Structures shall be galvanised protected with marine quality Epoxy based protective coat as follows:

Surface preparation	:	▪ Thorough cleaning to remove oil, grease, dirt, and other contaminants. De-rusting of all mechanical damage according to SIS 055900 Grade: ST 3 ▪ Apply with 2-pack self priming aluminium containing high build epoxy with solids by volume content of not less than 85% dry film thickness 75-100 microns.
Intermediate coat	:	2-pack epoxy paint of thickness of 75 microns solids by volume minimum 62%

Finish coat :
- 2-pack epoxy paint
- Dry film with non-skid properties
- Dry film thickness 75 microns
- Solids by volume minimum 62%

g) Materials not specified

Any materials not fully specified in these specification and which may be offered for use in the works shall be subject to approval of Engineer / Engineer's Representative without which it shall not be used anywhere in the construction works.

5.1.1.12. Workmanship

a) General

This Part deals with performing various items of works as per Technical Specifications and drawings and other conditions of the contract to complete the project or serving its intended purpose.

b) Standard

A high standard of workmanship in all trades will be required. The Contractor shall ensure that only skilled and experienced workmen are employed.

c) Contractor's Equipment

The Contractor shall be responsible for the supply, use and maintenance of all construction plant and equipment and he shall ensure that it is suitable for the work and is maintained in such a manner as to ensure its efficient working. The Engineer / Engineer's Representative may direct that the plant and equipment, which is not efficient and is prejudicial to the quality of the Work, be removed from Site and replaced by efficient plant and equipment to his satisfaction.

d) Facilities for Materials Testing Laboratory

The Contractor shall provide a laboratory for testing of concrete, concrete materials, and any other materials as directed by the Engineer/ Engineer's Representative.

Sufficient area shall be earmarked within the working area allotted by the Engineer / Engineer's Representative for Field Materials Testing Laboratory and sample room. The sample room shall be provided with adequate number of racks for storage of samples. The laboratory and the area for the sample room shall be connected to the main water and electricity services. The Contractor shall suitably staff the laboratory particularly the Technical Personal.

At the end of the Maintenance Period, the laboratory and sample room shall be dismantled and removed from Site. The dismantled materials and equipment shall be the property of the Contractor. The cost of constructing and equipping the laboratory and area for the sample room, maintaining during the currency of the Contract and dismantling the same at

the end of the Maintenance Period shall not be paid for separately and shall be deemed to have been included in the rates and lump sum prices.

5.1.1.13. Excavation and Backfilling / Filling

a) General

The material for filling behind the berths shall be excavated from the dredged material available at western side of the LNG tank farm. The Contractor shall provide all necessary supervision, labour, materials, equipment and tools to perform excavation, grading, filling, embankments, roadways, ditches and all other items in both wet and dry conditions with all lifts and descents. Before beginning excavation or filling, the Engineer / Engineer's Representative shall be kept informed and approval if required, shall be obtained.

b) Excavation

The whole of the excavation of the works shall be carried out to the required widths, lengths and depths and within approved lines and levels. Any excavation beyond such limits or instructions shall be made good by filling with other approved materials to the required compaction, by the Contractor, at his own expense to the satisfaction of the Engineer/ Engineer's Representative.

The Contractor shall provide all shoring, strutting, shuttering or other approved support to

the sides of the excavations as may be necessary to prevent any ground movement/sliding. The Contractor shall bear all responsibility connected with such shoring including dewatering notwithstanding the Engineer's / Engineer's Representative's approval. Cost of all such constructional requirements shall be deemed to have been included in the prices.

c) Disposal and backfill

Excavation material deemed suitable by the Engineer / Engineer's Representative for filling in other places shall be stockpiled in the vicinity of the excavation sites with the approval of the Engineer / Engineer's Representative.

Unsuitable or excess excavation material shall be transported to the spoil areas as directed by the Engineer / Engineer's Representative and the cost of such disposal shall be deemed to have been included in the price.

d) Supervision

The Contractor's supervising staff shall be fully qualified and experienced in the types of work being carried out under their supervision and shall be capable of ensuring that the work is executed efficiently and as per specification.

e) Temporary works

Wherever required, the Contractor shall furnish such details of his temporary works as may be called for by the Engineer / Engineer's Representative and the Contractor shall satisfy the Engineer / Engineer's Representative as to their safety and efficiency. The Engineer / Engineer's Representative may direct that temporary works, which he considers unsafe or

insufficient, shall be removed and replaced in a satisfactory manner. The Contractor will be solely responsible for any construction, fabrication, such as piling gantry including all the labour, materials, equipment etc., and the Engineer / Engineer's Representative shall be indemnified.

f) Codes

The years of publication against various standards, referred in this specification, correspond to the latest standards as on date of preparation of this specification. Hence during use of this specification the latest publications as on date shall be referred to. Where standards are not yet published by the BIS / IRC, relevant British Standards / ASTM or other International Standards shall apply. In case of any conflict in meaning between these specifications and those of BIS / IRC / British/International Standards, the provisions of these specifications shall prevail.

g) Base lines and Bench Marks

The Contractor shall establish and maintain, to the satisfaction of Engineer / Engineer's Representative, the base lines and benchmarks based on which the works are set out. Where the Engineer / Engineer's Representative provides such base lines and benchmarks; the Contractor shall maintain these throughout the period of construction without causing any disturbance to them.

h) Setting out / Survey

The setting out of the work shall be done with the Engineer / or his representative in attendance. The levels shown in the drawing are referred to port's Chart Datum which is 0.582m below MSL. The Contractor shall set out all the works to be executed by him, in line with the standard base lines, levels, position and bench marks and truly as per drawings within the accepted tolerance limits at no extra cost to Engineer. The Contractor shall be solely responsible for the setting out of all the works, to be executed by him and the approval of such setting out by the Engineer / Engineer's Representative shall in no way absolve the Contractor of his responsibility for carrying out the work to the true lines, levels and positions as per drawings.

i) Dewatering

The Contractor shall carry out all the works, in dry and workable condition and maintain the same in dry condition till the final handing over of works at no extra cost to the Engineer. For this the Contractor shall make all the necessary provisions of dewatering, wherever necessary, to the entire satisfaction of the Engineer / Engineer's Representative.

j) Safety of existing work

Before taking up any construction adjoining other property or existing work, the Contractor shall take all steps necessary for the safety and protection of such property or work at no extra cost to the owner. The contractor shall indemnify the Engineer from any such damages to the property of others.

k) Protection of existing services

The Contractor shall take all precautions necessary to prevent damage to or interference with underground or over ground services such as cables, drains, piping or piles, whether shown on drawings or not. Equipment etc., mounted in position shall be protected against falling debris etc., by means of tarpaulin or such other material at no extra cost to the Employer.

l) Handing over of work site

On completion of work, the Contractor shall remove all rubbish, debris, surplus materials, temporary work etc., from the site. The site shall be handed over in a tidy and workmanlike manner at no extra cost to the Employer.

5.1.1.14. Concrete (Plain & Reinforced)

This section covers the workmanship, special requirements & regulations with which the contractor must comply to achieve the following two objectives:

a) The provision, at all locations on the site, of dense workable concrete, having the specified characteristic strength.
b) The mixing and placing of concrete at all elevations, well compacted by vibrations, in well aligned and well-fixed formwork ensuring the internal and external dimensions of structures as per approved drawings and maintaining the size, shape, number and locations of reinforcements, inserts etc., as per the drawings, providing the surface finish after stripping off the formwork to ensure the structural configurations as per drawings as well as within the specified tolerance limits, curing and guaranteeing the characteristic strength, all as specified.

The mixing, placing, compacting, curing and finishing of concrete shall be done according to IS: 456-2000 "Code of Practice for Plain and Reinforced Concrete".

a) Qualified Personnel, Labour & Equipment

A fully qualified and experienced concrete quality control Engineer shall be employed by the Contractor and shall be available on Site at all times when concreting is taking place. Prior to commencement of the Works, the Contractor shall submit for the approval of the Engineer / Engineer's Representative details of qualifications and experience of the personnel to be engaged in the work of concrete and quality control. Operators for mechanical vibrators and mixers and foreman in charge of placing of concrete shall be fully trained and experienced for their class of work.

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

b) Mix Design

At the commencement of the contract at least 45 days prior to commencement of works the Contractor shall design the mix and make preliminary tests to determine the proportions by

weight of cement, fine aggregates, coarse aggregates and water necessary to produce required grades of concrete. The design of mixes shall be made according to I.S. 10262-1982 or any other approved standard methods through any of the reputed Institute to be approved by the Engineer / Engineer's Representative.

The Contractor shall furnish full details of the preliminary tests on each class of concrete along with the relevant calculations for approval of the Engineer / Engineer's Representative. The mix proportions shall be selected to ensure that workability of the fresh concrete is suitable for the conditions of handling and placing and when concrete hardens, it shall have the required strength, durability and surface finish as per the requirements of IS 456-2000 where ever applicable. The Contractor shall start concreting only after getting the approval of the Engineer / Engineer's Representative for such mix proportions.

However, such approval shall not relieve the Contractor of his responsibility to produce concrete having compressive strengths as mentioned in the specifications /drawings.

For all major and important R.C. works and special works, the Contractor shall make the design of mixes, for each grade of concrete as well as for various workability at his own cost.

No departure from the approved proportions will be permitted during the works unless and until the Engineer / Engineer's Representative gives written authorization for any change in proportion. The Engineer / Engineer's Representative shall have authority at any time to check whether the mixing of concrete is being carried out according to the approved proportions

The concrete made by designing the mix is termed hereinafter as "Design Mix Concrete".

For the purpose of general guidance, Table-5 of IS 456-2000 shall be followed for minimum cement content, maximum water cement ratio & min. grade of concrete. However, minimum cement content of 400 kg/m3 and a maximum water cement ratio of 0.45 shall be maintained for all grades of concrete for RCC and minimum cement content of 310 kg/m3 with maximum water cement ratio of 0.5 shall be maintained for PCC as per IS-4651 (Part-4), 2023 - "General Design Considerations for Planning & Design of Ports & Harbours".

c) Water/Cement Ratio

Once the Engineer / Engineer's Representative approves a mix the same shall be maintained and shall not be varied without the permission of the Engineer / Engineer's Representative, including the water/cement ratio. Maximum water / cement ratio shall never exceed the value given in the IS 456-2000 and IS 4651 for various exposures.

In the structures where the impermeability and shrinkage of concrete have an important bearing on the durability and serviceability of the structures, such as exposed structures near sea side, thin pre-cast members etc. the water cement ratio shall be kept low.

d) Workability

The workability of fresh concrete shall be such that the concrete is just suitable for the conditions of handling and placing so that after compaction it becomes completely consistent and homogeneously surrounds all the reinforcement and completely fills the formwork.

The workability of fresh concrete at the place of batching / mixing shall be ensured by proper test and at the place of disposition by means of slump test. During the finalisation of Trial Mixes, the relationship between compacting factor and slump test shall be established for each grade of concrete as well as for various levels of workability. The workability tests shall be carried out in accordance with IS: 1199 "Method of sampling and analysis of concrete".

In cases where the cement content is to be limited to reduce the heat of hydration, and the water/cement ratio is also to be kept low to reduce the permeability or due to other requirements the desired workability may be achieved with use of limited doses of approved admixtures or air entraining agent. In such cases the method of mixing and dosage of the admixture / air-entraining agent shall be according to the manufacturer's specification and with the approval of the Engineer / Engineer's Representative.

The degree of workability of concrete depends on the mix proportion. Suggested ranges of workability of concrete shall be in accordance with IS: 1199 and as per the table in section 7 of IS 456-2000.

Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall have the approval of the Engineer / Engineer's Representative.

e) Durability

A durable concrete is one that perform satisfactorily in the working environment during its exposure. Therefore the durability of concrete, depending on the exposure condition, is to be taken into account while designing the mix. For given aggregates, the cement content should be sufficient to make sufficiently low water cement ratio. The provision made in IS: 456-2000 shall be taken as guideline for durability considerations.

f) Trial Mixes

After approval of the Mix Design by the Engineer / Engineer's Representative, the Contractor shall make in the presence of Engineer / Engineer's Representative the Trial Mixes for each grade of concrete as well as for required workability.

Before starting the trial mixes, necessary preparatory works like sieve analysis of the aggregates, determination of densities of different ingredients and moisture contents in the aggregates, shall be completed according to the IS: Codes 383-2016 and 2386-1963.

Each trial mix shall be handled and compacted by the method which the Contractor proposes to use for that mix in the works and the mixes shall not show tendency of inadequate compaction by the method proposed. Similarly the trail mix shall be prepared using same type of plant & equipment including admixtures (if any proposed) as will be used for the works.

The compacting factor and the slump of each trial mix shall be determined immediately after mixing and the values shall not exceed the maximum value obtained in the mix design.

Nine numbers of 150-mm test cubes shall be made from each trial mix, three for seven-day test and six for 28th day test. These shall be cured and tested by the contractor in a nominated laboratory or field lab and certified copies shall be given to the Engineer / Engineer's Representative in accordance with relevant IS Codes. In order to have the specified characteristic strength in the field, the concrete mix as designed in the Design Mix shall have higher average compressive strength depending on the degree of quality control at site. If the size and special requirement of the work so warrants, the trial may be extended to cover larger ranges of mix proportions as well as other variables such as alternative source of aggregates, maximum size and grading of aggregates and different type and brands of cement.

The trail mix shall also be cast in mould similar to the one proposed for use in the work and compacted. After 24 hrs, the sides of the mould shall be struck and the surface examined in order to determine whether or not in the opinion of the Engineer / Engineer's Representative an acceptable surface can be obtained using the mix.

When all tests, mentioned for strength, consistency & surface finish are satisfactory, the Engineer / Engineer's Representative will approve the mix. Once a design mix is approved no variation shall be made in the mix proportion or in type, grading & source of any material without the consent of the Engineer / Engineer's Representative.

Before commencement of the concreting works of particular grade of concrete, the Contractor must complete the work of trial mixes and subsequent testing of the test cubes obtained there from the design of the Approved Mix for that particular grade of concrete.

The entire cost of all the trial mixes including all the preparatory works for trial mixes, preparation of test cubes and their testing shall be borne by the Contractor.

5.1.1.15. Batching of Concrete

a) Cement

Batching plant shall conform to IS: 4925. Cement shall always be batched by weight. A separate weighing device shall be provided for weighing cement. Where the weight of cement is determined by accepting the weight per bag, number of bags shall be weighed separately to determine the average net weight of cement per bag and the same shall be checked regularly.

b) Aggregates

For Design Mix concrete, the aggregates (coarse and fine) shall be batched by weight. Suitable adjustments shall be made for the variation in the weight of aggregates due to variation in their moisture contents.

c) Water

Water may be measured either by weight or by volume. When measured by volume, it shall be by well-calibrated conical shaped jar or vessel or from a calibrated tank fitted to the mixer.

d) Adjustment of water due to moisture contents in aggregates

It is very important to maintain the water cement ratio constant at its correct value. For the correct determination of amount of water to be added in the concrete mix, to maintain the water cement ratio constant, the amount of moisture content in both coarse and fine aggregates shall be taken into consideration, be as frequently as possible, the frequency for a given job being determined by the Engineer / Engineer's Representative according to weather conditions.

e) Determination of moisture content in the aggregates

Determination of moisture content in the aggregates shall be according to IS: 2386 (Part-III) - 1963. Where tests are not conducted, the amount of surface water may be estimated from the following table:

Surface water carried by Aggregates

	Aggregates % by weight	Lit/m3
Very wet sand	7.5	120
Moderately wet sand	5.0	80
Moist sand	2.5	40
Moist gravel & stone chips	0.25 – 2.5	20-40
Coarser the aggregate, less the water it will carry.		

f) Admixtures

No admixtures shall be used without written approval of the Engineer / Engineer's Representative. If permitted on works, admixture for concrete shall conform to the requirements of BS 5075 or relevant BIS. Any solid admixture, to be added, shall be measured by weight, but liquid or semi-liquid admixture may be measured by weight or volume as approved.

g) Accuracy of batching

The accuracy of batching shall be within the following tolerance:

Cement within plus or minus 2% by weight.
Aggregate within plus or minus 2% by weight.
Water within plus or minus 0.5% by weight.

5.1.1.16. Mixing & Transportation of concrete

a) Mixing of Concrete

Concrete shall always be mixed in a mechanical mixer /Batching Plant. Mixing by hand is not permitted. Before beginning of a run of concrete all foreign materials shall be removed from inner surface of mixing and conveying equipment. Similarly, all conveyances shall also be cleaned thoroughly.

Concrete shall be thoroughly mixed until there is uniform distribution of materials, and the mass is uniform in colour and consistency. Water shall not normally, be charged into the drum of the mixer until all other ingredients are already in the drum and mixed for at least one minute.

The mixing time from the time of adding water shall be in accordance with IS 1791-1985 but in no case less than 2 minutes or at least 40 revolutions.

b) Discharge from Mixer

The concrete shall be discharged from the mixer on to a level, clean, watertight platform or floor and then to carriers for transportation. Maximum fall height shall be limited to 1.5m.The area surrounding the mixer shall be kept clean.

When skips or mobile concrete carriers are used, concrete may be directly discharged from the mixer in to the skips or rotating drums of mobile carriers.

c) Transportation of concrete

Direct pumping of Concrete from Batching plant to the casting location is preferred mode for the transportation of concrete.. However during un-avoidable situations Concrete shall be transported from the mixer to the place of work as rapidly as possible and practicable and in such a manner that there shall be no separation or loss of any of the ingredients and maintain the required workability. No water shall be mixed with the concrete after it has left the mixer.

Where concrete is transported over long distances, the Contractor shall provide transit mixers. Concrete shall not be permitted for use in the works after initial set has taken place. It shall be ensured that the concrete distributing chutes are placed at an angle not more than 45 degrees from the horizontal.

Necessary concrete Pour Card shall be maintained at site.

d) Actions before placement of concrete

Program of works

At the beginning of every week, the contractor shall give his detailed concreting program for that week to the Engineer / Engineer's Representative. Such programs, shall specify all information such as the locations where concrete is to be poured, type/grade of concrete, volume of concrete to be poured, number and type of vibrators proposed to be used as well as proposed to keep as standby, number of skilled technicians and supervisors proposed to be engaged, the proposed time and period of pouring etc.

Checking & approval

Before placement of concrete, the contractor shall get all the formworks, reinforcements, inserts, conduits, openings, surface preparation etc., checked and approved by the Engineer / Engineer's Representative. To facilitate such checking, the contractor shall complete all his works according to the drawings and specifications well in advance before placement of concrete at least 36 hours for all major/ important/ complicated works and 24 hours for all minor/ordinary/simple works. The checks are purely in the interest of the work and to draw the contractor's attention to his contractual obligations to execute the works according to the drawings/specification and do not relieve the contractor from his responsibility in getting the end results for the quality & strength of concrete and for maintaining the shape, level & dimensions of the finished concrete, as well as the inserts, openings, other features within the tolerance limits.

e) Preparatory Works/Surface Preparation

For Concrete Directly on Earth Foundation

Earth foundation on which direct placement of concrete is specified, shall be rammed and consolidated as directed by the Engineer / Engineer's Representative such that it does not crumble and get mixed with concrete during or after placement. If the foundation is quite wet, the same shall be kept dry and then sufficiently consolidated, if necessary, a thin top layer of the wet soil shall be removed and replaced by sand or other suitable materials as directed by the Engineer / Engineer's Representative without any extra cost to the Engineer. Care shall also be taken that earth from the sides also does not get mixed with the concrete, during or after placement, before it has sufficiently set and hardened.

The earth foundation, over which concrete is to be placed direct, shall not be kept abandoned at the specified level and concrete shall be placed immediately following the final preparation of the formation otherwise suitable measures shall be taken, as directed by the Engineer / Engineer's Representative without any extra cost to the Engineer.

Concreting in Inclement Weather

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

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

f) Concreting Under Water

Where concrete is to be deposited underwater, the greatest care shall be taken to prevent the cement being washed out. The concrete shall be placed through a tremie pipe with

suitable hopper and plunger arrangements. Great care shall be taken to ensure that no segregation of concrete takes place and the Engineer / Engineer's Representative 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 minimize the entry of water into the tube and it shall be entirely sealed at all times and kept full of concrete up to the bottom of the hopper. Concreting operations once commenced are to be completed in full without break; otherwise, the structure shall be considered as rejected.

g) Construction joints

All such joints shall have continuous square bond grooves to produce a substantial and watertight key. Where the placement of concrete has to be resumed on a surface, which has hardened, removal of laitance and roughening shall be accomplished by cleaning by wire brushing, and washing by compressed air, water jet etc., and thoroughly wetted. For vertical construction joints neat cement slurry shall be applied on the surface immediately before the placement of concrete. For horizontal joints the surface shall be covered with a layer of freshly mixed mortar about 10 to 15 mm thick composed of cement and sand in the same proportion as the cement and sand in the concrete mix and applied immediately before placing of the concrete. On this surface (i.e. on the surface of joints) a layer of concrete not exceeding 150-mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots. To ensure water tightness, care shall be taken to pour concrete properly against the old surface.

h) Inside the formwork (cleaning, surface preparation etc,)

The interior of the formworks, where the concrete is to be placed, shall be thoroughly washed by high-pressure water jet or air jet to completely clean the entire volume from all sort of dirt, grease/oil, foreign and deleterious materials etc. The reinforcement shall be completely clean and free from all sorts of dirt, grease/oil, rust, foreign/deleterious materials etc. Before placement of concrete, the form works coming in contact with concrete, shall be coated with form oil or raw linseed oil material or provided with any approved material to prevent adhesion of concrete to the form work, but utmost care shall be taken so that such oily material do not come in contact with the reinforcement.

i) 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 2.14 of these specifications is not violated in case of continuous concreting. The concrete shall 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.

j) Placing and Compaction of Concrete

The concrete shall be placed and compacted before setting commences and should not be subsequently disturbed. No water shall be mixed with the concrete after it has left the mixer. Method of placing should be such as to preclude segregation. Approved mechanical vibrators of adequate power and having a frequency of not less than 6000 impulses per minute shall be used for compacting concrete. The vibrator shall be allowed to sink freely of its own weight until it enters the previous lift. Concrete shall not be over vibrated or under vibrated. No concrete shall be placed until the place of deposit has been thoroughly inspected and approved by the Engineer / Engineer's Representative. The contractor shall ensure that the concrete is thoroughly worked around the reinforcements and against external shutters so that all entrained air is expelled and the concrete surface when exposed is found good and free from the air pockets, honeycombing or other defects. All inserts and embedment properly secured in position and checked and forms properly oiled. No concrete shall be placed in the absence of the Engineer or his representative.

Concrete shall be placed on clean bed having the designed level. The bed shall be cleaned of all debris and other objectionable materials. Seepage water, if any, shall be controlled or diverted.

Concreting shall not be carried on during rains unless the Contractor has taken all precautions and the Engineer / Engineer's Representative has given necessary permission. Suitable measures shall be taken to control the temperature of concrete.

Concrete shall not be dropped from a height of more than 1.5 m except through a chute, placed at not more than 45 degrees from the ground. The design and type of which shall be subject to approval of the Engineer / Engineer's Representative.

The concrete shall be placed, spread and compacted by approved mechanical vibrator. All vibrators shall confirm to IS 2505. Vibrators shall not be used for pushing concrete to adjoining areas.

Utmost care shall be taken to avoid the displacement of reinforcements/ embedded parts or movement of formwork or damage to faces of the formwork or transmission of any harmful vibration/shocks to the concrete, which has not yet hardened sufficiently.

All members shall be concreted at such a rate that no cold joint is formed and fresh concrete is placed always against green concrete, which is still plastic and workable.

Should any unforeseen occurrence results in a stoppage of concreting for one hour or such other time as might allow the concrete, already placed, to begin to set before the next batches can be placed, the Contractor shall make at his own cost, suitable tongue, and groove construction joint, as approved by the Engineer / Engineer's Representative. The Contractor at his own cost shall also provide any additional reinforcement required as directed by the Engineer / Engineer's Representative. Before placement of new batches of concrete over that construction joint, the surface preparation according to this specification stipulated earlier, shall be done by the Contractor at his own cost.

The concrete shall be worked well up against whatever surface it adjoins and compacted to such a degree that it reaches its maximum density as a homogeneous mass, free from air and water holes and penetrates to all corners of moulds and shuttering and completely surrounds the reinforcement. All measures shall be taken to make the shape, size, and location of the finished concrete including its embedment, holes, openings etc., well within the accepted tolerance limit.

k) Construction Joint and Cold Joint

Construction joints shall be kept to the minimum, and provided as directed by the Engineer / Engineer's Representative. These shall be straight and at right angles to the direction of main reinforcement.

In all construction joints the reinforcements shall pass through as per approved drawings and the same shall not be disturbed in any way.

The vertical construction joints shall be provided by insertion of board keeping provision for passage of reinforcement/fixtures/embedment. All construction joints shall be made to form a tongue and groove joint.

- Cold joint

An advancing face of a concrete pour, which could not be covered before expiry of initial setting time for unexpected reasons, is called a cold joint. The Contractor shall remain always vigilant to avoid cold joints. If however, a cold joint is formed due to unavoidable reasons, the following procedures shall be adopted for treating it:

a) If the concrete is so green that it can be removed manually and if vibrators can penetrate the surface without much effort, fresh concrete can be placed directly over the old surface and the fresh concrete along with the old concrete shall be vibrated systematically and thoroughly.
b) In case the concrete has hardened a bit more than (a), but can still be easily removed by a light hand pick, the surface shall be raked thoroughly and the loose concrete removed completely without disturbing the rest of the concrete in depth. Then a rich mortar layer of 12 mm thickness, shall be placed on the cold joint and then the fresh concrete shall be placed on the mortar layer and vibrated thoroughly, penetrating deep into the layer of concrete.
c) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not rise in spite of extensive vibration, a tongue and groove joint shall be made by removing some of the older concrete and the joint shall be left to harden at least for 12-24 hours. It will then be treated as regular construction joint and the surface preparation of the same, before placement of concrete, shall be as described in the appropriate clauses of these specifications.

5.1.1.17. Curing of Concrete

All concrete shall be protected during hardening from the harmful effects of sunshine, moisture and drying winds. The purpose of curing is to prevent loss of moisture from the concrete itself so that the cement inside the concrete is sufficiently hydrated which of course is slow and prolonged process. As soon as the concrete has hardened sufficiently 8 hrs after placement of concrete / 4 hrs during hot weather the curing shall be started. Curing the concrete properly and sufficiently is also the sole responsibility of the contractor.

Different methods of Curing

Any one of the following methods may be used for curing as approved by the Engineer / Engineer's Representative.

a) Curing by direct water.
b) Curing of concrete with absorbent material and kept damp.
c) Membrane curing

a) Curing by direct water

Curing shall be done by Ponding. Wherever ponding is not possible only those area shall be cured by spraying water,

- Ponding

Ponding shall be used for curing slab and pavements. LEAN MIX MORTAR bunds may be formed over the slabs and water pumped or poured into them and the same is replenished at interval to make up for the loss by evaporation.

b) Membrane Curing

In place where water curing by ponding is not possible membrane curing shall be used in lieu of moist curing with the permission of Engineer / Engineer's Representative. Such curing compound shall be applied by spraying or brushing to the required thickness as per Manufacturer's recommendation/specifications.

5.1.1.18. Testing of Concrete

The Contractor shall carry out, all sampling and testing of concrete in accordance with all the relevant I.S. Codes, with particular reference to IS 456-2000 "Plain and Reinforced Concrete. Code of Practice." and as supplemented herein at his cost. The Contractor shall get all the required tests done in a Laboratory approved by the Engineer / Engineer's Representative. The test results in triplicate may be obtained from the laboratory and submitted to the Engineer / Engineer's Representative within 3 days after completion of the test.

The Contractor shall also establish a field laboratory at site for conducting routine tests such as compressive strength, sieve analysis, etc. and any other test which could be carried out at site.

a) Consistency test (Tests of fresh concrete)

At the place of deposition/pouring of the concrete, to control the consistency, the Contractor shall carry out slump tests and/or compacting factor tests in accordance with I.S. 1199-1959 as directed by the Engineer / Engineer's Representative. The results of the slump tests/compacting factor tests shall be recorded in a register for reference duly signed by both the Contractor and the Engineer / Engineer's Representative. That register shall be considered as the property of the Engineer and shall be kept by the Contractor at site in safe custody.

The results of the slump tests/compacting factor tests shall tally, within accepted variation of plus or minus 12% with the results in the respective design mix, for design mix concrete.

For any particular batch of concrete, if the results do not conform to the requirements as specified, the Engineer / Engineer's Representative has the right to reject that batch and the Contractor shall remove the same immediately from the site, at no cost to the Employer.

b) 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 IS: 516.

In order to get a relatively quicker idea of the quality of the concrete compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength test. If six-test cube are taken, 3 shall be tested for compressive strength at 7 days after casting and the remaining 3 at 28 days after casting with the approval of the Engineer / Engineer's Representative. In all cases 28 day compressive strength specified in Table-2 of IS: 456-2000 shall alone be the criterion for acceptance or rejection of the concrete.

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. The frequency of sampling of concrete shall be either according to clause 15.2 of IS: 456-2000 or as directed by the Engineer / Engineer's Representative.

The Contractor shall maintain a register at site with the following details entered and signed by both, the Contractor and the Engineer / Engineer's Representative. That register shall be considered as the property of the Engineer.

Reference to the specific structural member

a) Mark on cubes
b) The grade of concrete
c) The mix of concrete
d) Date and time of casting
e) Crushing strength at 7 days

f) Crushing strength at 28 days
g) Acceptability of the concrete
h) Any other information as directed by the Engineer / Engineer's Representative.

Acceptance Criteria of Concrete Strength

Concrete in a section of the work shall be considered acceptable strength provided both the following conditions are met with:

a) The average 28 days strength of test results relating to the section of the work exceeds the specified strength of concrete class by 10% which means that if the concrete grade used is M40, then the average 28days shall be more than 44N/mm2
b) Any of the individual 28days test results shall not be lesser than 90% of the specified strength i.e. if the concrete grade is M40 the individual results shall not be less than36N/mm2

c) Non-destructive Tests on Hardened Concrete

Core tests shall be conducted for deck slab at 50m intervals. If there is doubt about the strength or quality of a particular work or the test results do not comply with the acceptance criteria as stipulated under clause 16 of IS: 456-2000 non-destructive tests on hardened concrete (clause 17.8), core test and/or load tests or other type of non-destructive tests like ultrasonic impulse test etc., shall be carried out, as may be directed by the Engineer / Engineer's Representative, by the Contractor at his own cost.

The core tests and load tests shall comply with the requirements of clause 17.4 and 17.6 of IS 456-2000 respectively. In case of other types of special tests like ultrasonic impulse tests etc., the stipulation of clause 17.8 of IS: 456-2000 shall be applicable.

d) Concrete below Specified Strength

Should the test cubes fail to meet the minimum specified crushing strength the Engineer / Engineer's Representative may take one of the following decisions:

a) Reject the work and instruct that section of the works to which the failed cubes relate shall be cut out and replaced at Contractor's expense and the resultant structures affected due to such rejection shall be made good at contractor's expense.

b) Instruct the Contractor to carry out such additional tests and/or works to ensure the soundness of the structure at Contractor's expense. This will include, but not limited to, taking 100-mm diameter core samples for testing at locations to be decided by the Engineer / Engineer's Representative from hardened concrete.
c) Modification/remedial measures if approved by the Engineer / Engineer's Representative to be carried out at contractor's expense.

e) Concrete Failed in Non-Destruction Tests

In case the test results of the core tests or load tests in a particular work do not comply with the requirements of respective clause (17.4 for core test and 17.6 for load tests) of IS: 456-2000 the whole or part of the work concerned shall be dismantled and replaced by the Contractor as may be directed by the Engineer / Engineer's Representative at his cost to the satisfaction of the Engineer / Engineer's Representative. No payment for the dismantled concrete including relevant formwork, reinforcement, embedded fixtures etc. shall be made. In the course of dismantling if any damage occurs to the adjacent structure or embedded item, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Engineer / Engineer's Representative.

f) Rejection of Concrete

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.

g) Finishing of Concrete

On striking the form work, all surface defects such as bulges, ridges and honeycombing etc. observed shall be brought to the notice of the Engineer. The Engineer 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 Engineer may reject the work totally and his decision shall be binding. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

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

5.1.1.19. Steel Reinforcement

a) Material

Reinforcement shall be cut, bent to shape and dimensions as shown in the contractors bar bending schedules / drawings as approved by the Engineer / Engineer's Representative.

b) Storage

Steel reinforcement shall be stored in such a manner that they are not in direct contact with ground. Bars of different classifications and sizes shall be stored separately. In cases of long storage or in coastal areas, reinforcement shall be stacked above ground level by at least 15 cm, and a coat of cement wash shall be given to prevent scaling and rusting at no extra cost to the Engineer.

c) Bending and Placing

Bending and placing of bars shall be in conformity with IS: 2502-2023 "Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement" and IS: 456 -2000 "Code of Practice for Plain and Reinforced Concrete".

Bar Bending schedule shall be prepared by the Contractor and shall be submitted to the Engineer / Engineer's Representative, in triplicate, for approval at least two weeks before the bars are to be bent. The Engineer / Engineer's Representative shall check and return one copy for the Contractor's use, with amendments noted, if any. Any approval given by the Engineer / Engineer's Representative shall, in no case relieve the Contractor from being responsible for the accuracy and correctness of the bar bending schedule.

d) Welding of Reinforcement

Welding of mild steel reinforcement bars conforming to IS: 432 (Part-I) shall be done in accordance with IS: 2751 "Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete construction" with additional precaution that for lap welded joints the throat thickness of weld beads shall be at least 3 mm or 0.6 times the nominal size of weld (which is the radius of bar) whichever is more.

Welding of high strength deformed bars conforming to IS: 1786-2008 shall be done in accordance with IS: 2751 and IS 9417 using electric arc welding process using low hydrogen electrodes (Ferro Weld- 1 or Ferro Weld-II or equivalent). Oxy-acetylene welding shall not be used.

Butt welding of bars up to 32-mm diameter for vertical splices shall be done either by single bevel groove weld or double bevel groove weld, with bevel angle 45 degree. Butt welding of bars up to 32 mm diameter for horizontal splices shall be done either by single Vee-groove weld or double Vee-groove weld with chamfered angle of 45 degree to 60 degree. The diameter of welded joint shall be 1.2 times the diameter of bar. Edge preparation for butt-welding shall be done by shearing, machining and grinding. Oxy-acetylene flame shall not be used for cutting. Chamfered faces shall be smoothly finished by hand file if required.

Lap welding of bars up to 20 mm diameter shall have a minimum bead length of 12 times the diameter of bar or 200 mm whichever is more arranged on one or both sides. The throat thickness of weld beads shall be 5 mm or 0.75 times the nominal size of weld (which is the radius of bar) whichever is more. In case of unsymmetrical lap weld with weld bead on one side only, the maximum length of each weld bead shall be 6 times the diameter of bar or 100 mm (whichever is more), separated by an equal length in between weld beads. Splice bars used in symmetrical weld joint shall have same diameter as the parent bars. Lap joint with single splice bars shall have weld beads on both sides.

Lap welding of bars above 20 mm shall be done using splice plate or splice angle. Thickness of splice plate shall not be less than 0.65 times the diameter of bar and width shall not be less than twice the diameter of bar. The size of splice angle shall be such that its area of cross section is at least 1.62 times the area of bar being spliced.

More than one third of the bars shall not be welded at any one section and welded joints shall be staggered at a distance of 50 times the diameter of bars. Welding shall not be done

at bends or curved parts of bars and it shall be located at least at a distance of 50 times the diameter of bar from bends.

5.1.1.20. Mechanical Splicing

Mechanical Splicing with Couplers shall be provided for Reinforcement Bars as far as possible. The couplers shall be of standard parallel square thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that root thread diameter is not lesser than the parent bar to be joined. The material of the coupler shall be of same quality or of superior quality than the quality of material of the parent bars (i.e. reinforcement bars to be joined). When the joint is tested in universal tensile testing machine, the coupler should withstand to the tensile stress mentioned below. The coupler shall be qualified as per ASME, Section III, and Div.2. The hand tightening of coupler shall be sufficient in the field and no mechanical means shall be essential for tightening.

a) Manufacturing of Couplers

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number, diameter for traceability. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply. The certificate shall give salient material properties.

b) Threading of ends of the reinforcing bars

This threading activity shall preferably be done at site. The various stages involved in threading are as given below

c) Cutting

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain end surface, perpendicular to the axis of the bar.

d) Cold forging & threading

After cutting, the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done, preferably on lathe machine. The threads shall be square parallel type, to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic caps, before taking the bars out of the shop.

e) Quality control in making of threads

Double forging of bars is not permitted. In case of improper cold forging, the forged end of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges.

f) Installation of couplers in the field

The installation of couplers in the field, for joining reinforcing bars, shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned with acetone or any other solvent, just before installation.

Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached & then cleaned before joining the next bar.

The contractor shall arrange for a suitably qualified manufacturer's representative, experienced in mechanically connecting reinforcement, to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary. The work in shop is to be fully supervised by the manufacturer's representative.

The contractor shall submit to the Engineer, for his acceptance, a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

a) requirements for cleanliness
b) equipment for threading bars
c) method of locking the connections on both rebars
d) method of verification of final rebar alignment and coupler integrity.

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance standards shall be completely removed and the bars re-connected, as required.

g) Qualification Tests

The splices shall be qualified as per ASME Section III Div-2 by conducting following tests:

h) Static Tensile Test

Mechanical connections shall be tested in all reinforcing rebar sizes. All rebar transition connectors shall be tested. For each rebar size, a minimum of six connections in each load direction shall be tested in accordance with ASTM standards\

A tensile test on an unspliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength.

The average tensile strength of the splices shall not be less than the followings:

a) 90% of the actual tensile strength of the reinforcing bar being tested.
b) 100% of the specified minimum tensile strength

The tensile strength of an individual splice system shall not be less than the 125% of the specified minimum yield strength of the spliced bar.

i) Cyclic Tensile and Compressive Test

Cyclic tensile and compressive test: Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return.

j) Production tests

Static Tensile tests, as per ASTM A370, shall be conducted by contractor on each bar size & grade u sing straight sister splices. Frequency of the tests may be reviewed by the engineer.

5.1.1.21. Tests

Test pieces of welded bars shall be selected and tested in accordance with the provisions of IS 2751. The number of tests will be as laid down in IS: 2751 or such larger number as the Engineer / Engineer's Representative may decide having regard to the circumstances.

a) Cleaning

All steel for reinforcement shall be free from loose scales, rust coatings, oil, grease, paint or other harmful matters immediately before placing the concrete. To ensure this, reinforcements with rust coatings shall be cleaned thoroughly before bending/placement of the same.

b) Placing in position

All reinforcements shall be accurately fixed and maintained in position as shown on the drawings and by adequate means like mild steel chairs and/or concrete spacer blocks as required. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by 20G annealed soft steel wire or by tack welding in case of bars larger than 25 mm dia, as may be directed by the Engineer / Engineer's Representative. Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be spaced such that the main bars do not sag perceptibly between adjacent spacers.

c) Nominal Cover

Minimum nominal cover to reinforcement shall be 75mm for piles and 50mm for Beam/slabs as per standard codes (IS 456 -2000).

Erection of Embedded Metallic Parts, Inserts, Conduits

Bolts and inserts and pipes, which are required to be embedded in concrete members, shall be securely fixed in position as shown in the drawings, before commencement of concreting. Bolts shall be checked for accuracy in alignment on both the axes. Limits of tolerance in alignment and level shall be as shown in the drawing or described elsewhere in these specifications.

Where bolts are housed in sleeves, special care shall be taken after concreting is over and has partly set to ensure that the bolts move within the sleeves. The annular space of the sleeve shall be plugged with suitable stoppers to prevent the ingress of water, grout, dust, rubbish or other foreign material into it, both during and after concreting. Opened conduits shall be plugged similarly. Where channels, unshapely profiles or other similar inserts are required to be placed in concrete, special care shall be taken to keep the grooves of such profiles free from the ingress of concrete, slurry etc., by suitable packing material, if necessary.

All threads for bolts and inserts shall be greased at intervals and kept covered to prevent damage. Necessary templates, jigs, fixtures, supports shall be used as may be specified or required or directed by the Engineer / Engineer's Representative free of cost to the Engineer.

Exposed surfaces of embedded materials shall be painted with one coat of anti-corrosive paint or bituminous paint, as desired, without any extra cost to the Engineer. If welding is to be done subsequently on the exposed surfaces of the embedded parts, the painting for a length of 50mm beyond each side of the weld line shall be cleaned off.

d) Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Engineer.

e) Shuttering

The formwork for concrete structures shall be as per IS 14687. The Contractor shall design all shuttering, formwork, supports and staging. The Contractor shall submit drawings and calculations to the Engineer / Engineer's Representative for scrutiny when called upon to do so. The shuttering shall be designed for a live load in addition to the weight of the green concrete, or such other load considered being necessary. The Contractor shall be responsible for the correctness and strength of the formwork including its supports.

f) Material

The staging and supports may be made of Steel or Water-proof Plywood. These shall be securely jointed or otherwise fastened and spaced at suitable intervals as the design may warrant and shall be suitably braced at regular intervals horizontally and diagonally. The

formwork shall be of steel plate on steel frame, wooden boards with steel sheet lining, or plywood or seasoned timber board.

g) Fixing

The shuttering shall conform to the shapes, lines, levels and dimensions shown in the drawing. It shall be fixed in perfect alignment and securely braced so as to be able to withstand, without appreciable displacement, deflection or movement of any kind, the weight of all construction, movement of persons and plant. It shall be so constructed as to remain rigid during the placing and compacting of concrete without shifting or yielding and shall be sufficiently water tight to prevent loss of slurry from the concrete.

All props shall be supported on sole plates and double wedges. At the time of removing props these wedges shall be gently eased and not knocked out. The formwork shall be so designed that the sides are independent of the soffits and the side forms can be removed easily without any damage or shock to the concrete.

h) Contractors Responsibility

Any damage resulting from faulty preparation, premature or careless removal of shuttering shall be made good by the Contractor at his own expenses.

i) Irrecoverable Shuttering

In cases where the shuttering cannot be removed without damaging the structure itself or where removal of shuttering is rendered impossible due to the nature of construction or where the Engineer / Engineer's Representative may so instruct, such shuttering shall be classified as irrecoverable shuttering. However, such abandoning of shuttering will be permitted only in situations where it will not remain exposed or otherwise cause damage of any kind.

j) Chamfers and Fillets

All corners and angles shall be formed with 45 degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfer and fillets, unless otherwise detailed or specified shall be 25x25mm. For heavier work chamfers or fillets shall be 50x50mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

k) 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 Engineer

l) Grout

The scope covers the grouting under base plates, grouting between the joints of precast concrete, grouting the pockets/holes/opening etc.

m) Grouting under Base Plates

Grouting under base plates of equipment's/structures shall be of cement mortar 1:2 for thickness up to 25 mm. For thickness exceeding 25 mm, concrete using 10 mm downgraded aggregates shall be used. The grout shall be placed in position well rammed until the whole space is completely filled with concrete. No vibrators shall be used. Quick setting cements shall be used in the preparation of mortar or concrete, where so specified.

The grout shall either be "dry" concrete or mortar or "wet expanding" concrete or mortar as the Engineer / Engineer's Representative may direct. A dry grout shall have a slump not exceeding 6 mm. It shall be rammed under the horizontal surface with the aid of suitable tools. A "wet expanding" grout shall have a slump of at least 125 mm but not exceeding 225 mm. To this shall be added an expanding admixture approved by the Engineer / Engineer's Representative and in accordance to the Manufacturer's instructions.

n) Grouting the Pockets/Holes in Concrete

Depending upon the size of the pockets/holes in the concrete, the mix of the grout shall be either of concrete or of cement sand mortars. In filling the holes of foundation bolts an expanding admixture of approved type shall be used as per manufacturer's specification.

o) Workmanship

The surface of the concrete over which grouting is to be applied shall be thoroughly prepared to provide a clean rough surface. If necessary, chipping shall be carried out on such surface to make it completely rough. Then the surface shall be wetted. Bolt pockets shall be cleaned immediately before the base plate is placed in position. Before grouting the surface shall be thoroughly cleaned with compressed air/water jet.

Before placement of grout, the surfaces (except in the case of bolt holes) shall be wetted with cement slurry. In case of bolt holes/pockets water from such pockets shall be thoroughly removed by some suitable means and no cement slurry shall be applied.

Hand mixing is not permitted and the grout shall always be machine mixed. If however in some special cases where the quantity of grout is so small that it cannot be machine mixed, hand mixing may be allowed but the same shall be done under the strict supervision of an experienced supervisor of the Contractor.

The grout shall be placed within 30 minutes of being mixed. The grout shall be poured and then worked into position by suitable means until the space is completely filled. The Contractor shall take all possible measures during grouting so that the grout fills the space completely and thoroughly. Where the gap is very small or unapproachable for the placement of concrete, the Contractor shall grout by pressure grouting and in that case the mix may be of cement sand mortar of the appropriate grade but in any case the water cement ratio shall be as low as possible. Neither "Dry" grout (having slump 6mm or less) nor expanding wet grout shall be grouted with any type of vibrating machine

p) Curing

After 10 hours of grouting, the same shall be covered with wet gunny bags and the surface shall be kept continuously moist at least for 10 days.

5.1.1.22. Precast Concrete

The requirement of the clauses relating to concrete and reinforced concrete shall be observed in the case of precast concrete work so far as they are applicable, as well as the following requirements relating to the pre-cast concrete work, in particular. All precast units shall be cast on a suitable bed or platform with firm foundations and free from wind.

a) Pre-casting Yard

The pre-cast units shall be cast on or their shutters supported from a suitably prepared level, unyielding paved area. Contractor shall be responsible for the accuracy of the level of shape of the bed of platform.

All precast units shall be cast on suitable yard, beds or platforms with firm foundation and free from wind. The platforms shall have smooth plaster finish. The yard shall be fenced and shall have a curing tank of adequate size. The Contractor shall be responsible for the accuracy of the level or shape of the bed or platforms. Each unit shall be cast in one operation and proper serial number and date of casting shall be impressed or painted on it.

When units are cast directly on to concrete floor slab, Contractor shall ensure that the parts of the floor on which the units rest are sufficiently smooth and level or are made so by laying temporary screeding which must be removable without damage to the floor surface, in all cases a membrane of waxed paper or other approved material shall be carefully laid on the floor underneath the moulds to prevent the concrete adhering to the floor.

Holes for Fixing, Service etc.

a) Holes shall be formed at the positions shown in the drawing or as approved by the Engineer / Engineer's Representative, using appropriate template or any other approved forms prior to concreting.
b) Holes for fixing precast units shall be cored accurately in the positions if shown in the drawings and at right angles to the surfaces from which they are cored unless otherwise shown or approved by Engineer / Engineer's Representative.
c) Holes to receive fixing bolts which bear on the surface of the holes shall be permanently cored with galvanized steel tube, the ends of which must finish flush with the surface unit.
d) No holes shall be made in the hardened concrete without the permission of the Engineer / Engineer's Representative.
e) Necessary lifting hooks of suitable (not less than 12mm dia) M.S rounds shall be provided for handling.

b) Shutters

All shutters shall be strongly constructed closely and joined smoothly to ensure true sharp and a perfect surface. Shutters are to be so designed that they can be taken apart and reassembled readily.

The formwork for moulds shall be constructed of well-seasoned timber or steel sheets such as to give a form finished surface. All component parts of formwork shall be so hold that during concreting, there is no deformation of the form resulting the units not conforming to dimensions and there is no leakage of cement slurry, while steel sheets with rigid steel frames may be used, surfaces with plywood backing and plastic or Formica lining is preferred for form finish. However, where linings are not used, special form oils approved by the Engineer / Engineer's Representative shall be used. The oils that give stains to the surfaces shall not be permitted. There should be no visible offset, bulges or misalignment of concrete.

Precast concrete beams, and similar other units shall be cambered wherever shown in the drawing or directed by the Engineer / Engineer's Representative.

c) Casting Tolerance

The casting tolerances, unless otherwise ordered or directed, shall be within 3 mm. of true dimensions.

d) Striking Shutters

The method and time after casting of units and striking the side shutters shall be subject to approval of the Engineer / Engineer's Representative and as per the provisions of relevant IS codes. In the event of any damage resulting from premature removal of shutters or from any other cause, the unit or units concerned will be liable to rejection and to replacement by the Contractor at his own cost.

e) Curing

All pre-cast work shall be protected from the direct ray of the sun for at least 10 days after casting and during that period each unit shall be kept constantly watered or preferably be completely immersed in water; curing shall be at least for 15 days. The units shall be built in to their positions not earlier than 28 days after the date of casting.

f) Lifting and Stacking

Lifting and stacking of pre-cast units shall be undertaken without causing shock, vibration or undue stress to or in the units. Pre-cast units shall not be lifted, transported or used in the works until they are sufficiently matured; the crushing test on the test cubes which are to be kept with the pre-cast units will be used to assess the maturity of the units. The Contractor shall satisfy the Engineer / Engineer's Representative that the methods he proposes for lifting, transporting and setting pre-cast units will not overstress or damage the units in any way. In the event of damage, unit or units concerned will be liable to rejection and if so rejected shall be immediately broken up and removed from the Site. The Contractor shall replace such rejected units at his own cost.

g) Marking

The Contractor shall ensure that all pre-cast units are properly marked in clean and legible manner with the reference number and the date of casting, which information shall be clearly visible where the units are stacked. Reinforced pre¬-cast members shall be clearly marked to indicate the top face.

h) Pre-casting Records

Full and accurate records are to be maintained for all pre-cast work. Every unit shall have a reference number. Date of casting, date of removal from bed and date and position of placing shall be recorded together with test cube results.

i) Cast in Items

Fittings and items of embedment which are to be set in position before the surrounding concrete is deposited shall be protected by painting or otherwise, as directed by Engineer / Engineer's Representative, against the defects of the water in and chemical action of concrete. Particular care shall be taken to ensure that concrete completely surrounds and is in intimate contact with all casts in items and is properly compacted thereabout.

j) Dimension of Pre-cast Units

a) The Contractor shall before commencing manufacture of pre-cast units; check all dimensions on the detail drawings governing accuracy of fit and assembly in accordance with the general arrangement and assembly drawings.
b) The dimensions of pre-cast units must not vary by more than the tolerance specified and any unit, which shall not comply with the same, shall be rejected at the directions of the Engineer / Engineer's Representative. Any loss of material / labour on account of rejection shall be borne by the Contractor.

k) Transport, Storage & Placing

Transportation of all units to the site will only be allowed either:

- 28 days after fabrication,
- after the required compressive strength is reached

Transportation, storage and placing of the pre-cast concrete units shall be done carefully and in such a way as to avoid damage and to keep the surfaces of the units free from dirt or other undesirable marks.

Loading and unloading, storage and placing of the pre-cast concrete units at the Site shall be done by skilled labour and under supervision of a competent supervisor.

Lifting and handling of pre-cast concrete shall be done only at the positions shown on the approved drawings and only vertical lifts will be allowed.

During storage, pre-cast concrete units shall be supported on blocks placed exactly under the bearing locations and at no other points.

During transport, storage and placing, the contractor must take all necessary precautions to avoid damage to the reinforcement of the pre-cast concrete units.

All lifting, handling and storage procedures shall be got approved by the Engineer / Engineer's Representative before their implementation.

Any proposal for erection equipment, temporary works and abnormal loading on a member during construction shall be submitted to the Engineer / Engineer's Representative for information

No pre-cast concrete unit shall be laid on its side or upside down, unless such a position is shown by calculation for the satisfaction of the Engineer / Engineer's Representative.

Any pre-cast concrete unit, which is damaged or has any perceptible faults, will be liable to be rejected by the Engineer / Engineer's Representative.

Except in the case of service duct covers and unless otherwise specified or shown on the Drawings, approved bearing or washing pads shall be inserted at all joints and seating to prevent direct contact of concrete to concrete or concrete to steel.

l) Joints between Pre-cast Deck Unit

All surfaces of pre-cast units, which will eventually be joined to other pre-cast units or in-situ concrete or mortar, shall be treated as previously specified under construction joints. However, joints specified to be filled with dry packed concrete shall not have their surface coated with mortar. Continuous concreting shall be done in a single operation as per the requirements of IS 456 and IS 2974.

5.1.2. BORED CAST-IN-SITU CONCRETE PILE

This specification covers the piling work required for the proposed Berths. The Contractor shall be deemed to have visited & carefully examined the site & surrounding, and satisfied himself about the site condition etc. and all other matters affecting the work. Claims and objections due to ignorance of site condition shall not be considered after submission of tender.

The Geo technical Investigation Report available is for reference. Information given in bore logs is to be followed as guidance only and for any discrepancy found therein during execution, the Employer is not responsible. The Contractor at his cost if required shall carry out any additional geo- technical investigation. The contractor shall be responsible for verifying and interpreting all such data furnished by the Employer.

a) Codes / Standard

Design, Construction and testing of bored piles shall be carried out in accordance with the relevant sections of IS: 2911 (Part I/Section 2)- 2010: 'Code of practice for design & construction of Bored Cast- in- Situ concrete piles' in conjunction with this specification. If for any material or workmanship, appropriate Indian Standards or Codes are not available

or have not been adequately specified in the Technical Specification, such materials& workmanship shall conform to other suitable Standard & Codes as may be approved by the Engineer / Engineer's Representative.

In case of any conflict between the requirement of this specification & those of the referred codes / standards, the former shall govern. Any special requirements as shown or noted on the approved drawings shall govern over this specification.

b) Materials

All the materials proposed to be used, shall be free from any objectionable substances, shall confirm the following stipulation & shall be approved by the Engineer / Engineer's Representative. Any testing required proving the suitability of such materials should be carried out by the contractor at his own cost & in the presence of the Engineer / Engineer's Representative. Any material rejected by the Engineer / Engineer's Representative shall be immediately removed from the site.

Reinforced Cement Concrete for Piles shall be with minimum Cement content of 400 Kg/m3 and the Maximum shall be 450 Kg/m3. The slump of concrete for piles shall be between 100 mm to 180 mm. The water-cement ratio shall not exceed 0.45.The minimum grade of concrete for piles is M40. To achieve the specified slump using specified water cement ratio without compromising with strength, if required, suitable admixtures shall be used subject to approval of the Engineer / Engineer's Representative.

Preliminary mix design shall be done in accordance with IS: 10262-2019 & SP: 23 subject to approval of the Engineer / Engineer's Representative. Cube tests, slump test & other relevant tests for preliminary mix design and Routine cube test, slump test for regular concreting shall be carried out at site / site laboratory at contractor's own cost. Concrete cube tests shall be done as per IS:516-2021. The calibration certificate of the testing machine done freshly shall be available at site. If the Engineer / Engineer's Representative has any doubt about the calibration, the contractor has to check the same at an approved laboratory at his own cost. All such tests shall be conducted in presence of Engineer / Engineer's Representative. Frequency of cube test shall be guided by clause 15.2 of IS: 456-2000 or at any deterioration in concrete quality if felt by Engineer / Engineer's Representative, whichever occurs earlier. Slump tests (apparatus conforming to IS: 7320) shall be carried out at least once for each pile or more frequently, if desired by the Engineer / Engineer's Representative.

c) Equipment & Accessories

The equipment & accessories should be compatible with the type of sub-soil, method of installation, type of founding strata & required penetration in the founding strata.

The capacity of rig shall be adequate so as to bore up to required depth with specified diameter. Rig shall be equipped with suitable chisel or chopper to penetrate through any

local obstruction/ hard strata including solid rock, if required. No excuses, whatsoever, in relation to the inability of equipment shall be entertained during execution of work.

Contractor must furnish a detailed list of equipment & accessories (in sufficient quantities to complete the job within scheduled time frame & as per specification) to be deployed by him for this job indicating quantity, type, capacity/dimension & model/make of each along with his offer & reconfirm the same, in writing immediately after mobilisation to site.

d) Method of Construction

The contractor shall furnish to the Engineer / Engineer's Representative, before commencing the work detailed method of construction he intends to adopt for piling work together with the program of construction.

e) Boring

Boring shall generally be carried out by recommended procedure as set out in IS: 2911 by rotary or percussion equipment, grabbing equipment or by reverse or direct mud circulation method.

Boring of any pile shall not be carried out if any of the adjacent pile within a clear distance of 5m, had been freshly concreted within past 24 hours

If soil is found to be unstable it shall be stabilized by using casing / liners of suitable thickness with a stiffener at the bottom depending upon the diameter of the piles and soil conditions. Casing or liner plates shall be provided from cut-off level up to 5m below the Existing Bed Level (or) 1m below Final Dredge Level whichever is maximum. The method of boring & providing casing shall be such that the finished cross section of concrete pile shaft at any location shall be not less than that shown in the drawing. The Contractor shall submit with the tender his method of boring & providing liner plates or casing where required.

Bentonite if used shall be of the best quality. Bentonite shall be mixed thoroughly with clean fresh water to make a suspension, which will maintain of the pile excavation for the period, necessary to place concrete and complete construction. It should form a suspension, which remains stable for the construction of marine piles. Necessary tests shall be conducted periodically as directed by the Engineer / Engineer's Representative.

During the course of boring if hard layers are encountered, chisel or a chopper may be used. The piles shall be installed with due consideration for safety of adjacent structures by a method, which leaves their strength unimpaired, and which develops and retains the required bearing resistance.

f) Termination Criteria of Piles:

It shall be ensured that the pile is founded in suitable strata. Before founding the pile SPT shall be conducted at the proposed founding level. Founding level of each pile will be individually approved by the Engineer / Engineer's Representative satisfying himself from

observations and all data including SPT tests at his disposal, of the soundness of the end-bearing stratum. In case of rocky strata the pile shall be socketed a minimum of one diameter of the pile or as directed by the Engineer / Engineer's Representative. In other soils the penetration shall be as per designs, with the approval of the Engineer / Engineer's Representative.

g) Reinforcement

Reinforcement as required shall be made into stiff cages sufficiently welded to withstand handling without any damage or distortion. The bars shall be placed as not to impede the placing of the concrete. Reinforcement shall be placed immediately after cleaning and inspection of the bottom of bore holes. The reinforcement should be supported away from the sides of the shaft by means of suitable spacer blocks (75mm) to ensure concentric alignment in the shaft. Steps shall be taken to ensure correct positioning of reinforcement in the piles without any distortion during concreting.

h) Formation of Pile

Immediately before placing of reinforcement and concreting, the bored hole shall be cleaned of all the loose material, debris and all the water shall be removed.

Then the bored hole shall be cleaned with Air Flushing before flushing the bore with fresh Bentonite slurry (if used) to completely replace the old Bentonite slurry used during the previous operations. This shall be carried out for about 45 minutes.

Upon completion of cleaning of the pile shaft, a sample of Bentonite suspension shall be taken from the base of the pile shaft using an approved sampling device. If the specific gravity of the Bentonite suspension exceeds 1.10 or its sand content exceeds 2%, the placing of concrete shall not proceed. In this event, the contractor shall modify or replace the Bentonite or continue cleaning the bottom of the shaft as directed by the Engineer / Engineer's Representative.

Contractor has to ensure the maintenance of bored depth both at pre & post flushing stage. Immediately after cleaning concrete shall be so placed as to fill the entire volume of the tube or bore without the formation of voids caused by the faulty consolidation or entrapped air. Proper care shall be taken to ensure that the fluid alluvial soil does not penetrate between batches of the concrete.

In case of boreholes stabilised by Bentonite slurry or under water, concrete shall be placed by means of tremie pipe. The tremie pipe must extend up to the bottom of the borehole at the start and may be withdrawn in sections as the level of concrete rises in the borehole, but its discharge end shall at all times be embedded in the concrete to a minimum depth of 2 m to avoid mixing of fresh concrete with Bentonite slurry. Placing of concrete should be continuous and the pile holes will be maintained full with the Bentonite slurry where used throughout the concreting operation. Used Bentonite, containing muck, debris arising from boring of pile shall be collected, transported and disposed off at a place to be identified by

the Engineer / Engineer's Representative. Rate for boring quoted by the Contractor shall include the expenses incurred of such disposal.

Temporary stoppage of work may be permitted only during boring stage. Thereafter right from boring or chiselling of final portion of pile length through subsequent activities of flushing, lowering of reinforcement cage, lowering of tremie, pre-concrete flushing & up to concreting of full pile length, no halt whatsoever in the execution of work shall be permitted. During execution continuous delivery of concrete shall be guaranteed in-order to minimize the re-handling of the concrete.

Concreting of pile shall continue until the pile is fully formed up to a level not less than 600mm above the cut off level of piles and the top of the piles shall be brought up above the cut off level / 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. Trimming of pile top shall not be permitted before 7 days of concreting in case of mechanical chipping and 3 days in case of manual chipping.

i) Standard of Acceptance

The piles shall be accepted as satisfactory only when the work has been executed in accordance with this specification, IS Codes, and the Standards stated below, and any instructions given by Engineer / Engineer's Representative at site from time to time:

a) The total volume of concrete shall not be less than 95%and not more than 120% of the actual shaft volume. The calculated volume for this purpose shall be the cross sectional area inside the bore multiplied by the length of the shaft (i.e. from cut off level to founding level). If actual quantity is found to be considerably less than 95% special investigation shall be conducted and appropriate measures taken.
b) The concrete shall be of the design strength (as per acceptance criteria) by the cube test results.
c) The toe of pile shall be at approved bearing level in each case
d) The pile shall not be out of plumb by more than 2%
e) The tilting of the head of the pile at top shall not be more than 75 mm.

If an individual pile fails to meet the requirements specified in any of above clause/s, such pile shall be deemed to be defective.

When any pile is found defective, such piles shall be rejected and one or more piles shall be installed as a replacement of defective pile as necessary without any extra cost to Employer and with the approval of Engineer / Engineer's Representative. Defective piles shall be left in place.

During construction it shall be ensured that all piles are properly braced by suitable ISMC / ISMB to avoid any tilting of the piles after concreting till they are permanently interconnected by regular beams

j) Record

The contractor shall maintain a record for each pile indicating the following data and shall be signed jointly with Engineer / Engineer's Representative.

a) The date and time of commencement and completion of the piling operation
b) The particulars of the equipment and method of boring and concreting.
c) The location and type of pile, Pile number, with a reference to approved drawings.
d) The diameter of the pile and verticality.
e) Bored depth, concreted depth and nature of strata at founding Level.
f) The volume of concrete poured, quantity of cement, w/c ratio used and Slump of poured concrete.
g) Details of reinforcement provided.
h) The sequence of installation of pile groups.
i) During boring operation, a separate record for rate of advancement of borehole in terms of effective time vs. boring depth shall be maintained for each pile. The effective time implies the time required exclusively for boring operation barring the time for other activities such as Temporary stoppage, cleaning of hole, in-situ tests, if taken etc.

k) Pile Testing

I. Initial Pile Load Test – Vertical Load

Initial Vertical load test shall be carried out on the specially constructed test piles. Test load shall be 2.5 times the design load or pile failure whichever is earlier. Preparation of pile and other procedures of testing etc. shall be carried out as per the instructions of Engineer the Engineer / Engineer's Representative. Cost of test pile shall be deemed to be inclusive in the overall price quoted.

II. Initial Pile Load Test – Lateral Load

The test shall be carried out on the specially constructed test piles. Test load shall be carried out in accordance with IS: 2911- (Part-IV). Preparation of pile and other procedures of testing etc. shall be carried out as per the instructions of Engineer the Engineer / Engineer's Representative.

III. Routine Load Test (Vertical)

The Routine Load Test shall be carried out on piles as required by the Engineer / Engineer's Representative. Load tests on piles shall be carried out only after 28 days from the date of casting the pile.

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 or pile failure whichever is earlier. The hydraulic jack shall be of adequate capacity and shall have a pressure gauge and remote control pump.

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

a) 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.
b) The 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.
c) A jack or two jacks, depending on the capacity of the jacks and the ultimate test load shall be inserted between the gap formed by the top of the plate resting on the pile and the lower flange of the main R.S.Js of the loaded platform. The jacks should preferably be connected and operated by one pump.
d) 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 R.S.Js of the platform
f) Readings of settlement and rebound shall be recorded with 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 end rest upon non-movable supports. The supports should be at least 5 x d away clear from the pile where "d" is the diameter of the pile. Readings on the dial gauges are to be observed immediately before and after application of loads and immediately before and after release of loads.
g) The test load shall be applied in equal increments of about 1/5 of the design load until the test load is reached.

Each stage of loading and unloading shall be maintained until the rate of movement of the pile top is not more than 0.02 mm per hour. Unloading shall be done us under:

i. Test load to design load
ii. Design load to 50 % of the design load
iii. 50% to 25% of the design load
iv. 25% to complete unloading

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

IV. Pile Integrity Testing

Non-destructive integrity testing of bored piles, as decided by the Engineer / Engineer's Representative 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. Qualified and experienced specialists in this field shall conduct the test. Engineer's / Engineer's Representative decision shall be final regarding acceptance of piles passing integrity test but of questionable workmanship.

V. Dynamic Test

High strain dynamic testing of bored piles, as decided by the Engineer / Engineer's representative shall be conducted as ASTM D4945. The test set up comprises of

- Apparatus for applying impact force
- Apparatus for obtaining dynamic measurements,
- Apparatus for Recording, Reducing & Displaying data.

Qualified and experienced specialists in this field shall conduct the test. Engineer's / Engineer's Representative decision shall be final regarding acceptance of piles passing test but of questionable workmanship.

VI. Minimum Number of Samples/Tests

Sl No.	TESTING OF PILES	NUMBER OF TESTS
1	Initial Pile load test	Vertical- 1 nos Horizontal – 1nos.
2	Routine Load Test	1% of total piles
3	Pile Integrity test	10% of total number of piles

6. ELECTRICAL SYSTEM FOR THE OUTER HARBOUR

The specifications for the electrical network given in this document is intended to provide general criteria to the contractor based on which detailed engineering of the electrical network shall be done in the execution stage.

This section specifies the general criteria for electrical setup works, including the provision of all associated elements. The final positioning of apparatus shall be determined by the Contractor in coordination with the Engineer during the detailed engineering phase to meet site-specific conditions. The extent of electrical installations and services described herein shall be read in conjunction with other sections of the overall project specifications. Contractor shall assume full responsibility for the detailed engineering, coordination, procurement, fabrication, supply, delivery, setup, inspection, inspection, activation, and operational readiness of all electrical systems and apparatus, including packaging, transportation, handling, storage, preservation, and supply of consumables at site, to achieve a fully functional and integrated facility in accordance with these specifications. Civil works related to electrical, control, and allied facilities shall be covered under the civil specifications.

The following basic Electrical Data viz., desired/available voltage levels, frequency and other such details shall be followed for this project and accordingly the apparatus for the port will be designed.

Table 6.1 Basic Electrical Data

Sl.No.	Description	Data	Remarks
1	Incoming Voltage from Grid	22KV, 3 Phase, 3 Wire	SC Rating 26KA
2	Frequency	50 Hz	-
3	Primary Distribution Voltage	22KV	SC Rating 26KA
4	Secondary Distribution/Utilization Voltage	6.6KV	SC Rating 40KA
5	Low Voltage system	415V	SC Rating 50KA
6	High Voltage Motors	6.6 kV, 3 Phase, 3 Wires	-
7	Low Voltage (LV) Distribution	415 V, 3 Phase, 3 Wires	4 Wire for Lighting
8	Control supply for HV and LV switchgear	110 V DC	-
9	MCC Contactor coils	220V AC	-

10	Switchgear & Protection circuit voltage	110 V DC	-
11	Solenoid valve voltage level	220 V AC	-
12	Digital inputs and outputs	220V AC	-
13	Lighting	415V/230V	-

6.1. SCOPE OF WORK

The project consists of the following Electrical Installations.

- Main Receiving Station (MRS)
- Main Power Distribution network.
- Sub-stations in the Port area.
- Power supply arrangement to Mobile equipment and other machines.
- Power supply to Port illumination network.
- Power distribution for Air conditioning and ventilation network.
- Power supply to reefer containers.
- Power supply arrangement to Ships in Port.
- Installation of Emergency Power Generator.
- Power supply to Utilities (Water & Air network, lifts etc).

As per the regulations of TANGEDCO, for Outer Harbour the Main Receiving Station (MRS) shall receive the power from the State Grid through a 66KV OH line. The MRS shall be located at a location close to the gate Complex for Outer Harbour. The 66KV power at MRS is stepped down to 22KV for distribution to the Sub-stations. Four Sub-stations are proposed in the port area out of which two are planned for Phase I and two for Phase II. To connect these Sub-stations 22KV routing shall be done. From MRS, the 22KV shall be stepped down to 6.6KV at the substations for further distribution and utilisation for the large capacity motors. 6.6KV Transformers will be installed in the sub stations for feeding 415V apparatuses.

Contractor's extent of works shall include for the detailed engineering, supply, transportation, delivery, setup, setting to work, inspection and activation of the completely assembled electrical infrastructure systems and services from Main Receiving Sub-station (MRSS), Distribution substations. The items listed below is not necessarily exhaustive and the Contractor shall include for all items essential for a completely assembled functional/ efficient network.

Liaise and co-ordinate the completely assembled electrical works and network for the completely assembled Outer Harbour Project with the controls, mechanical and civil structural setup elements as well as other installations by other agencies

Provide and commission completely assembled EHT (66 kV) Gas Insulated Switchgear (GIS) systems, including switchgear assemblies, busbars, metering devices, protection systems, internal control wiring, DC power cabling, and all associated accessories as per specification. This also includes depository works and laying of transmission lines with all related components up to the substation.

Provide and commission 66 kV/22 kV ONAN-type power transformers, along with all specified accessories, delivered as a completely assembled unit.

Provide and commission all control and relay panels, incorporating switchgear, busbars, metering, protection systems, internal control wiring, DC power cabling, and all other accessories as per specification.

Provide and commission low-tension (LT) switchgear assemblies, busbars, metering devices, protection systems, internal control wiring, DC power cabling, and all associated accessories as per specification.

Provide and commission Uninterruptible Power Supply (UPS) systems, including protection devices, internal control wiring, DC power cabling, and all other accessories as per specification.

Provide and commission diesel generator (DG) sets, including protection systems, internal control wiring, DC power cabling, obtaining CPCB and other statutory approvals, and all associated accessories as per specification.

Provide and commission all 110 V DC Battery and Battery charger network including DC distribution Board, inter connection cables and all as a completely assembled unit as per specification

Provide and commission APFC panel, interconnection cables and all as a completely assembled unit as per specification.

Provide and commission LV General Maintenance Units having 415V input voltage, busbars, metering, protection, internal control cabling, DC power cabling and all other accessories as a completely assembled unit as per specification.

Provide and commission Ship to Shore Units (Cope points) having 415V input voltages, connectors, internal control cabling, and all other accessories as a completely assembled unit as per specification.

Provide and commission all high tension (22kV) VCB cubicles including switchgears, busbars, metering, protection, internal control cabling, DC power cabling and all other accessories as a completely assembled unit as per specification.

Provide and commission area high mast, streetlights, and LED lights. For interior lighting of buildings completely assembled with all accessories like conduits and pull boxes. Luminaires completely assembled with all accessories as per specification to provide fully functional and high reliable Illumination network.

Supply, setup, inspection and activation of Main Power and Sub Distribution Boards, with all other accessories as a completely assembled unit as per specification.

Supply, laying, inspection, and activation of all high tension (11kV) power cables including cable termination kits, cable glands, cable joining kits, etc., laying, dressing, fixing, on cable trays, cable ducts, cable trenches, walls or any other cable trucking network as per specification

Supply, laying, inspection, and activation of all low voltage and control cables including cable termination kits, cable glands, cable joining kits, etc., laying, dressing, fixing, on cable trays, cable ducts, cable trenches, walls or any other cable trucking network as per specification

Supply, setup, inspection and activation of all earthing systems including supports, bends, joints, welding, bolting, riveting etc. and all accessories as per specification.

Supply, setup, inspection and activation of all Earthing and Lightning protection network with all accessories as per specification.

Supply, setup, inspection and activation of power cabling to the cranes as per specification and all essential coordination with the crane manufacturer /vendor/setup/inspection/activation teams.

Arranging Inspection, inspection, setting to work, activation and approvals from statutory authorities (Central Electricity Authority) of all the above installations including all electrics associated with the project, systems, and apparatus in parts and upon completion of each individual network, including site inspection as per specification. Any prior intimation, sanctions/approval in this regard shall also be obtained. Contractor shall also take care of time-to-time changes in the approval procedure till obtaining the final approval. Allowance for FATs and SATs witness inspection by the Employer/Engineer of all systems and elements of the electrical setup.

Preparation and submission of all detailed engineering drawings for approval including Shop drawings, Assembly drawings, Layouts and Working drawings, General Arrangement Drawings, Single line diagrams (power and control) of the completely assembled HT and LT Power Distribution Systems, high mast lighting, electrical control panels, switchboards, consoles and cabinets, electrical systems, cable routing, ducting, cable ladders, trays, trunking and conduit, including support systems to completely assembled the setup and assembly of all electrical installations. Installation method of all electrics shall also be submitted for approval.

Preparation of a full grading and discrimination study and consequent protection parameters and settings for all circuit protective apparatus.

Preparation of Arc flash studies to determine and provide suitable warning boards for each switchgear and substation protection and accessories in accordance with studies for SITC of substation protection and PPE apparatus. Rubber mats (IS 15652-2006 for all HT and LT apparatus's), 22kv and 6.6kv gloves, Tools box with tools, first aid box, Framed single line diagram, First aid in case of electric shock, etc.

Training and instruction of the Employers Operational and Maintenance Staff in all the above electrical installations and systems in their operation and maintenance criteria.

Preparation and submission of suitable As-Built drawings, Operation and Maintenance Manuals, Testing and Commissioning Documentation including the provision of all final and reviewed Shop drawings, Assembly drawings and Working drawings in both electronic format and 3 No. hard copies.

Co-ordinate, engineering in detail, integration, inter connections and interfaces with above mentioned extent of works to provide all accessories and apparatus whether major or minor including and/or additional to establish a fully functional Electrical System compliant with essential codes, standards and regulations, to provide electrical power to Outer Harbour and its buildings and substations as per specification

6.2. GENERAL DESIGN AND CONSTRUCTION REQUIREMENTS

In the case of electrical works, IS codes are to be followed. In the absence of IS codes, IEC shall be followed. In the absence of IEC, appropriate international standards shall be followed. Additionally, Central Electricity Authority rules and regulations, Indian Electricity act shall be followed for compliance and approval.

The engineering and setup of the electrical installations shall comply with the parts, sections or specific items from standard documents specifically referred to herein and to any related parts, sections or other items contained therein and implied by those specifically referred to. Specific references within this specification shall not relieve the Contractor of the requirement to comply fully with all relevant engineering and construction standards.

The whole of the electrical installations shall be designed in detail and constructed to ensure, so far as is reasonably practicable, their safe operation at all times and under all foreseeable conditions, intentional or otherwise.

The detailed engineering and construction of the electrical installations shall be such as to facilitate and, so far as is reasonably practicable, to always ensure the safety of personnel and plant, for

- In construction of the installations and associated plant.
- In inspection and activation of the installations and associated plant.
- In operation and use of the installations and associated plant.
- In maintenance and repair of the installations and associated plant.

- in eventual dismantling of the installations and associated plant at the end of its useful life.

Facilities shall be incorporated in the detailed engineering of the electrical installations to enable appropriate parts of the installations to be made safe, preferably by all conductors therein being made electrically dead, without shutting down the whole installations or the whole plant.

The detailed engineering and construction of the electrical installations shall take account of the need for and make provision to ensure that adequate working space, means of access and escape, lighting and other facilities are supplied to enable operation and maintenance of the installations to be carried out safely and efficiently.

The detailed engineering of the electrical installations and selection of apparatus for incorporation therein shall take account of their suitability with regard to all likely or reasonably foreseeable conditions in which the installations and apparatus may be required to operate.

Particular consideration shall be given to the following: -

Likely load and fault conditions.

- The ratings of apparatus and its abilities to handle load and fault conditions.
- Requirements for electrical protective devices and systems.
- Likely environmental conditions and conditions of use and abuse of the plant and associated electrical installations.
- The operational criteria of the plant served by the electrical installations.
- The need for safe and reliable activation, inspection and maintenance procedures to be applied to the plant and its electrical installations.
- Contractor shall take account of the local seismic and dynamic conditions in the selection, erection, arrangement and detailed engineering or electrical apparatus and its supports.

Operational life of all electrical apparatus shall be minimum 25 years unless specified in the following apparatus specifications.

The inter-relationships between individual items of apparatus and between the plant and its electrical installations shall be thoroughly considered to ensure proper selection of all electrical apparatus for overall safety and reliability.

All electrical apparatus incorporated in the installations shall be so selected and installed that it will not experience any effects beyond the levels for which it is rated and/or following tests carried out. Among the effects to be considered and of specific relevance to electrical apparatus are the following: -

- Load currents.
- Transient overloads

- Fault currents including earth leakage currents.
- Pulsating currents, harmonic currents and rapidly fluctuating loads
- Power factor and frequency variation of alternating currents
- Normal voltages to earth
- Normal voltage between conductors
- Transient over-voltages.
- ATEX /PESO certified apparatus for hazardous areas locations.

Consideration will be required of both the likely magnitude of the effects and their likely durations to ensure that apparatus ratings are suitably selected.

All apparatus shall be so selected and installed as to ensure its suitability for operation in its intended location. Factors to be considered shall include but not be limited to the following:

- Mechanical damage including impact, stress, strain, abrasion, wear, vibration and hydraulic and pneumatic pressure.
- Effects of the weather, which include both short term (e.g., wind, ice and snow, lightning) and long term (e.g., temperature cycling) effects.
- Natural hazards including animals, trees and plants, tides and solar radiation etc.
- Ambient temperature and pressure.
- Liquids and their effects, including humidity, condensation, splashing, or immersion, cleaning with liquids and hosing down.
- Dirty conditions including contamination by liquids or solids, corrosive conditions, flammable substances, explosive substances and mixtures.
- All reasonably foreseeable conditions and effects shall be considered, and apparatus shall be appropriately designed in detail and installed.
- The information listed below shall be supplied by the Contractor for review by the Engineer prior to ordering of materials and setup commencing on site.
- Name of Employer and location and intended purpose of the setup(s) shall be stated on all documents.
- State any operational or environmental factors which influence or affect the engineering or construction of the setup or apparatus. (Different sections or areas of the setup may be subject to differing influences.)
- Details of any particular environmental hazards which are relevant to the proposed installations. e.g., high or low temperature(s), potential mechanical damage, vibration, moisture, corrosion, explosive atmospheres, etc.

Complete information about the source of supply is to be stated, e.g., origin of setup, Voltage, frequency, capacity. Full details required by IS Regulations are to be stated. The type of network earthing is to be stated.

The method of protection against electric shock is to be stated. The ratings and settings, where they are adjustable, of all shock protective devices are to be stated.

Where protection against indirect contact is by earthed equipotential bonding and automatic disconnection of supply the basis of calculation and the impedance criterion used are to be stated.

Indicate the detailed provisions for main equipotential bonding including the items bonded and the size and type of bonding conductors. Indicate the provisions for supplementary bonding.

Confirm the type and size of all cables, including final circuits and protective conductors. For all main and sub-main cables from the origin of the setup to each final distribution board indicate the route and the method of setup.

For each rating and type of final circuits, e.g., lighting, small power etc., state the calculated.

maximum and minimum values of earth fault loop impedance and voltage drop at rated current, based on the maximum and minimum route lengths for circuits of that rating and type.

For each item of switchgear, including fuses and distribution boards, and control gear the rated normal current and short-circuit rating are to be stated. For circuit-breakers and protective relays the current and time settings, where they are adjustable, are to be stated.

The proposed IP classification(s) for all electrical apparatus including switchgear and control gear, instrumentation, luminaires, cable terminations and rotating machines is to be stated.

Provide full information required for inspection and inspection purposes.

The loads shall be balanced across the three phases as reasonably practicable as possible and the respective transformers of the low-tension switchboards.

7. TECHNICAL SPECIFICATIONS FOR ELECTRICAL INSTALLATIONS

7.1. 66 KV SWITCHGEAR

The switchgear shall be of the SF6, gas insulated three phase encapsulated type, suitable for accommodation within a building and capable of continuous operation under the climatic conditions existing at the Site. Duplicate busbar switchgear shall be supplied with busbar selector disconnectors as per specification in the Schedules to facilitate the changeover of individual circuits from one busbar to the other with the circuit on load and a bus coupler closed.

The apparatus offered shall be adequately protected from all types of network voltage surges and any apparatus essential to satisfy this requirement over and above that specified shall be included. Easy access shall be supplied for all apparatus, which needs regular checking and / or maintenance, by means of fixed type ladders, platforms or similar facilities. Access for a mobile platform to reach any part of the apparatus, all manual operating handles, etc. shall be planned within the overall quoted price of GIS.

The engineering shall include all facilities essential to enable the performance of the specified site checks and tests to be carried out. Contractor shall state the test facilities supplied and indicate any attachments or special apparatus supplied for this purpose.

Circuit-breakers, disconnectors, earth switches, VTs, CTs cable termination chambers, all and any other chambers and components shall be capable of withstanding a gas over pressure of 130% of normal operating pressure continuously.

All grounding network, special tools and tackles, SF6 gas for site filling, O & M manuals etc. required for erection, operation, inspection and maintenance of GIS shall be supplied within the quoted price.

The embedded plates and channels for the GIS foundations and maintaining floor tolerances shall be supplied by GIS supplier. Anchoring bolts for fixing GIS and LCCs shall also be supplied by the GIS Vendor

All electrical switchgear, the components of the control network, the protection scheme shall be conforming to the relevant IEC standards and publications of the latest issue

The life of the GIS and its components forming part of it, shall have a minimum lifetime of at least 25 years.

7.1.1. Current Ratings

Every current-carrying part of the switchgear including current transformers, disconnecting switches, busbars, connections and joints shall be capable of carrying its specified rated normal current continuously under IEC rating and in no part shall the temperature rise

exceed the values IEC specified in relevant Standards. The derated current rating to site ambient (50 deg C) shall be declared in the technical schedules against above items.

Every part of the switchgear shall also withstand, without mechanical or thermal damage the instantaneous peak currents and rated short-time currents pertaining to the rated breaking capacity of the circuit breaker as per relevant single line diagram. Rated duration of short-circuit shall be taken as one second. The primary rating of the current transformers shall not differ from that of the associated circuit breakers unless specified otherwise.

The engineering of sliding type current carrying connectors and joints shall be such that they meet the mentioned conditions over the full permitted range of movement. Where such joints may be made or adjusted on Site, full details of alignment procedure, together with any essential alignment tools or gauges shall be described in the maintenance manual and included in the supply of special tools.

7.1.2. Connections to Outgoing Circuits

Cable header suitable for connecting plug-in type cable termination shall be supplied as per specification for the outgoing circuits. When the circuits are connected via cables directly to the SF6 switchgear terminals the sealing ends shall be to the specification.

Design of cable termination apparatus shall ensure that the following conditions are maintained throughout the life of the apparatus:

- The insulating material, either gas or oil, from inside the cable does not escape and penetrate the switchgear enclosure.
- The SF6 gas does not enter the cable from the enclosure.
- The cable sealing end does not introduce moisture into the gas in the sealing end enclosure.
- The sealing end is capable of withstanding the cable test voltages and differential pressures without damage including overpressure of +130% of normal operating pressure.
- Manually operated disconnecting links shall be supplied for facilitating cable inspection without removing the termination from the switchgear end for each cable circuits and without degassing.

7.1.3. Plug-In Type Cable Termination

Cable header ends shall be suitable for terminating the cables specified directly into the GIS switchgear using 132kV plug-in type cable termination. The bushing part (socket) of plug-in-type termination network and accessories shall be supplied, installed and tested by the GIS manufacturer as part of GIS extent of supply. The dimensions and terminal arrangements shall be submitted for approval by the Authority before manufacturing is commenced. Cable header ends shall be suitable for connecting 2 cables per phase with cross section of 630 mm2 copper/XLPE 132 kV cable for all feeders. At present one cable shall be connected, and the spare cable sealing ends shall be supplied with dummy plugs within the quoted

price. However, for IBT circuits, cable header shall be suitable for terminating 1 No., 1Cx630 sq.mm. Cu/XLPE cable per phase. For all circuits, GIS shall be completely assembled with the bushing part (socket), connecting conductors, shields, accessories, etc.

Where required to reduce local heating when single-core cables are adopted, non-magnetic gland plates shall be supplied or alternatively, non-magnetic inserts.

The cable termination fixing criteria shall be coordinated with cable termination manufacturer for fixing the cable termination. (Plug-in type) The cable termination matching with the bushing part shall also be supplied as per standard requirement.

Removable links shall be supplied close to the GIS to enable cable sheath tests to be carried out. All cable terminals shall be of adequate size to ensure no overheating takes place at rated current.

Insulators used in the manufacture of cable sealing ends shall be sound, free from defects and thoroughly verified so that the glaze or surface treatment is not depended upon for insulation.

The insulators and fittings shall be unaffected by the filling media or rapid temperature changes likely to arise when operating in the Site condition.

7.1.4. Busbar And Connection Gas Chambers

The switchgear units shall be divided into several gas-filled compartments, sealed from each other by gas- tight partitions so that any leakage may be quickly localized. The various gas zones shall be further sub- divided when essential to restrict any internal arcing damage, and to enable gas-handling procedures to be completed with the minimum of delay. The partitions should confine any internal faults to a respective section of the switchgear. Enclosures shall be designed to minimize burn through in the event of internal arcing. The gas zone partitioning shall preferably be carried out either between busbar disconnectors and busbar or along the busbars, between each two circuits. The metal cladding enclosure for the switchgear shall be made from non-magnetic material, preferably aluminium alloy.

Busbar of each bay shall have separate gas compartment partitioned from adjacent bay. Each cable head shall be in separate gas compartment for circuits with two cable head. Gas barrier insulators shall be painted with yellow colour.

Busbars chambers shall be so arranged as to allow maintenance on one busbar, i.e., gas removal, and retain the other busbar and circuits in service.

The busbar phase conductor shall be copper, or aluminium adequately supported by cast resin insulators or other approved material equally supported, at least at both ends of each section making provision for free axial movement of conductor.

Proposals for the partitioning of gas zones shall be clearly indicated on the drawings submitted with the tender. The length of circuit outgoing bus-duct belonging to one gas zone

shall be limited to maximum 20m. Gas volumes and duration of gas handling procedures shall also be indicated in the technical schedules.

Total time for gas evacuation and filling of the largest chamber shall not exceed 10 hours.

The apparatus and connections within each compartment shall be so arranged as to allow ready removal and replacement of any section with minimum isolation and disturbance of adjacent pressurized sections.

This feature should also permit the erection and inspection of extension units alongside apparatus already in service with the minimum of outage time being required for final connections. All external gas pipe work shall be connected via vacuum, on-return couplings of proven engineering, which will enable joints to be broken and remade without loss of gas.

Suitable arrangements shall be supplied for the thermal expansion and contraction of the busbars and busbar chambers without detriment to the current carrying capacity or gas volume.

Devices shall be supplied for each section of switchgear as appropriate to allow for pressure relief to the switchgear room. All relief devices shall be located such that operation of the devices shall not endanger personnel working on the apparatus or in the vicinity of the apparatus. Where essential the devices shall be fitted with cowls to deflect any gases or fragmented parts away from locations where personnel may be expected to be present.

7.1.5. Circuit-Breakers

Circuit breakers shall be puffer or Self-Generating Gas Pressure type and shall use the SF6 gas conforming to IEC or other approved standard as the insulating medium as well as for arc quenching.

Circuit breakers shall be single break type.

The circuit breakers shall be suitable for an operating sequence of O - 0.3 sec – CO – 3 min.

Circuit breakers shall comply with IEC standard 62271-100 and shall have valid type test report based on the above standard conducted on an independent test lab or witnessed by independent observers.

Evidence of type test report as per the standard shall be submitted along with offer. The capacitive current switching, line charging and cable charging current, restrike performance, mechanical & electrical endurance, making and breaking current etc. shall be as per IEC 62271- 100.The circuit breakers shall have first pole to clear factor of 1.5. The transient recovering voltage performance shall be as per IEC. All circuit breakers whether cable or OHL shall be suitable for auto reclose duty.

The offered circuit breakers along with operating mechanism shall preferably be type tested for mechanical endurance class M2.

If the bidder does not have circuit breakers of class M2 in the production range, alternately class M1 may also be offered.

If the circuit breakers are not type tested as per the IEC 62271-100, the new type tests shall be conducted preferably in an independent test laboratory. If tests are performed on manufacturer's premises, the tests shall be witnessed by independent observers.

A lockout feature shall be incorporated to prevent operation of the circuit-breaker whenever the gas pressure falls to a value below which it would be incapable of performing in accordance with its rated duty. Gas monitors shall be temperature compensated.

An alarm feature shall also be incorporated to give indication of falling gas pressure prior to the lockout of the circuit breaker.

Suitable facilities shall be included for gas sampling and for draining and replenishing the gas volume for maintenance. Absorption of moisture and the decomposition products of arcing or discharge in the gas shall be achieved by integral filters.

The switch room arrangement shall allow for full mobility of the gas handling plant along the switch room.

7.1.6. Circuit-Breaker Operating Mechanism

The circuit-breaker operating mechanism shall be of motor charged spring operated. Operation will normally be from a remote or supervisory position, but facilities shall be supplied for operation locally by electrical release and by direct manual release from stored energy devices when the circuit breaker is isolated for maintenance. It shall be possible to padlock each local control function in the open position. Operation counters of non-resettable type shall be fitted to all circuit- breaker mechanisms.

The mechanism and its control scheme shall be such that, in the event of an electrical tripping pulse being applied to the circuit-breaker during the closing stroke, or of the mechanism failing to latch in the closed position, the circuit-breaker shall open fully and in such a manner as to be capable of interrupting its rated breaking current. Mechanical indicator shall be supplied for CB "ON" and CB "OFF" position.

The mechanism and its control scheme shall be such that the mechanism shall not make repeated attempts to close the circuit- breaker when the control switch is held in the CLOSE position in the event of failure to latch on the first closing attempt or in the event of a trip signal being given to the circuit-breaker.

The electrical closing and tripping devices, including direct acting solenoid coils and solenoid operated valves, shall be capable of operation over the ambient temperature range when the voltage at their terminals is any value within the voltage range stipulated in IEC 62271-100 and in addition over the range of all operating conditions of the batteries and chargers.

The circuit breakers shall be supplied with two trip coils.

The operating mechanism shall be suitable for a rated operating sequence of O-0.3 sec-CO- 3 min- CO.

7.1.7. Spring Charged Operating Mechanisms

Spring operated mechanisms with proved satisfactory service experience shall be arranged for motor charging but means shall also be supplied for charging by hand.

When fully charged the spring mechanism shall have sufficient stored energy to permit the operating sequence O-CO/2CO to be performed following the loss of supply to the charging motor.

A mechanical indicating device shall be supplied to indicate the state of the spring. The indication shall be visible with the doors of the mechanism cabinet closed. An auxiliary switch shall give the remote indication of "spring discharged".

The mechanism shall be charged automatically, for further operation as soon as the circuit breaker has completed a closing operation. The time required to power charge the spring shall not exceed 30 seconds.

The spring shall be fully charged before it can be released to close the circuit breaker. It shall not be possible for the breaker to close whilst the spring is being charged.

Spring closing mechanisms shall be designed such that it is not possible for a fully charged spring to be released inadvertently due to external shock or vibration caused by the breaker opening under short circuit conditions or any other cause.

The mechanisms shall be supplied with means for charging the spring by hand. During this process no electrical or mechanical operation of the mechanism shall endanger the operator or damage the apparatus.

An indicating device shall be supplied at the local control panel and the main control room and also over the supervisory network to indicate a spring failing to be charged by a pre-set time after circuit breaker closing.

Means shall be supplied for discharging the spring when the circuit breaker is in the open position without the circuit breaker attempting to close.

7.1.8. Disconnecting and Earthing Switches

Disconnecting and earthing switches shall be arranged to permit safe maintenance of any section of the apparatus when the remainder is alive. Disconnecting switches shall be arranged for operation while the apparatus is alive but will not be required to break current other than the charging currents of open busbars and connections (circuit breaker bushings) or load currents shared by parallel disconnectors under the conditions of this Specification.

Disconnectors of earth switches shall comply with the requirement of IEC 62271-102.Disconnectors shall preferably be housed in compartments partitioned from circuit breakers.

Line disconnectors gas zones shall be separated from the cable sealing ends or outdoor bushing gas zone.

Switch mechanisms shall be so designed that the disconnector cannot be opened by forces due to currents passing through it and shall be self-locking in both the "open" and "closed" positions. The mechanism shall open and close all three phases simultaneously.

Power operated drives shall be supplied which shall be suitable for local, remote and supervisory control (supervisory control of earth switches is not required) and should be fitted with a removable emergency manual operation facility. It should be possible to lock-off the manual and local facility and padlock the mechanism in the open and closed positions with the motor automatically disengaged.

Local mechanical position indicators shall be supplied on disconnecting and earthing switches and shall be visible from ground level.

For safe earthing of the busbars and feeders, high-speed fault making spring driven earth switches shall be supplied. The contacts of these earth switches shall have the same fault making capability as that of the circuit breaker. With earthing switches of the high-speed fault making type, it shall be impossible to completely assembled a slow close operation.

Each section of busbar, which can be electrically isolated from other sections of busbar by means of disconnectors or circuit breakers shall incorporate high speed earthing switches as per specification above.

The mechanisms of the high-speed earthing switches shall be spring operated. It shall be possible to charge the spring by DC motor and manually. During the manual charging of the spring, motor operation shall be prevented. The spring shall not be charged when the earthing switch is in open position, but the charging of the spring shall be initiated as a sequence of the closing operation.

Slow speed maintenance earthing switches shall be operated locally only with the mechanism driven with a DC motor and manually. During the manual operation the supply circuit of the DC motor shall be automatically disconnected. Interlocks shall be supplied to prevent unintentional use of this earthing apparatus.

Earthing switches shall be arranged such that, with a minimum use of tools and special fittings, they may be used to facilitate such tests as CT primary injection, timing, voltage drop and resistance measurement without the necessity to open gas-filled compartments. The current rating and insulation level of the injection contact assemblies shall be adequate for the required inspection parameters. Detailed means of performing these tests shall be supplied. All earthing switches shall have insulation terminals to enable CT primary injection, timing test, cable fault detection, etc. without shut down of busbars or adjacent bays.

7.1.9. Interlocking

An interlocking scheme shall be supplied which considers the following basic criteria.

- To safeguard maintenance personnel who may be working on one section of the apparatus with other sections live.
- To prevent incorrect switching sequences which could lead to a hazardous situation to plant, apparatus, and personnel.
- To prevent earthing of live circuits.
- To prevent simultaneous operation of two or more devices of the same bay.

The interlocking scheme shall be electrical for all operational interlocks and preferably of the mechanical/key type for maintenance safety interlocks but shall be effective when the apparatus is being controlled from driving mechanisms local control cabinet, remote control panels or network control centre.

All mechanical interlocks shall be applied at the point at which hand power is used so that stress cannot be applied to parts remote from that point.

All electrical interlocks shall so function as to interrupt the operating supply and a network of interlocks shall be supplied which shall cover the emergency hand operation of apparatus which is normally power operated. Failure of supply or connections to any electrical interlock shall not produce or permit faulty operation. Electrical bolt interlocks shall be energized only when the operating handle of the mechanism is brought to the working position. Visible indication shall be supplied to show whether the mechanism is locked or free. Normally padlocks, shall be supplied whereby the bolt can be operated in the emergency of a failure of interlock supplies.

Where key interlocking is employed tripping of the circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency tripping device shall be kept separate and distinct from the key interlocking.

All disconnecting devices shall be interlocked with associated circuit-breakers and disconnectors in the same station so that it shall not be possible to make or break current on a disconnecting device unless a parallel circuit in that station is already closed.

In double busbar stations the provision for on-load changeover of busbars is required. The busbar disconnecting devices shall be so interlocked with the appropriate busbar coupling and sectioning apparatus's that sections or sets of busbars cannot be paralleled by means of the busbar disconnecting devices unless a parallel circuit is already closed through the circuit- breakers of the appropriate busbar coupling and sectioning apparatus. In all other circumstances, the busbar disconnecting devices of apparatus other than busbar sectioning and coupling apparatus shall be so interlocked that their respective circuit breakers can only be coupled to one set of busbars at a time. It shall not be possible to parallel sections of busbars except through the circuit breakers of the busbar coupling and sectioning apparatus. The bus coupler CB tripping shall be inhibited during on-load bus transfer and trip circuit faulty alarm shall be initiated in such situation.

7.1.10. Auxiliary Switches and Contactors

Auxiliary switches shall be supplied on all circuit breakers and disconnectors for local and remote & SCADA indication, control and interlocking. - Repeat relays of special robust engineering may be used where essential. Busbar protection should have direct driven auxiliary contacts for CT circuits. With each circuit-breaker, disconnecting device, and earthing device, there shall be supplied all essential auxiliary switches, contactors and mechanisms for indication, protection, metering, control, interlocking, supervisory and other services. All such auxiliary switches shall be enclosed in dust free housing. Not less than ten spare auxiliary switch ways shall be supplied with each circuit breaker, disconnector and earth switches. All auxiliary switches shall be wired up to a terminal board in the local control cubicle of the switchgear whether they are in use or not in the first instance and shall be arranged in the same sequence on all apparatus.

Each busbar disconnector shall be supplied with three Nos. early make late break type, direct driven auxiliary contacts to be used for busbar protection CT circuits.

Switches shall be supplied to interrupt the supply of current to the tripping mechanisms of the circuit breakers directly after the operation of the latter has been completed. All such switches and mechanisms shall be mounted in approved accessible positions clear of the operating mechanism and shall be adequately protected. The contacts of all auxiliary switches shall be strong and shall have a positive wiping action when closing. Direct acting auxiliary switch contacts shall be used in conjunction with busbar protection schemes.

If sufficient aux. contacts are not available, the contacts shall be multiplied by using suitable latching relays (bistable relays) so that the failure of DC supply shall not cause a mal-operation or undefined position of circuit breakers, disconnectors or earth switches.

If any discrepancy between the aux. contacts and latching relay contacts, this shall be monitored and alarmed locally and for remote indication.

7.1.11. Current Transformers

Current transformers shall be of the toroidal core type preferably encapsulated in epoxy resin.

The current transformers shall contain no hygroscopic materials, which could affect the moisture contents of the SF6 gas in the CT chamber. The rated short-time thermal current shall not be less than the through fault capacity of the associated circuit breakers.

The characteristics of current transformers shall be submitted to the Authority for approval together with details of the protection, instrumentation or measuring apparatus with which each current transformer is to be used. Each current transformer shall be capable of providing the essential output to operate the related devices satisfactorily at the lead burdens involved.

Each current transformer shall have a continuous extended current rating of at least 1.2 times the rated current.

The characteristics and capacities of current transformers used for protection circuits shall be calculated by the relay manufacturer who shall prove by calculation, the suitability of the CT's being supplied in conjunction with the relay manufacturers criteria for the relays and apparatus offered.

Where multi-ratio secondary windings are specified, a label shall be supplied at the secondary terminals of the current transformer indicating clearly the connections required for each ratio. These connections and the ratio in use shall also be shown on the diagram of connections. All connections from secondary windings shall be brought out and taken by means of separate insulated leads to a terminal block specially designed for the CT circuits, mounted in the Local Control Cubicle. The secondary windings shall be earthed at one point through a removable link, which shall be in the relay panels for protection and in the control panel for instrumentation.

CT terminal blocks located in the local control cabinets shall have shorting/ disconnecting links to allow inspection with the circuit in service and on load. It shall be possible to carry out primary injection inspection of the CTs including magnetizing curve inspection, when the switchgear is fully assembled, or retesting of the CTs during the service life of the switchgear without interruption of supply to adjacent circuits.

The secondary windings of each set of current transformers shall be capable of being open circuited for one minute with the primary winding carrying the rated current.

Unless otherwise approved, all current transformers shall be installed with the P1 terminals adjacent to the busbars. The polarity of the primary and secondary windings of each transformer shall be clearly indicated at the respective terminals and in addition labels shall be fitted in a readily accessible position to indicate the ratio, class and duty of each transformer.

The current transformer particulars as per specification in latest IEC 60044-1 shall be given on an accessible plate mounted external to the current transformer.

7.1.12. Voltage Transformers

Voltage transformers shall be of electromagnetic type and of metal-enclosed engineering, which shall be compatible with the switchgear. They shall contain no hygroscopic insulating material, which could affect the moisture contents of the SF6 gas in the VT chamber. The bus voltage transformers shall be supplied with motor operated disconnectors for disconnecting the VT for maintenance, inspection etc. Line voltage transformers shall be supplied with manual disconnectors.

The voltage transformers shall be capable of discharging the capacitance of line, cables and switchgear, which may remain connected to them during switching operations. Contractor shall declare any limitations of the apparatus for this duty.

Voltage transformer secondary and tertiary circuits shall be supplied with miniature circuit breakers or fuses as close to each voltage transformer as possible and shall be labelled with winding and phase indication. For single-phase voltage transformers separate earth links for each secondary shall be supplied and each neutral lead shall be connected together at a single earth point in the local control cubicle. Earthing of the VT HV winding shall be through a link separate from the LV winding.

A fixed ladder or other arrangement shall be supplied for each voltage transformer to enable an easy access to the voltage transformer and to the VT MCB/fuse box.

The ratio and phase angle errors of voltage transformers shall not exceed the permissible limits prescribed in the relevant Standard and shall be capable of meeting the following additional criteria from 5% rated primary voltage to 90% rated primary voltage:

- Voltage error - not exceeding + 3%
- Phase angle error - not exceeding + 120 minutes.
- The voltage transformer shall have a voltage factor withstand rating of 1.2 continuous 1.9 times for 8 hours without saturation.
- Voltage transformers shall be capable of carrying continuously without injurious heating 50% burden above their rated burden. Damping resistors shall be supplied for VT open delta windings. The manufacturer shall submit the calculations of such damping resistors for FEWA approval.
- The neutral side of all voltage transformers shall be earthed.
- It shall not be possible for the voltage transformer secondary circuits to be connected in parallel, except through interposing voltage transformers associated with synchronization scheme to prevent any possibility back energization through synchronizing circuits.
- Mechanical shock indicators shall be fitted to the VT to indicate how the VT was handled during transit. Maximum allowed shock level should be specified by the manufacturer. In case that the shock indicator shows the shock, record which is higher than the maximum allowed level, voltage transformer shall be returned to the factory for inspection and retesting, with all associated costs borne by the contractor. Opening of VT chambers shall not be allowed at site, unless otherwise approved by the Authority. The other criteria of VT shall be as per IEC 60044-2

7.1.13. SF6 Immersed Insulation

Busbars and items of switchgear shall be supported in the enclosures by insulators of materials compatible with SF6 gas and the products of gas decomposition.

Gas barrier insulators and bushings, including gas-oil and gas-air bushings shall comply with the specified conditions for sealing of enclosures. The Engineer shall be advised of engineering pressures used and may require test evidence to substantiate performance under extremes of differential pressure and temperature. The surfaces of insulation in

contact with SF6 shall not be glazed or otherwise treated with silica compounds or other materials, which may deteriorate in the presence of decomposed gas or arcing products. Alternative glazing or surface treatment, which is compatible with SF6 and its by-products, may be acceptable subject to prove durability.

The insulators should be free at all times of partial discharges at all voltage levels within the working range and shall be tested for voids and partial discharges during manufacture.

SF6 immersed insulation shall otherwise comply with the relevant clauses for insulators and bushings.

The apparatus shall be designed such that no heating elements will be required for satisfactory operation within the range of ambient temperatures and pressure encountered under service conditions.

The minimum dew point temperature in unheated SF6 gas filled apparatus shall not exceed minus 20 deg. C the working pressure, measured at least 24 hours after the gas filling.

7.1.14. Sealing Of Enclosures

To prevent ingress of moisture or leakage of gas during the service life of the apparatus, the sealing materials used at all joints and interfaces shall satisfy the following criteria:

- Not affected by SF6 gas
- Non-hygroscopic, containing no silicon non-ageing and non- shrinking.
- Retain resilience for long periods under stress Stable under all temperature conditions.
- Seals including those at compartment partitions shall continue to function correctly throughout the temperature and pressure ranges in service and the pressure differentials, including vacuum and test pressures, during erection, maintenance and subsequent revisions.
- Expansion bellows and diaphragms and pressure relief devices shall be designed to be free of leakage under the same conditions as stated for seals.

7.1.15. Gas Losses

The Manufacturer should guarantee the apparatus for a gas loss of not more than 1.0% per annum in any single gas compartment. In case of extensive and repeated gas leaks at any time during the warranty period, the Authority will have the right to request the contractor to replace the part of the assembly, which causes the leakage. All costs associated with such works shall be borne by the contractor.

7.1.16. Local Control Cubicle

Each circuit-breaker bay shall be supplied with a separate, free standing local control cabinet containing local control switches and a mimic diagram for the operation and status indication of the circuit-breaker and all associated disconnectors and earth switches together with

selector switches to prevent local, remote/supervisory controls being in operation simultaneously. Integral LCCs are not acceptable.

Local manual release facilities shall be supplied for closing and tripping the circuit breaker. The operation of both releases shall be subject to lockout if insufficient stored energy is available. Local manual releases shall be supplied with locking off facilities.

Sufficient electrical terminals shall be supplied for the termination and inter-connection of all cabling associated with remote and supervisory control, alarms, indications, protection and local ring main supplies. The low voltage control cables, terminations and accessories required for cabling between 132kV GIS and local control panel (LCC) shall be supplied by the manufacturer.

7.1.17. Tests

Type tests shall have been carried out on the switchgear components in accordance with the relevant IEC standards preferably by an independent test laboratory.

The performance of the components of the switchgear shall be substantiated by test data relevant to the particular designs offered. The type test certificates issued by Test Laboratories for the type of apparatus offered or similar engineering shall be submitted by vendor.

Following are the Type tests which needs to be conducted for entire bay as per IEC 62271-203.

- Dielectric tests.
- Radio interference voltage (RIV) test Measurement of the resistance of circuits
- Temperature-rise tests
- Short time and peak withstand current tests Verification of the protection.
- Gas lightness test
- Electro-magnetic compatibility tests (EMC) Additional tests as aux. & control circuit
- Verification of making and breaking capacity Mechanical and environmental test
- Proof tests for enclosures Pressure test on partitions
- Test under conditions of arcing due to an internal fault Insulator test
- Corrosion tests on earthing connections

7.1.18. Routine Tests

The routine tests on GIS, LCCs and accessories shall be carried out as per the latest edition of relevant IEC standard. The completely assembled routine test report including GIS, LCCs, CTs, VTs, cables from GIS to LCC etc. arranged section wise for each bay shall be submitted for authority engineers' approval.

7.1.19. Packing and Storage

Preparation of shipment shall be made after all inspection and inspection of apparatus has been accomplished and apparatus has been released for shipping by the Buyer.

Switchboard shall be shipped in sections to suit ease of handling for transportation and setup.

Each shipping section shall be supplied with supports in the form of suitable steel sections, lifting eyes etc. to maintain alignment of parts during shipping, handling, hoisting and setup. Location of lifting points shall be clearly marked on shipping containers and on drawings. Each shipping section shall have its weight and centre of gravity clearly marked on the container.

7.1.20. 66 kV/22 kV Power Transformer

The Power Transformers shall be Core Type, Oil Immersed with ONAN/ONAF cooling and suitable for Outdoor setup. The transformers shall be completely assembled with standard accessories and equipped with Buchholz relay with double floats, one for alarm and one for trip, Nitrogen Injection Fire Protection System, Dial type Thermometers with alarm and trip contacts for oil and winding. Magnetic Type Oil Level Gauge with alarm contacts, OLTC, RTCC with the following specifications

- Conformation to Specification: IS 2026 1977 (Part I to V)
- Type: Two winding Transformer.
- Primary Voltage: 66KV
- Secondary Voltage: 22KV
- No. of Phases: 3
- Frequency: 50HZ
- Power Rating: 66 /22 kV
- Transformer Connection: Dyn11
- Winding: Copper
- Type of cooling: ONAN/ONAF
- Tap Changer: On load tap changer Application: Outdoor application Cooling Equipment: Radiator
- Primary Terminals Type: Condenser Type Bushing as per IS:2099 Secondary Terminal: Outdoor terminal bushing.
- No. of Taps: Vendor to specify.
- Suitability: To suit Parallel operation Max. ambient temperature: 50°C
- % Impedance at rated current: Vendor to specify
- Value of load and no-load loss: Vendor to specify Details of aux.
- Power supply: Vendor to specify Insulation level for each winding.

- (Power frequency & Impulse): Vendor to specify.
- Protection Devices and accessories: Oil surge relay / Buchholz relay Pressure relief valve/ Explosion vent Dehydrating Breather
- Temperature Indicator to indicate oil and winding temperature and alarm/trip circuit at pre-set temperatures.
- Oil level indicators
- Insulating oil as per IS:335 1993.
- Conservator tank
- Oil drain Valve Air release device
- Oil filling hole with cover Filter Valve
- Lifting lugs Jacking lugs Rollers/skids Inspection cover Rating Plate
- Terminal Marking Plate Two Earthing Terminals
- Nitrogen Firefighting network

The transformer shall be subjected to all kinds of Type tests in accordance with Relevant I.S. (IS:2026) with latest amendment. The power transformer 22kV secondary side neutral shall be resistance earthed to limit the 22kV network earth faults to low values.

Manufacturer shall give warranty for at least 5 years the apparatus with lifetime support of spares and accessories.

7.2. CONTROL AND RELAY PANELS

The life of the Control and Relay Panels and its components forming part of it, shall have a minimum lifetime of at least 25 years

The panels shall be 'Simplex' type. Panels shall be sheet steel enclosed dust and vermin proof type. Panels shall be floor mounting, free standing, formed on a framework of standard sections.

The enclosure shall be of cold rolled sheet of 3 mm for front and back and 2.5 mm thick for rest. Panel supporting structure shall be so designed to form a rigid structure.

All doors and openings shall be supplied with neoprene gaskets. The panels shall be suitable to be installed on a base frame supplied in one piece along with foundation bolts. Amply dimensioned oblong holes shall be supplied at the bottom of all the panels for their setup on base frame in addition the panels shall have an additional base channel at the bottom with smooth surface. Anti-vibration type mounting shall be supplied. A suitable removable undrilled gland plate shall be supplied for cable entry from bottom. Suitable double compression type cable glands for control cables of required size quantity and material shall be included in the extent of supply. The degree of protection of the panels shall be IP52.

All instrument and control gears and relays shall be mounted on the front All apparatus shall be flush or semi-flush type.

Checking and removal of components shall be possible without disturbing the adjacent apparatus. It shall be possible to set all the measuring relays "in situ". All mounted apparatus inside the panels shall have "identification tags of self-sticking Engraved tapes; in addition, identification numbers shall be painted on panel wall to give permanent identification mark. The mounting of terminal blocks and any other auxiliary apparatus such as transducers interposing CTs etc. shall be done in such a way so as to be readily accessible but without impeding the access to internal wiring and components.

The centre line of switches push-buttons and indicating lamps shall be not less than 750 mm from the bottom of the panel. The centre line of relays, meters, recorders shall not be less than 450 mm from bottom of the panel. All switches, push buttons, indicating lamps, relays, etc. shall be neatly arranged in a matching manner.

The control panels shall be matched with other panels in dimension, colour and mimic.

The simplex panels shall consist of vertical front panels with mounted apparatus and rear wiring access. Doors shall have handles with locking facility.

7.2.1. Wiring

All wiring shall be done with PVC insulated, 650V grade, single core multi strands (minimum 3 strands) annealed copper conductors suitable for temperature and humidity specified. The cross section of the wires for voltage, current and control circuits shall be 2.5 Sq.mm and that for the alarm circuits shall be 1.5 Sq.mm. The wires shall be vermin proof and shall be laid in plastic troughs. Respective phase colour shall be used for PT & CT circuits. Black colour shall be used for auxiliary AC supply & neutral of CT & PT circuits and grey colour shall be used for DC control circuits.

Colour coding for the wires shall be as per IS:375. Each cable shall be Minimum 20% spare terminals shall be supplied on the panels.

The terminals shall be suitable to receive crimped wires to give positive connection. All terminals shall be properly shrouded against accidental contact. Sufficient terminals shall be supplied so that, not more than one wire is connected to each terminal. The terminal blocks shall be 600V grade 10 amps rated, one piece moulded completely assembled with insulated barriers, stud type terminals, washers, nuts and lock nuts and identification strips. Terminal blocks for the CT and PT secondary leads shall be supplied with test links and isolation facilities. Also, CT secondary leads shall be supplied with short circuiting and earthing links. Test terminal blocks shall be supplied in TVM/ kWH circuits.

7.3. LT SWITCHGEAR

The life of the switchgear and its components forming part of it, if applicable shall have a minimum lifetime of at least 25 years.

The switchgear shall be suitable for continuous operation under the service conditions as stated in the Data Sheets. Switchgear shall be suitable for use in a saline, sulphureous and dusty atmosphere. Condensation shall be considered as per specification in data sheet.

The switchgear shall be suitable for setup and satisfactory operation in a pressurized substation or in substation with restricted natural air ventilation.

The switchgear completely assembled assembly shall be designed for earthquake as per seismic zone specified in datasheet and shall be designed as per IS 1893, ensuring no permanent damage, no significant or permanent deformation of parts or any form of mal operation of apparatus. Site specific seismic calculations supporting the same shall be submitted by the Supplier during detail engineering. Supplier shall need to provide appurtenances, such as anchor bolt for stick welding to embedded steel changed for anchoring the switchgear to foundation. Such appurtenances shall be suitable for specific seismic criteria

7.3.1. Constructional Features

Switchgear cubicles shall be free standing, floor mounting, flush fronted, compartmentalized and arranged to form a single structure with a common busbar assembly. Switchgear shall comply to form 3B or better.

The Switchgear shall be supplied with integral base frame for each vertical panel which shall be suitable for directly bolted or tack welded to the Buyer's base frame. The frame of individual vertical panels shall be fabricated using pressed and shaped cold rolled sheet steel of adequate thickness or by using suitable mild steel structural section. Wherever required, stiffeners shall be supplied to increase stiffness of large size doors and covers.

Switchgear shall not exceed a height of 2500 mm. Maximum operating height of any handle shall be approximately 1800 mm above floor level and minimum operating height shall be approximately 300 mm above floor level. Switchgear shall be of dust and vermin proof construction with IP-42 as a degree of protection and shall be self-ventilated unless otherwise stated in data sheet.

Switchgear and Busbars shall be arranged to permit future extension at both ends. End of Busbar shall be suitably drilled for this purpose. Panels at extreme ends shall have opening which shall be covered by using screwed plates. Details of drilled holes in busbar and opening shall be clearly indicated in the suppliers drawing.

All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease and dirt by pickling, emulsion cleaning. The sheet steel shall be adequately pre-treated & epoxy powder coated.

Interlocks, Busbar shutters, covers, shall be supplied to prevent incorrect or unsafe operation and to prevent access to live parts. Interlocks shall be supplied to prevent opening of the front doors of cubicles whilst the circuit breaker / switch is in the closed position.

The Switchgear shall be divided into distinct sections comprising of: -

Individual feeder module which shall be integral multiples of basic module, containing all associated apparatus, enclosed in sheet steel enclosure on all sides and the rear except cable alley side and supplied with hinged door on the front.

A completely enclosed, Busbar compartment running horizontally and a vertical Busbar compartment serving all modules in vertical section.

Vertical cable alley covering the entire height, except horizontal Busbar compartment with minimum 300 mm width for MCC modules at right hand side. For PCC feeders' adequate power & control cable termination shall be supplied at rear end and with adequate number of slotted cable support arms.

A horizontal separate enclosure for power and control buses with tap off connections to each vertical section.

The circuit breakers and contactor-controlled modules shall be fully draw-out type and shall have distinct service, test and isolated positions.

The apparatus pertaining to a draw out type module shall be mounted on a fully withdrawable chassis which can be drawn out effortlessly without unscrew/unplug any wire or cable connection (communication connector can be manually disconnecting plug and socket type). For module having heights above 600mm additional guiding mechanism shall be supplied to ensure alignment of draw out contacts.

Automatic safety shutter (mechanically operated) shall be supplied for each withdrawable circuit breaker/module to ensure there is no access to vertical busbars when module is removed from assembly. Each set of shutters shall be capable of being individually operated and pad lockable in the closed position. Shutters shall be marked as follows: -

- 'BUSBAR' on shutters covering busbars,
- 'INCOMING SUPPLY' on shutters covering incoming feeder cables,
- 'CIRCUIT' on shutters covering outgoing feeder cables.
- Key interlocking shall be supplied on incoming, outgoing and sectionalized units as indicated in Single line diagram(s)/data sheet.

The MCC shall consist of motor starters & power feeders, feeder housed in separate compartments within the MCC. Selection of component for motor starters shall comply with coordination type-II as per IEC-60947.

All disconnecting contacts for power and control circuit of draw out modules shall be of robust and proven engineering, fully self-aligning and spring loaded. Both fixed and moving contacts shall be made of silver-plated copper. Contacts should be replaceable. The spring-loaded power and control draw out contacts shall be on withdrawable chassis. Detachable plug and socket terminals are not acceptable.

- Control Circuit contact rating: Min 15A.
- Power Circuit contact rating : Min 100A

If ventilating louvers are supplied, they shall be supplied with fine-screened brass or GI meshes from inside to prevent entry of vermin and dust.

In general motors rated up to and including 75 kW shall be switch-fuse and contactor operated. Motors rated above 75 kW up to and including 160 kW shall be breaker operated. Motor feeders rated 30 kW and above shall be supplied with motor space heater, ammeter and current transducer (in one phase only, if specified in the data sheet). For motors below 30 kW, essential arrangement for 24 Volt AC supply for winding heating shall be supplied. Motor feeders rated above 22 kW shall be supplied with CBCT for earth fault protection.

Power feeders rated above 63A shall be supplied with suitable earth fault protection.

LV Switchgear (PCC, PMCC and MCC) shall be supplied with 20% spare outgoing feeders for each type and subject to minimum one number. All the spare feeders shall be completely assembled with power, control, protection and metering apparatus.

7.3.2. Circuit Breakers

Circuit breakers shall be: -

- Withdrawable.
- Air break engineering

Incomer and bus coupler shall be 4 pole and outgoing feeder shall be as per Single Line Diagram/Datasheet Suitable for uninterrupted duty and utilization category B as per IEC 60947.

Circuit breakers of identical rating shall be interchangeable. Circuit breakers shall be electrically operated with provision for manual (mechanical) operation. Tripping, closing, control and indication supplies for circuit breakers shall be as shown in the Single line diagram(s)/data sheet.

Circuit breaker operating mechanisms shall be motor wound spring. The closing spring shall be automatically recharged after discharge and be ready for next closing command. The closing spring condition - “charged” or “discharged” shall be shown via a mechanically driven indicator. The spring charging motor shall be mechanically decoupled as soon as the manual charging handle is coupled.

Circuit breakers shall be supplied with minimum 6 NO and 6 NC potential free latch type auxiliary contacts, rated 10 A at 240V A.C. and 2A (inductive breaking at 220 V D.C.).

Breaker shall be equipped with distinct On, OFF, spring charged indication. Breaker chassis shall be equipped with the operation counter.

'Red', 'Green' and 'Amber' indicating lamps to show 'Closed', 'Open', and 'Auto-trip' conditions of the circuit breaker.

Closing and trip coil shall operate satisfactorily under the conditions of supply voltage variation, as per specification in data sheet.

Circuit breaker shall be supplied with an anti-pumping facility in the circuit breaker closing circuit. The circuit breakers shall have distinct service, test and isolated positions. Locking facilities shall be supplied in 'Service', 'Test', and 'Isolated' positions. In test position the breaker will be tested without energizing the power circuits.

Circuit breakers shall be supplied with trip circuit supervision to monitor trip circuit continuity and trip circuit supply. Alarm and indication facilities shall be supplied for each circuit breaker and a volt free group contact supplied via internal bus wiring for remote common alarm.

Circuit breaker shall be supplied with mechanical operation counter.

7.3.3. Disconnecting Switch

Air break switches shall be of the heavy duty, group operated load-break, fault- make type, complying with the criteria of IEC 60947-3 standards. The switch shall have a quick-make, quick-break mechanism operated by a suitable external handle, with position indicator. This handle shall have provision for padlocking in ON and OFF position. All switches shall be 4 pole type.

Continuous current rating of switches shall be suitable to load specified in load list. All live parts of the switch shall be shrouded. The compartment door shall be interlocked mechanically with the switch such that the door cannot be opened unless the switch is in OFF position. Means shall be supplied for defeating this interlock at any time. Switches shall be capable of withstanding the let through fault current of back-up fuses or circuit breakers.

7.3.4. Fuses & Indicating Lamps

Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of not less than 80 kA. Fuses shall be supplied with visible indication to show blown out position.

Fuse ratings chosen by the SUPPLIER for application in various circuits shall be subject to the BUYER'S approval. Fuses shall preferably be mounted in moulded plastic carriers and shall be completely assembled with fuse bases.

Current time characteristics of fuses shall be furnished along with bid document. The fuse on incoming feeder, if specified, shall be chosen to provide discrimination with downstream motor/feeder fuses. Lamps shall be clustered type LED module pilot lights in thermoplastic enclosure with polycarbonate lens and diffuser. LED shall be protected by in-built fuse with surge suppressor. Lamp and lens shall be replaceable from front.

7.3.5. AC Contactors

The contactors shall be three poles, air break type designed for duty class III - Category AC3 (for unidirectional motors) and Category AC2 for distribution circuit with non-bouncing silver/ silver alloy contacts.

Contactors for reversible motors shall be of AC4 duty. Reversing contactors shall be electrically and mechanically interlocked. Standard automatic star-delta scheme with 3 set

of contactors and 1 timer shall be applied where it is required in the Single line diagram. Contactor utilization category shall be AC 3.

For special loads such as transformers, capacitors, lighting, a suitable current rating and utilization category shall be selected by the Supplier.

7.3.6. Moulded Case Circuit Breakers

Moulded case circuit breakers (MCCBs) shall be supplied, when specified in datasheet for use in lieu of switch- fuse for the motor/power controls. The MCCBs shall conform to the IEC 60947-2 standards. The outgoing MCCB of a low voltage MCC or Switchgear have a Icu equal to the symmetrical rating of the apparatus.

Supplier shall select the rating/size of MCCB, considering motor higher starting current and higher instantaneous peak inrush current of Motor with IE2 or IE3 as per specification in MCC datasheet.

Supplier shall select the rating/size of MCCB, considering motor higher starting current and higher instantaneous peak inrush current of Motor with IE2 or IE3 as per specification in MCC datasheet.

MCCB shall be supplied with shunt trip and auxiliary contacts. All the contacts shall be wired up to terminals. MCCB shall be 3 pole or 4 pole, as per specification in datasheet. MCCBs in AC circuits shall be suitable for simultaneous opening and closing of all poles.

Operating mechanism shall be quick-make, quick-break and trip-free type. The ON, OFF and TRIP positions of the MCCB shall be clearly indicated and visible to the operator. Compartment door shall be interlocked mechanically with the MCCB handle such that the door cannot be opened unless the MCCB is in OFF position. MCCB terminals shall be shrouded.

7.3.7. Miniature Circuit Breakers

Miniature circuit breakers for use in control circuits shall comply with the criteria of IEC 60947-2 standards. MCB shall be trip free, with manual close / open mechanism. Automatic tripping provision for overload and short circuit shall also be supplied. MCB shall be supplied with required number of auxiliary contacts as per circuit requirement along with suitable no. of spare contacts.

7.3.8. Control And Selector Switches

Control and selector switches shall be of dust protected heavy duty completely assembled with escutcheon plates clearly marked to show the function and positions. Contacts shall be silver surfaced, rated 10A at operating voltage.

The switches shall be of sturdy construction suitable for mounting on panel front.

All push buttons shall be heavy duty, shrouded, push to actuate and spring return type. They shall be supplied with inscription plates engraved with their functions. Each push button shall

have 2 NO + 2 NC contacts, rated 10A and 0.5A at their respective AC and DC operating voltage. Start PB shall be green in colour and stop PB shall be red coloured, mushroom head stay put type.
L-R switch type LOCAL-REMOTE selector switch shall be stay put type with pistol grip handle key lockable. Ammeter & voltmeter selector switches shall be four position type. Ammeter selector switches shall have made before break feature to prevent open circuiting of CT secondary. Selector switch shall be suitable for semi flush mounting with only switch front plate and operating handle projecting out.

Breaker control switches shall be pistol grip black and selector switches shall be oval or knob, black. Breaker control switches shall be 3 position spring return to neutral. The contact shall be rated to carry breaker opening & tripping coil current.

7.3.9. Instrument Transformers

CT and VT rating and accuracy class as per specification in Data Sheet are tentative, Supplier shall select suitable rating based on connected relay and/or meter in the circuit. For CTs & VTs, GA along with OEM mould type & other essential drawings to be supplied by supplier during detailing stage.

The CTs and VTs shall be dry type and shall be able to withstand momentary and short time current ratings of the associated Switchgear. The current transformers shall be mounted on the fixed portion of the Switchgear but not directly on buses or the breaker truck.

Current Transformers, Voltage Transformers and CBCTs shall be cast resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made. Number of CT, CT rating, accuracy class for metering and/or protection shall be as indicated in Single line Diagram. However, to ensure proper operation of protective relaying circuits, the CTs shall have relay accuracy class rating of at least twice the specified voltage across their burden at maximum short circuit capacity of switchgear.

CTs shall be supplied with test links in both secondary leads for carrying out essential test and measurement. CT secondary connection shall be carried out through ring type lug. CT shorting terminals shall be Screw type in Nylon 66 housing.

Voltage transformers shall be protected with suitable rated primary, secondary and tertiary fuses/MCB. Primary fuses/MCB shall have a rupturing capacity equal to the rupturing capacity rating of the associated Switchgear. Fuses/MCB shall be supplied on each sub circuit. It shall be possible to replace voltage transformers without the need to de-energize the main bus bars.

The terminals of V.T. secondary and tertiary windings which are required to be connected to earth shall be earthed by an isolating link without a fuse. CTs and VTs shall have polarity marks indelibly marked on each transformer.

Instrument transformer nameplates shall be fixed in a position so that details can easily be read when fitted in the cubicle. CTs and VTs shall be fixed in a position so that proper access

is available for repair, maintenance and replacement. CTs and VTs shall have polarity marks indelibly marked on each transformer.

7.3.10. Metering, Protection, Control and Indication

Metering, protection, control and indication shall be supplied as per specification on the Single line diagram(s).

Meters and relays shall be flush mounting and fitted on the front of the Switchgear. In MCC fed motor feeders, the protection relay shall be rail / base plate mounted. Auxiliary contactors shall be mounted on base plate. Meter and Relay shall be suitable to withstand the reflected CT secondary current of switchgear rated fault current.

All analogue type indicating instruments shall be moving coil type and shall be scaled such that rated value corresponds to between 50 and 80% of the angular deflection. External zero adjustment and calibration shall be possible on all indicating instruments to facilitate adjustment without dismantling the instrument.

Meters shall be of microprocessor-based multifunction type and shall be with communication protocol, as per specification in data sheet. All breaker feeders shall be equipped with integrated control, metering & protection numerical relays whereas MCC motor feeders shall be equipped with microprocessor-based protection device with communication facility as indicated in data sheet. Numerical relays shall be with conformal coating and G3 complied and shall be suitable to sulphurous /saline gasses. Auxiliary supply for these relays shall be universal and in the range of 110V-250V AC/DC. Protective relays shall, wherever possible, be of the draw out type with hand reset operation indicator.

Multifunction numerical relays shall be selected to provide an integrated protection, continuous measurement and monitoring functions. Features such as self-diagnosis and external inspection, disturbance recording, sequence of event recording, time stampings shall be available with the relay. Relevant data shall be possible to be stored in non-volatile memory backed up by battery. The relay shall have multiple setting groups, optically isolated input and output, with front LCD display and menus, fixed function and programmable LEDs, keypad and password protection.

All functions including protection, automation, communication, LEDs, input and output shall be programmable and can be modified, if required, using the front panel user interface.

Dual Communication port compatible with IEC-61850 for connectivity with electrical automation network shall be supplied for Multifunction numerical relays. For microprocessor-based relay of MCC motor feeders, communication port for Modbus TCP/IP communication shall be supplied.

Submission of documents pertaining to overall network life cycle - maintain hardware spares and software maintenance /updates during warranty and post warranty with essential service level agreement plans. Warranty to include the System warranty to cover essential periodic software updates.

Protection Relays for motor feeders shall also have following features:

- The relay shall be designed for current dependent overload protection against excessive temperature rise, phase failure and phase unbalance.
- The selected model shall be universal & shall be driven through external CT.
- Relay shall be suitable to accept CBCT input.
- Motor relay shall have programmable 4-20mA analogue output.
- The relays shall have adjustable overload trip classes for catering to various types of starting and loading conditions.
- The relays may have a facility for enabling reacceleration (if specified in datasheet) and programmable restart during voltage dip or the same shall be achieved by external means.
- Separate output contacts shall be supplied for earth fault protection.

Relay shall be hand reset type, unless otherwise specified. The relay shall be housed in dust tight enclosure, suitable for IP 52 degree of protection. Voltage free alarm contacts shall be supplied for alarms and indication as shown in the Single line diagram(s)/data sheet.

All power switch, control switch and push buttons are operable without opening the compartment and cable alley door except DC external power supply, DC control supply in ACB feeders and MCB for motor space heater.

The control of motor feeders shall be governed by process control requirement. Suitable no of input and output contacts shall be wired to terminal block / Marshalling terminal block to facilitate interface with the process control as per Process interface document. The project specific motor control philosophy shall be followed for DCS interface.

7.3.11. Earthing

An earth busbar sized for the full short circuit rating of the switchgear shall be supplied along the full length of the Switchgear structure. Main earth busbar shall be brought out through grommet at the end covers on both ends of switchgear to facilitate connection to Buyer's earth grid. Earth busbar shall be bolted or welded to the framework of each unit and each breaker earthing bar. Vertical earth bus shall be supplied in each vertical section which intern shall be bolted to main horizontal earth busbar.

Where frame leakage protection is specified a separate insulated bus bar is required in addition. All non-current carrying metal work of the Switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through copper flexible of size 2.5 sq. mm earthing braid and shall be arranged so that it cannot be trapped as the door is opened or closed.

Positive earthing of the circuit breaker frame shall be maintained, both in service and test position.

All withdrawable chassis shall be earthed through spring-loaded silver-plated copper scrapping earth contact which make-before & break-after the power contacts are engaged or disengaged. Earthing connection through manual plug & socket connection is not acceptable.

Provision shall be made for earthing cable screen and Armour to the earth busbar. All control, instrument and communication cables, if any, shall be earthed suitably to prevent any electromagnetic interference and ensure electromagnetic compatibility.

Each earthing point shall be marked with an "E", Earth wire shall be ferruled as “E” and jumper connection to be ferruled with the connecting terminal number. Earthing bus network and required accessories shall be supplied with two bolts for each joint.

Green & yellow colour bands shall be supplied for identification of earth busbar. Earthing of all apparatus and components shall be done separately. Not more than two wires shall be terminated on the earth bar together.

7.3.12. Main Bus Bar

Main busbars and connections shall either be manufactured from copper or high conductivity aluminium /Aluminium alloy mounted on non-hygroscopic ceramic or resin cast insulators. Main busbars including branch connections shall be fully insulated except in cable/busduct compartment(s). FRP shrouds shall be supplied at joints and tap-offs.

Main busbar shall be of the same cross-sectional area throughout the length of the Switchgear. The current rating of the neutral busbar shall be half of the phase busbars unless otherwise specified in data sheet. In case of TPN network, there should be provision for vertical neutral bus bar in each vertical. Phase to phase & phase to neutral clearance between busbars, droppers and other links shall be minimum 25 mm.

The main and vertical Busbars shall be run in separate air-filled compartment(s), not requiring access for any other purpose. Main Horizontal Busbars and vertical droppers shall be insulated with heat- shrinkable PVC sleeves of applicable grade and marked to indicate the phase colouring which shall be red, yellow, blue and black, unless specified otherwise. Necessary de-rating due to insulation shall be considered for sizing the busbars.

Busbars at bus section switches shall be arranged to permit safe work when one bus-section is de-energized. Branch connections shall be sized as per the circuit breaker or switch rating. The short circuit rating of the vertical busbars shall be same as of the main busbars. Busbars and connections shall be adequately sized, braced and supported to withstand the mechanical forces and thermal effects resulting from the Switchgear rated short circuit current and carry the type test certification.

Copper surfaces at aluminium to copper joints shall be tinned plated. Bus insulator shall be non-hygroscopic, flame retardant, track resistant type with high creepage distance. Bimetallic connectors shall be furnished for connections between dissimilar metals.

7.3.13. Secondary Wiring

Secondary wiring shall be copper conductor PVC insulated, FRLS, 600V grade. Minimum conductor size shall be 1 mm² (except electronic wiring). Minimum wire size for CT secondary circuit shall be of 2.5 mm2.

Identification of CT/PT secondary wires shall be done using coloured wires i.e., Red for R phase, Yellow for Y phase, Blue for B phase and Black/Grey for Neutral.

Secondary wiring within the MCC shall be securely held in position (either looped or run in conduit/ trunking). Where wiring passes through compartments, it shall be run in conduit or trunking and if metallic, bonded to the main frame.

Secondary wiring or auxiliary bus layout shall permit alterations to individual circuits without requiring shutdown of the completely assembled MCC. Bus wires or auxiliary bus for control, indication, heaters shall be supplied within the MCC and individually fused.

Wiring identification shall be by heat shrinkable printed ferrules, of insulating material adjacent to the terminals. Flexible cables shall be used for connections on door mounted apparatus. Wiring shall be loomed, wrapped in flexible PVC conduit and be firmly clamped (non- adhesive type) at both ends to prevent movement at terminations.

All wiring for external connections shall be brought out to individual terminals on a readily accessible terminal block. Not more than two wires shall be connected to a terminal. AC & DC terminals shall be segregated.

All cutouts through which wires are being taken are to be supplied with gasket / grommet at the edge. Potential terminals of door mounted apparatus shall be shrouded.

7.3.14. Transducer

Transducers required for conversion of AC electrical quantities such as voltage, current and power shall be of low burden type having 4 – 20 mA and shall be galvanically isolated dual channel output which is compatible with secondary indicating instrument. Transducer shall be suitable for input voltage and/or current as per specification in the data sheet. Supplier shall indicate the burden in “Ohms” which can be connected for 4-20mA output.

7.3.15. Power Supply for Control and Service

Unless otherwise specified, control supply shall be tapped from respective module. Wherever specified in Data sheets, 230 V AC Control supply for contactor modules in PMCC and MCC shall be supplied with 415 / 230V control transformers to feed power to control circuits and associated apparatus, such as power contactors, auxiliary contactors, indicating lamps. 230V AC Control Supply shall run through auxiliary bus bars. Auto manual changeover scheme shall be supplied for changeover of AC control power supply and any single point/component failure will not result failure of AC control power supply. Sufficient contacts as per specification in Single diagram or datasheet shall be made available for AC Control Supply fail alarm / indication / annunciation. Control supply from UPS source, if

specified in Data sheet, suitable terminal/ MCB shall be supplied to connect external UPS power.

Power supply to panel and motor space heaters, panel illumination lamps and plug- socket units shall be arranged from 230 V AC supply tapped from respective Bus in the panel. The 230 V AC supplies shall run through auxiliary bus bars. Supply to different modules and motor space heaters shall be fed from these bus bars through Single Pole MCB or switch-fuse unit and neutral link. Required number of contacts shall be made available for remote AC fail alarm, indication and annunciation.

Dual redundant 110 V DC control supply will be made available to each PCC and PMCC for breaker operated feeders. DC control power supply shall be dual redundant with auto changeover scheme with diodes and

auto/manual selector switch. DC control power supply shall not be interrupted in event of any single point failure. Bus or Bus-wires of adequate capacity shall be supplied to distribute power to different modules. 2 pole switch- fuse units shall be supplied at each module for DC supply.

7.3.16. Cable Terminations

Cable terminating facilities and terminals shall be suitable for the specified cable type and conductor size. Consideration and provision shall be taken by the Supplier on the apparatus engineering for the use of cables with aluminium or copper conductors as mentioned in datasheet.

Terminal blocks shall be arranged and positioned to afford ready access for carrying out external cable termination, inspection, inspection and maintenance. There shall be ample clear space allowed between the terminals and the gland-plate for the spreading and termination of external conductors. Terminal blocks shall be mounted in a single deck arrangement. Terminal blocks for the connection of external control wiring shall be of the cage clamp type with a facility to connect two wires on each side of the terminal. A minimum of 20% spare terminals shall be supplied.

All external wiring shall be on one side of the terminal block only. All terminal blocks shall be shrouded or supplied with transparent covers. Pinch screw type terminals are not acceptable. Terminals for different voltages shall be separated by partitions. Terminal boxes, wherever specified shall be suitable for dry type terminations unless otherwise specified.

A terminal box or chamber with undrilled gland plate or entry panel of sufficient dimensions to terminate the specified cables shall be supplied. Cable entry either from top or bottom, shall be as stated in the data sheet. Positioning of cable terminations shall avoid obstruction of other cable terminations. Removable covers shall be supplied for easy access for terminating cables.

There shall be sufficient clear space between the terminal block and the cable entry for the spreading and termination of external conductors. Termination of single core cables shall be

through a non-magnetic gland plate and provision shall be there for bonding and earthing any armour.

Separate cable facilities shall be supplied for each cubicle and for power and control cables. Adequate support arrangement shall be supplied for each cable to avoid undue strain on the cable terminations.

Where bus duct is specified, adequate provision shall be made for supporting and fastening of the bus duct at the Switchgear, if required. The terminals shall be supplied with a sufficient pre-drilled contact area for accepting flexible connectors and proper access shall be supplied for making off the connections while the bus duct remains in place.

Inter panel wiring within each shipping section shall be Supplier's responsibility. For wiring between shipping sections, Supplier shall provide terminal blocks on adjoining shipping sections and supply suitable connecting (jumping) wires.

Main DC supply terminals shall be screwing type in Nylon 66 housing.

In two tier arrangements of breakers, there should be no crisscross arrangement of the link work. Outgoing links of top tier ACB should be longer that the bottom ACB links for ease in cable termination.

All withdrawable modules shall have power cable termination facility in cable alley, and it shall be possible to terminate or disconnect power cables without removing the modules.

Polycarbonate grade transparent shrouds shall be supplied for all live exposed terminals. Terminal markers shall be supplied on both sides of control terminals. Terminal block shall be identified with sticker mentioning the terminal series. Identification sticker shall be put on a suitable bracket so that it is clearly visible.

Terminal marking and control wiring in similar feeders shall be identical. For connecting remote Input and

output contacts, marshalling terminal compartment (MTB) shall be supplied in Switchgear. Terminals shall be wired to MTB as per requirement.

For single core cables of feeders in top and middle compartment, separate cable supporting arrangement for cable of individual feeder shall be supplied using aluminium channels. This is to avoid heating of the support due to eddy current loss.

7.3.17. Anti-Condensation Heaters

Motor anti-condensation heaters, if specified, shall be supplied from the same source as those for the MCC. They shall be controlled through an MCB and auxiliary contacts of contactor, such that the heater is energized when the motor is stopped and totally isolated when Main Circuit Isolator or MCCB is open.

7.3.18. Space Heaters, Plug Sockets and Illumination

Each vertical section shall be supplied with thermostat-controlled space heater, illuminating lamp (LED) and 5A, 3 pin plug sockets. Cubicle heater, motor heater, socket and lamp circuits shall have individual switch fuse units.

7.3.19. Surface Finish

Switchgear shall have an internal and external surface finish as indicated in the switchgear datasheet. The finish shall provide adequate protection against corrosion under the specified site conditions. All components shall be fully tropicalized. If special treatment may be needed because of extreme environmental service conditions, as indicated in the material requisition, the Supplier shall provide details of the proposed special surface treatment along with the bid.

7.3.20. Labels

Labels shall identify switchgear cubicles, compartments, and components. Nameplates, rating plates and labelling of apparatus and wiring shall be in accordance with the relevant IEC/IS Standards and ISO 3864. Functional unit label designations shall be located at front and rear of panel, be of laminated engraved black and white plastic with black lettering approximately 20 mm high giving the designations shown on the single line diagram. All withdrawable components shall have a circuit label.

Each device including relays, meters, push buttons, lamps, fuses, contactors, and timers shall be clearly labelled to indicate its purpose. Labels shall be positioned to provide easy identification and correspond to the designation on the panel drawings. Such labels shall have minimum lettering sizes of approximately 6 mm high for external labels and 4 mm high for internal labels. Fuse labels shall show the rating of each fuse.

Internal labels shall be secured adjacent to the apparatus but not on removable covers. If specified in data sheet arc flash label shall be supplied. External labels shall be engraved on laminated plastic and attached with stainless steel screws and nuts or screws into tapped holes. Where the label is longer than 100 mm, holes shall be elongated and supplied approximately every 100 mm. A main nameplate shall be affixed in a prominent position on each Switchgear giving the following information:

- Supplier's name or trademark
- Purchase Order number
- Equipment tag number
- Switchgear designation
- Rated network voltage, phases, wires and frequency
- Rated fault current
- Busbar rating
- Year of manufacture

- BUYER's name
- Order Item number

Labels shall have black characters on a white background. Danger labels shall have white characters on a red background. “Danger” label shall be supplied on all four sides of the Switchgear in Hindi, English & Local language. Warning labels shall have black characters on a yellow background. Labels shall be made of a non- corrodible material.

7.3.21. Accessories

A completely assembled set of any special tools required for erection, operation, maintenance and inspection of the switchgear shall be supplied. The Supplier shall provide a list of special tools, along with the bid. A suitable storage box or wall mounted rack shall be supplied.

The Supplier shall provide 3 extra sets of switchgear cubicle locking keys within.

7.3.22. Spares

When specified in material requisition, SUPPLIER shall provide separate priced lists of recommended activation and operating spares for 2 years.

Commissioning spares and consumables as approved by the owner, shall be supplied.

7.3.23. Inspection And Testing

Switchgear shall be subjected to the routine tests, besides type tests, if required as per Material requisition or Purchase order. The switchgear Supplier shall provide certified test results of all the routine tests carried out on each Switchgear panel and component.

Complete tests including type tests, if any specified in material requisition, shall be carried out on at least one switchgear panel of each type of the lot ordered. The switchgear panel types that need to undergo completely assembled tests shall be decided with the Buyer during Purchase Order stage.

The Supplier shall provide test certificates with bid for each engineering and rating of switchgear, Current transformers, Voltage transformers, relays, meters and other auxiliary apparatuses used in the Switchgear. Tests shall be as those listed in the relevant IEC standards. The tests shall be for the precise cubicle configuration proposed, including any adapter units between Switchgear and control gear. The Buyer reserves the right to witness the following tests:

- Routine tests on all Switchgear and components as per specification in the IEC 60947 standards.
- Operational (electrical and mechanical) tests on all components.
- Protection operation by secondary injection of current and voltage as required.
- Protection operation by primary injection of current as applicable
- Interchangeability test

- Type tests carried out for this application.
- The Supplier shall give two weeks' notice of tests prior to commencement.

7.3.24. Routine Tests

Routine tests as per IEC 60947, shall comprise of the tests listed below as a minimum.

- Power frequency voltage test
- Lighting Impulse test
- Besides above listed Routines tests, following inspection and test to be performed:
- Dimensions check
- Visual checks Insulation resistance test
- High voltage test of auxiliary circuit
- High voltage test of main circuit
- Contact resistance measurement.
- Interchangeability test on breaker
- Measurement of resistance of the main circuit
- Electrical function test: dielectric strength of auxiliary devices, Verification of correct wiring, test of auxiliary device, Protection operation by primary injection of current and voltage, Verification of availability and correct operation of all protection and control functions of all protection relays and control circuits.
- Mechanical operation test: Operational (electrical and mechanical) tests on all components
- Painting thickness test

7.3.25. Type Tests

Type tests shall comprise of the tests listed below as a minimum.

- Short time current withstand and peak current withstand test.
- Single phase short circuit test
- Temperature rises test
- Impulse test
- Power frequency voltage test
- Internal arc test for the specified short circuit rating (if arc resistant MCC specified in material requisition

7.3.26. Packing, Preservation, Shipment and Storage

Preparation of shipment shall be made after all inspection and inspection of apparatus has been accomplished and apparatus has been released for shipping by the Buyer.

Switchgear shall be shipped in sections to suit ease of handling for transportation and setup.

Each shipping section shall be supplied with supports in the form of suitable steel sections, lifting eyes to maintain alignment of parts during shipping, handling, hoisting and setup. Location of lifting points shall be clearly marked on shipping containers and on drawings. Each shipping section shall have its weight and centre of gravity clearly marked on the container.

7.4. UPS

The apparatus (including auxiliaries) covered by this specification shall be designed and constructed for a minimum service life of minimum 25 years, with the periodic maintenance requirement of more than two years in accordance with the Contractor's recommendation.

The apparatus shall, in all respects, be designed to be suitable for operation under site service conditions stated within this specification, under periodic maintenance of all items of apparatus/controls in accordance with the Contractor's maintenance recommendation.

The UPS shall, in all respects, be suitable for operation in an atmosphere considered to be humid, saline, sulphureous and dusty. Unless otherwise specified in the datasheet(s), apparatus will be installed indoor in air-conditioned building(s). UPS shall be suitable for maximum and minimum ambient conditions as per specification in the datasheet(s). UPS shall be suitable for site environmental condition as stated in UPS Datasheet.

Contractor shall consider site supervision of setup and supervision of activation of apparatus/ network supplied.

7.4.1. Operational Requirements

The UPS shall be suitable for the electrical network characteristics as indicated in the UPS data sheet. The specific criteria and configuration of each UPS will be given in detailed datasheet(s) and Single-line diagram(s).

The network voltage & frequency and its corresponding variations shall be as follows:

- Voltage: 415 V ± 10%,
- Frequency: 50 Hz ±3%,
- Combined Voltage & frequency variation: ±10%,

All components shall be rated for the electrical network characteristics as indicated above.

Supplier shall ensure availability of spare parts and maintenance support of the offered apparatus till the lifetime of the UPS. Supplier shall give a notice of at least one year to the Buyer before phasing out of the product / Spares.

Any firmware update required during the lifetime of the UPS needs to be supplied by the Supplier. Supplier to ensure that software update is compatible with the installed hardware.

The UPS shall be fully digital, and shall either be dual redundant UPS, or single UPS, as per specification in datasheet, which shall include Microprocessor based Thyristor or IGBT bridge rectifier, Microprocessor based IGBT inverter bridge along with Control units,

Electronic static switches, Manual bypass switch, Input, Output & Bypass transformers, Battery MCCB/Fuse Disconnect box, Display and Mimic diagram for monitoring & control, Distribution Board and Central Synchronization module. UPS engineering shall be such that there are no single point failures.

The UPS shall digital microcontroller-based network. Each UPS set shall have provision for "ONLINE" fault diagnostic unit, which shall supervise the UPS continuously, locate faults and shall record data of network and electrical disturbances for UPS for an adequate period. It shall also have essential local interface port for record extraction and diagnostic purpose. Further Ethernet (TCP/IP) based network management interface for remote monitoring, event log and disturbance records extraction, and digital interface with condition monitoring network shall be supplied.

UPS shall have capability of time synchronization with external Time Master clock over SNTP with 1ms accuracy. In case of external clock is not available, both the UPSs running in redundant configuration shall have time synchronization with each other.

All components shall be rated for at least boost charging voltage plus full load criteria at continuous operation for the specified life of the UPS units and in the specified engineering conditions. All components shall be capable of withstanding the thermal and dynamic stresses resulting from internal and external short-circuits and circuit switching operations. Damage arising from component failure should be confined to the component concerned.

Isolators and switches shall be rated for at least 125% of the maximum continuous load rating of the UPS and any short-term overload rating. They shall have load-break, fault make capability and be fitted with ON/OFF indicators. Main circuit switches (mechanical) shall comply with IEC 60947 and be of the manually operated air- break type and rated for continuous duty. They shall comply with utilization category AC23 and DC23 for AC and

DC switches respectively. Moulded-case circuit breakers shall be category P-2 in accordance with the IEC 60947-1 standard.

Contactors where supplied shall be solenoid operated air-break type and compliant with IEC 60947 and rated for continuous operation for AC or DC application as appropriate to the service. The utilization category for DC contactors shall not be less than DC-5 and for AC contactors not less than AC-3. They shall be capable of making on to peak asymmetrical let through fault current permitted by the breaker or fuse upstream and of holding until the fault has been cleared by MCCB/MCB or fuse.

The UPS shall be designed to ensure that harmonic component in the input current is limited as per IEEE 519.Suitable filters shall be supplied, as required. All UPS units shall comply with the criteria for EMC, as per specification in relevant IEC standards. The Supplier shall confirm that radio frequency interference generated by the UPS units shall be in accordance with IEC-61000.

Electrical protection shall be designed by the apparatus Supplier for all major components with respect to the required discrimination during engineering inrush and fault conditions. Both rectifier and inverter shall be protected against reversed battery polarity.

Under a fault condition on an outgoing distribution circuit, the inverter shall be capable of operating the downstream protection within 20ms without damage and without recourse to the bypass supply. Protection shall be supplied against all AC and DC transients and steady state abnormal currents and voltage.

Minimum overall UPS efficiency shall be 85%, unless otherwise stated in Datasheet. For higher efficiency of the UPS under part load conditions, all components shall be selected based on maximizing the component efficiency at part load condition.

Fully rated battery MCCB with an additional auxiliary contact or fused disconnect switch shall be housed in a wall mounted box. The wall mounted enclosure of the device shall be certified for use in Zone 1, Group IIC, T3 gases for Ni-Cad battery. It shall be suitable for padlocking in “OFF” position. When a circuit breaker is specified, it shall be supplied with a shunt trip protection. The MCCB or fuse switch shall be used for the cable protection between UPS and battery network.

Supplier shall provide the MTBF figures for each of the Rectifier, Inverter, Static switch and entire UPS module during along with the bid. The Supplier shall submit, along with the bid, the guaranteed maximum heat loss in kW from the apparatus.

7.4.2. Rectifier

The Rectifier shall be a constant voltage, adjustable current limiting, self-regulating, static semi-conductor type and shall incorporate a “Soft start” feature to gradually accept load on initial energization. Duration of the soft start shall be as indicated by the Supplier.

The rectifier shall be sized to fulfil the inverter input criteria when the inverter is delivering its rated output, as well as recharging the fully discharge battery automatically to full capacity for the rated duty within 8 hours. The rectifier output (voltage regulation and AC ripple) shall be compatible with the battery and inverter input criteria under both float and boost charge conditions. Voltage control shall be step-less, smooth and continuous.

The Supplier shall provide details of the RMS actual (engineering) and maximum permissible ripple current through the battery along with the bid.

Current limiting shall be incorporated, adjustable to 200% of maximum continuous rated current and factory set to 100%. The total harmonic current consumption shall not exceed 5% for 12 pulse configurations. The total harmonic disturbance injected into the mains supply by the rectifier shall be less than or equal to 5%.

DC network shall have a centre point high impedance earth fault monitoring network to limit the maximum earth fault current to 10mA.Alarm for High DC voltage and rectifier shutdown shall be supplied. Both physical and electrical isolation shall be supplied between the power

and control circuits. Supplier to ensure acceptable method to limit the DC voltage appearing at the Inverter input within the tolerance level.

Each rectifier shall be supplied with an input circuit breaker, surge protective device (metal-oxide varistor/ TVSS) to protect against supply side switching transients along with the Isolation transformer. The rectifier shall be capable of precise voltage regulation to prevent damage to the battery. The output voltage variations shall be stabilized within +/- 1% of set value for:

- Mains input voltage and frequency variation, as per specification in UPS datasheet.
- Load variation of 0% to 100% with a ripple content of 3%.

The rectifier unit shall be designed to boost charge a completely discharged battery. The boost charging mode shall be automatic or manual, selectable by a switch or HMI. The boost charging cut-off after full battery charging shall be manual as well as automatic with selector switch or HMI. If manual boost charging is specified, it shall revert automatically to float charge in a pre-selected time (charging shall continue until fully charged) or when the battery is fully charged, whichever is the sooner. Charge voltage compensation for the battery operating temperature shall be supplied.

The rectifier shall have a feature of online battery capacity monitoring by periodic inspection through discharging battery up to a certain level.

7.4.3. Inverter

The inverter shall be microprocessor based IGBT and of the current limiting type with a short circuit proof engineering by employing a crowbar circuit for providing adequate protection.

The Inverter shall have nominal output voltage and frequency and their tolerance, as per specification in the data sheet(s). The inverter output voltage and frequency shall not exceed the operational tolerances, as measured at the output terminals of the unit during the following conditions of UPS loading: -

- Load variations between zero and the rated output of the UPS.
- Load power factors over the range 0.7 lagging to unity, unless otherwise stated in datasheet. The transient recovery time for the above disturbances shall be 1 cycle maximum.
- D.C. input voltages over the range corresponding to battery rapid charge and battery discharge operation during the specified discharge times till rated battery end cell voltage.

The inverter shall control the output voltage of the UPS such as to maintain synchronism with the mains bypass voltage during variations in mains frequency as per specification in datasheet. The dynamic output voltage variations shall not exceed ±1 % (value should be as per load criteria) in the event of instantaneous load changes of 100% rated output. The output voltage shall be restored to the steady state limits within 25 milliseconds. inverter shall then automatically re-synchronize to the external reference. The rate of frequency

change during synchronizing shall not exceed 0.25 Hz per second unless otherwise specified in the datasheet, when changeover is by static switch.

The waveform of the output voltage shall be sinusoidal with a total harmonic distortion not exceeding 4% under linear load conditions and not exceeding 5% under the non-linear load conditions.

3-phase inverters shall be capable of supplying 100% unbalanced non-linear load at full KVA output capacity. The voltage unbalance shall be limited to 5% for a three-phase output with 100% load unbalanced.

The inverter shall be capable of delivering the following overload levels based on the nominal rating:

- 200% for 100ms
- 150% for 1min
- 125% for 10min
- 105% continuously

The inverter shall be capable of delivering suitable short circuit current based on above mentioned criteria and to operate main output circuit fuse links or breaker in case of downstream fault when the UPS is not synchronized with the mains bypass supply. When the main output circuit is a fuse links, then it shall be of the slow-acting type Gg, in accordance with IEC 60269.

The Supplier shall detail out digital controller technology as adopted for controlling the inverter.

7.4.4. Static Bypass Switch

The static switch shall be an automatic solid-state change-over switch having make before break action in both directions so that no interruption to the load occurs. This shall ensure that the inverter is permanently synchronized to the bypass in order to avoid phase jumps or even phase reversals to the load at the instant of transfer. The static bypass switch shall be rated for following overload levels based on nominal rating:

- 125% for Continuous Operation
- 1000% for 100ms

Facilities shall be supplied to manually and automatically initiate transfer of the load from the inverter to the bypass circuit and from the bypass circuit to the inverter. The combined detection and switching time required to transfer the load from the inverter to the bypass circuit in the event of instantaneous loss of inverter output voltage shall not exceed 0.5 milliseconds for synchronous and 20 milliseconds for asynchronous mode respectively.

7.4.5. Maintenance Switch

The maintenance switch rating shall be compatible with the inverter output, shall have the essential short time load carrying and interrupting capacity to meet the criteria of the UPS network, as per specification in the datasheets(s). The maintenance switch shall be make-before-break assuring UPS load power continuity and shall operate to limit transfer overlap time to less than 10 milliseconds. The neutral pole shall also be switched. The maintenance switch shall be mounted in the bypass enclosure within the UPS cabinet, allowing the inverter and static bypass switch to be electrically isolated or completely removed for maintenance. This shall be an electro-mechanically interlocked to prevent operation of the manual bypass switch unless the static transfer switch is in bypass mode.

A white pilot lamp for "source synchronized" shall be supplied adjacent to the operating handle of the manual bypass switch. Lamp shall be lit under synchronized conditions. A warning label shall be supplied adjacent to the bypass switch to warn the operator against operating the switch, if out of synchronism.

7.4.6. Transformers

Each UPS shall be supplied with an input transformer, output isolation transformer and bypass transformer. The input, output and bypass transformers shall be dry type, double wound transformer with Class H insulation, completely assembled with faraday shielding in the input, output and bypass. The input transformer shall be suitable for 12 pulse, 3 phase bridge rectifiers. Transformers shall be naturally cooled; with the temperature rise for normal operations will be limited to that for Class B insulation. All these transformers shall be an integral part of the UPS and shall be able to function efficiently considering the temperature rise requirement. For single phase output, the bypass transformer shall be Scott connected.

7.4.7. Distribution Board

Distribution boards shall be either integrated with the UPS or separately mounted and shall be supplied as shown in the UPS single-line diagram. Any special criteria of the distribution board shall be indicated in the data sheet.

The Distribution board shall be supplied with suitably rated, 2 Nos of MCCB protected incomers along a bus-tie MCCB breaker (applicable for Dual redundant UPS configuration). Suitable interlock shall be supplied such that only two breakers can close at a time. The outgoing shall be Fuse-switch/MCB protected as per Single line diagram. UPS DB incomer breaker shall be coordinated with upstream and downstream protection device. All poles of the supply including the neutral pole shall be switched by means of MCB. Shunt tripping and earth leakage detection shall be as per the Data Sheet. For separately mounted distribution boards, an incoming feeder circuit breaker shall be supplied which shall have an auxiliary contact for alarm purposes.

7.4.8. Battery

If specified in the datasheet, an online battery health monitoring network, shall be supplied to monitor true battery capacity and a test facility for verifying battery capacity shall be supplied.

The residual rms ripple current in the battery circuit shall not exceed 5% of the C10 capacity for VRLA batteries and 20% of the C5 for NiCd batteries. For VRLA batteries, temperature compensation of the battery charging voltage shall be supplied for the rectifier, with an accuracy of ± 1%. The temperature sensor shall be located at the centre of the battery rack (by others) and shall adjust the rectifier output voltage in line with the battery Supplier's recommendation. The size and type of interconnecting cables between battery and UPS shall be recommended by the UPS Supplier.

7.4.9. Instruments and Alarms

All controls, indication, meters and HMI shall be flush mounted on the front panel and shall have the status of all major network components continuously.

Metering, Indication devices and Alarm devices shall be supplied as per specification in the data sheet and shall be indicated in the UPS SLD. This shall include but not be limited to the following:

- Mains failure
- Inverter failure
- Battery failure
- Load bus fault
- Bypass supply out of limit.
- Static switch failure
- Component failure
- Load on Bypass
- Rectifier failure/Fault
- Opening of outgoing circuit breakers
- Asynchronism
- Fan Failure
- Common alarm

Each alarm specified shall be supplied with local indication (HMI or individual LED). Potential free contact of Form C (NO-NC) shall be supplied for connection to a remote location and monitoring network. Where specified in the data sheet(s) and/or Single Line diagram(s) serial communication link(s) shall be supplied to facilitate remote control/indication.

7.4.10. Earthing

Two internal copper earth bars shall be suitably sized to carry the prospective fault current, shall run through the apparatus full length. The UPS network shall have fully rated ground bus with two internal ground terminals, one at each end. An external brass connecting stud of size 10mm shall be supplied for connection with plant earth. One earth bar shall be used for apparatus earthing. All non-current carrying parts shall be bonded through this earth bar. The neutral of the inverter output and bypass transformer shall be connected to a separate earth bar via removable link, which shall be electrically insulated from the other earth. This earth bar is to facilitate connection to the common earthing network by means of an insulated conductor.

7.4.11. Control Units

This control unit shall be utilized to optimize the control of the rectifier, inverter and static switch to provide following:

An optimum single phase or three phase supply of load as per specification in the datasheet(s).

Optimum controlled charging of the battery.

An optimum DC voltage supply for DC loads if specified.

Synchronized and asynchronized load transfer between inverter and bypass.

7.4.12. Electrical System Operation Modes

The AC UPS Operating modes shall be in accordance with the single line diagram and as described below:

a) Normal Mode:

Each UPS shall accept primary AC input power supply and deliver secure continuously AC output supply with regulated voltage and frequency to its respective load distribution board while simultaneously float charging the battery. This shall be applicable for all types of UPS configuration, such as Single UPS and Dual redundant UPS, as stated in this specification.

b) Emergency Mode (On mains failure):

Upon loss of the primary ac source, the UPS load shall continue to be supplied by the inverter(s) which, without interruption, shall obtain its power from the battery(s) for the period specified in the UPS Data Sheets. In case of total failure of all the primary ac source, it shall obtain its power from the battery(s). The UPS shall first change to battery mode and finally if battery is discharged to end cell voltage level, then change to bypass operation mode if the bypass supply is available.

c) Recharge Mode:

Upon restoration of the primary AC source, the rectifier(s) shall restart automatically and supply the inverters whilst simultaneously recharging the batteries at the rate determined by the rectifier(s) capacity and the battery voltage.

d) Static Bypass Mode:

On failure of a single or multiple UPS inverter (as applicable), or Inverter output voltage more than 5% above or below the normal, or Load current exceeds overload rating and time, or Battery discharge voltage limit reached or on Manual initiation, the UPS static Bypass transfer switch shall automatically transfer the respective UPS load bus to the bypass AC supply without break.

e) Manual Bypass Mode:

For continuity of UPS load power during UPS maintenance, the manual bypass switch shall allow the UPS load to be switched to the bypass source without interruption.

f) Battery Maintenance (Eliminator) Mode:

If the battery only is taken out of service for maintenance, the UPS shall continue to operate and meet all specified performance criteria except for the reserve time capacity.

7.4.13. Construction

The rectifier, inverter and static switch shall be installed in one or more free standing, self-supporting CRCA steel cabinets forming an enclosure. The frame thickness shall be min. 2mm while the doors and covers shall be of 1.6mm thick. Each cabinet shall be suitable for operation and maintenance with similar units on either side. Door locking by a central pad lockable handle with top and bottom ‘shot bolts’ shall be supplied. All around clearance shall be as per Supplier standard for ease of maintenance and shall also meet the local regulations.

All the cable connections shall be from bottom and front of the panel, unless specified otherwise in the datasheet. If top cable entry is required same shall be indicated in data sheet. The enclosure shall have a degree of protection of at least IP4X unless otherwise specified in the datasheet(s).

Internal cooling of the unit shall be by natural or forced fan assisted air ventilation. Where air circulation fan(s) are used to assist natural convection, redundant fans with filtered input air shall be supplied. Filters shall be easily removable for cleaning or replacement.

Each UPS unit shall include all components shown in the data sheet(s) and/or Single Line Diagram(s) and all other circuit protective devices, regulators, filters, instrumentation, and related components required to ensure the integrity and reliability of the network.

Equipment and components located within the enclosure shall not be mounted directly on the walls of the enclosure. The location and grouping of components and auxiliary apparatus shall permit easy identification and access for operational, maintenance and repair purposes, without interruption of supply to the load. Suitable partitioning between individual

items shall be supplied where essential to allow adjustment and inspection to be carried out safely.

Un-drilled removable gland plate(s) of thickness 3mm shall be supplied and adequately sized for all external cables. The plates shall be located to provide ease of access for terminating the size and type of cable specified. Gland plate and terminals shall be spaced so that at least 250mm is available for terminating the core of the external cables.

Busbars shall be adequately rated, tinned copper covered with adequate rated insulation. Busbar shall be colouring coded and live parts shall be shrouded to ensure completely assembled personnel safety. Power supply terminals and terminals powered from outside sources shall be shrouded (guarded) with electrical grade transparent covers. Internal cubicle wiring shall be 1100V grade, PVC insulated stranded copper conductor with FRLS property. All wiring shall be adequately designed to meet. Wiring shall be run in wire ways with ample spare capacity. Each wire end shall have PVC ferrule or plastic sleeve type permanently embossed markers to match wiring diagrams and terminal numbers. For control wiring, pre-insulated crimped terminals shall be used and for power wiring crimped lugs with PVC shrouds shall be used, shielding behind transparent panel(s) is an acceptable alternative. For ribbon cables associated with electronic circuits, numbers shall be supplied on terminals/connectors.

Terminal blocks shall be supplied and clearly marked for wiring that will be installed by the Buyer. Supplier's wiring for external connection shall be terminated to one side of terminal blocks and no more than two wires per terminal shall be permitted. Individual terminals shall be supplied for all external connections. External connections shall not be made directly to component terminals.

The paint colour shall be shaded as per RAL 7032 with a thickness of 80 microns.

7.4.14. Inspection and Testing

Each UPS shall be subjected to the routine tests. The UPS Supplier shall provide certified test record of all the routine tests carried out on each UPS. Routine tests shall be witnessed by Buyer or Buyer's representative. Type tests if specified in the material requisition shall be carried out as indicated below. The type test may be waived off for any valid Type test certificate supplied with the bid to prove that tests have been carried out adequately on similar rating & engineering UPS.

7.4.15. Routine Tests

Routine tests shall be conducted in accordance with applicable IEC standard and comprise of the tests listed below as a minimum:

- Visual Inspection test
- AC or DC Voltage test (dielectric strength test)
- Protective impedance test

- Protective equipotential bonding
- Insulation test
- Besides above listed Routines tests, following inspection and test to be performed:
- Full load heat soak run (on one unit of each rating).
- Step load application/rejection.
- Steady state regulation.
- Rectifier and inverter current limiting.

Output voltage waveform measurements/analysis at no load, 50% and 100% load and at unity and on one unit of each rating at specified power factor. The waveforms shall also be analysed during changeovers/load transfer tests.

For three phase units, measurements of input voltage, input current, DC voltage, DC current, output voltage, output current, output frequency and output waveform distortion shall be carried out under balanced condition for one phase using a balanced three phase load.

- Input inrush current measurement.
- Dynamic simulation of load changeover (in and out of synchronism).
- Voltage variation waveform under instantaneous load changes of 100% rated output.
- Voltage variation waveform under inverter output short circuit.
- Load transfer tests.
- Measurement of efficiency.
- Protection co-ordination.
- Functional alarm and tripping check.
- Operation of all apparatus.
- Type tests shall comprise of the tests listed below as a minimum
- Visual inspection
- Impulse voltage test
- AC DC voltage test (dielectric strength test)
- Partial discharge test
- Insulation test
- Harmonic measurement at no load voltage.
- Asymmetric loading test on three phase UPS.
- Noise level test.
- Short Circuit withstand test.
- df/dt, dv/dt and df/dt + dv/dt (combined).
- G3 compliance test for PCBs.
- Transformer burn-in/temperature rise tests.

- AC capacitor accelerated aging test.

7.5. DIESEL GENERATOR

Supply of 3 numbers of Diesel engine rated for 1.5 MW DG set with shaft mounted radiators Coupled with 22 KV Alternator.

a) Engine instrument panel-Microprocessor Based required as described in Data sheet.
b) Starters, batteries and battery chargers suitable for 24V DC
c) Electronic governors having Class A1 Governing
d) Engine lubrication systems including pumps, piping, oil coolers, and oil Filters and reservoir.
e) Exhaust silencers (residential type) with Flexible Exhaust (SS) as required to completely assembled Exhaust network.
f) Mounting of control and switching apparatus to the concrete Foundation, separate from the Generator frame.
g) Safety shutdown controls
h) Fuel day tanks completely assembled with high & low-level indicator and side glass gauge for Measurement of fuel oil in the day oil tank & accessories as required.
i) Supply if Neutral Isolation panel cum NGR panel for DG set. (The Neutral Grounding Resistors shall be designed to limit the Volt current to full load value. The Neutral Grounding Resistor will be housed in a cubicle and will be of Stainless Steel or Cu/Ni Alloy.)
j) Power panels, AMF and sync panel.
k) Cables and wires completely assembled with terminal lugs accessories for all required network.

Contractor shall undertake a detailed analysis and observation of existing 22 kV cubicles where they need to interlock the supplied panel. All the setup & interlocking work shall be performed by the bidder.

7.6. BUS DUCTS

The offered bus ducts for indoor switchgears shall have service life for minimum 25 years.

7.6.1. Construction

For Aluminium Bus duct, Bus bar shall be fabricated from aluminium and the conductors shall be continuously nickel/ tinned / copper / suitably plated for the entire length. Rating of busbar shall be as per SLD, and it shall be 3Phase +100% Neutral+ 50% integral earth including bends.

Bus bar conductors shall be insulated with single/multilayer of insulation of class F.

Electric connection shall be made at joints by single/multi bolt joint construction which ever suited. Joints shall be realized by a torque spanner (wrench) and shall be set as per the manufacturer engineering. To prevent the joints to be damaged during transport, they shall be protected by plastic caps, which shall be removed before setup. Standard or designed

locking network shall be put in place to prevent loosening of any screw and requiring any tightening schedule during maintenance. The engineering should have a provision to identify unravelling of the screw/nut by a degree and a marker to indicate, if the bolt has shifted from net position.

Each bus bar shall be jointed to the adjacent section by single/multi bolt-joint clamps without drilling the bus bar. Joint between two sections shall be such that a completely assembled sub assembly is removable so that isolation of individual sections is possible without disturbing other sections.

Inspection windows shall be supplied over the joints to check tightness.

The enclosures of Bus ducts shall be totally enclosed non ventilated type. Ingress protection for the enclosures shall be IP 54 for indoor Bus duct and IP 65 for outdoor Bus duct as per IEC 60529.

All non-current carrying metal work of the bus duct shall be effectively bonded to this earth bus. The ducts shall be designed for a continuous current rating. Cross section of neutral busbar shall be same as that of the phase- busbar. The short circuit rating shall be as indicated in schedule of price and SLD. Both ends of the Bus Duct shall be supplied with flexible end joints or other suitable arrangement to approval of Engineer.

The enclosure of Bus Trunking System shall be fabricated from 1.6 mm thick CRCA sheet steel/ GI/ extruded Al and shall be powder coated to colour shade RAL 7032 after regress metal treatment process.

Enclosure shall be rendered dust proof and vermin proof by adequate gasketing etc. to provide ingress protection of not less than IP 54 for indoor Bus duct and IP 65 for outdoor Bus duct as per IEC 60529. The gasket material shall be suitable for more than the class of insulation. The Bus bar Trunking System shall be manufactured in convenient section to facilitate easy transportation and setup. The sections shall be connectable to form vertical or horizontal runs as required. Each section shall be supplied with suitable support arrangement from walls / ceilings as required. Expansion joints may be supplied as per manufacturer's engineering and recommendation.

7.6.2. Flanged End Box

Flanged end box shall be supplied to accommodate flange end for connecting the bus trunking with the flanges of panels, transformers and DG Sets etc. through flexible connections. Phase matching of bus trunking with apparatus shall be done prior to setup.

7.6.3. Expansion Joints

The bus bar network shall be equipped with standard expansion joints or with expansion bolts in each unit length to compensate thermal elongation of the bus bar. As far local conditions permit, the longest bus bar unit lengths shall be used to minimize electrical losses

at the butt or bolted connections of the bus bars. The bus bar junction points shall be suitably marked for identification.

Flexible connections shall be supplied by braided or multi leafed conductors for termination.

7.6.4. Tap Off Provision

Rising Mains shall have provision to install the tap off boxes at minimum 3 locations in standard length of 3 m. Plug in points shall have a hinged sheet metal that provides IP protection similar to specified for Bus duct. There shall be provision for up to 3 plugs in tap off boxes. Rating of plug-in tap off boxes shall start from 100 ampere and shall be up to and including 400 amperes. Plug in tap off boxes shall have an electrical interlock mechanism which also insures that plug in tap off box cannot be removed mechanically from the bus bar when the box is at ON position. Tap off boxes shall be suitable for any brand of MCCB. Tap off boxes shall be manufactured of similar material and colour as main bus duct. Tap off boxes shall be plug in type with earth contact to make first and break last. Tap off boxes shall have spring loaded contacts for uniform contact pressure on bus bars. Tap off boxes shall be supplied with door interlocking and interlocking with bus trunking to ensure plug in and plug out possible only in OFF condition. All tap off boxes shall be compatible with all rating of bus trunking and shall be suitable for interchanging between sandwich/air insulated trunking. Tap off outlets shall be available as required by the network engineering. Tap off outlets shall have safety shutters to prevent access to live bus bars when not in use. Degree of protection in the open conditions with shrouding shall be IP 2X to offer personal safety protection.

7.6.5. Thrust Pads

Thrust Pads shall be supplied in the raising main systems for essential support to the rising mains and to prevent bus bar expansion in downward direction.

7.6.6. Accessories

Bus trunking network shall be completely assembled with all accessories like bends, Ts, vertical anchors, expansion joints, flexible connections etc. to suit site criteria. Bus trunking systems shall be completely assembled in all respects. All accessories shall be deemed to be included in the straight length of the bus duct and rising mains.

7.6.7. Terminal arrangement

Suitable arrangements shall be available for cable terminations so that the cable weight doesn’t come on the terminals.

7.6.8. Safety Factor

The contractor will submit the Bus duct support calculation incorporating safety factor not less than or equal to 3 and dead weight of the bus duct along with hanging arrangement detail.

7.6.9. Grounding

Bus trunking network shall be supplied with two independent earthing GI conductors' size of at least 50x6 (mm)/ as suitable throughout the length of the network. The earth flats shall be effectively connected to the enclosure by riveting/bolting. End covers shall be supplied as required. Neutral shall have same cross section as phases. All parts of the bus enclosure, supporting structures and apparatus frames shall be bonded to the ground bus.

7.6.10. Type test

LT Bus Bar Trunking network (Bus duct) offered shall comply to verification and Type test criteria of IEC 61439-6. Type inspection shall be conducted from accredited Lab. Copies of the test certificates for same rating shall be submitted at the time of vendor approval. These shall not be more than 5 years old.

7.6.11. Routine and Acceptance Test

Testing at manufacturers' works shall be conducted before dispatch as per Routine verification criteria as per IEC 61439-6.

7.6.12. Test at Site

Physical check including checking damage/crack in any components, tightness of bolts and connections etc. Insulation test after setup according to manufacturer's test procedures Testing earth continuity.

7.6.13. Installation of Bus Duct

Installation of the Bus Duct shall be carried out as per manufacturer's instructions and setup shall be verified by the manufacturer before energizing. For Bus Duct horizontal runs, horizontal expansion units shall be supplied at suitable intervals at least every 40 m and at expansion joints of the building structure and the network shall be supported at least every 1.5 m. Annular space around or Bus Ducts while crossing walls shall be filled up by sealing material by contractor in accordance with the manufacturer's instructions.

7.6.14. Warranty

Manufacturer shall give warranty for at least 5 years for offered apparatus.

7.7. DRY TYPE TRANSFORMERS

The Dry Type transformer shall have minimum life of 25 Years.

7.7.1. Construction Details

All distribution transformers shall be encapsulated Cast Resin Dry type in IP-23 enclosure.

The transformer shall be supplied with a modular enclosure with degree of protection IP42, unless otherwise specified in data sheet. Transformer name plate rating shall account restricted air circulation due to enclosure which shall have maximum 1 meter clearance all around. There shall be no de-rating (nameplate rating) on account of transformer location

inside the pressurized substation. If required in engineering, enclosure shall have louvers and wire mesh for ventilation, however, same has to be approved by Buyer.

All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

Magnetic Circuit: Whenever the CRGO sheets are punched or sheared into laminations, laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets. The laminations shall be free of all burrs and sharp projections.

The engineering of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths with in itself or to the earthed clamping structure and production of flux components at right angles to the plane of the laminations, which may cause local heating. However Magnetic core shall be effectively earthed at single point.

7.7.2. Windings

The winding material for HV & LV shall be Cu –ETP grade copper. Transformers shall be suitable for earthed neutral network as per specification. The windings/and connections of all transformers shall be braced to withstand shocks, which may occur during transport or due to short circuits, repeated peak loads and other transient conditions during service. All insulating components shall be of class “F’’. Coil clamping rings shall be of suitable insulating material. Axially laminated material other than Bakelite paper shall not be used.

Windings shall not have sharp bends, which might damage insulation and/or produce dielectric stresses.

Coil shall be supported using dried and high-pressure compressed wedge type insulation spacers at frequent intervals. All threaded connections shall be locked. Leads from the winding to the terminal board and bushings shall be rigidly supported to prevent injury during short circuits/vibration.

Tapping: Off circuit tap changing links shall be supplied with tapping rang of +10% to -10% in step of 2.5% on primary windings. Tapping as per specification shall be supplied on the high voltage winding of each transformer and shall be arranged so as to maintain electromagnetic balance of the windings. Transformer shall be designed to deliver it’s rated output in any taps with overheating / damage to core and windings.

Enclosure: The cast resin transformer with the supporting skids / wheels shall be supplied with sheet steel / Galva bond enclosure (with lift off horizontal panels for accessing terminals) completely assembled with louvers to provide IP-23 protection and the louvers shall be such as to make the enclosure poke free/safe to touch. Louvers shall be supplied

with wire mesh. Door Limit switches shall be supplied to trip upstream breaker, in the event of accidental opening of Doors.

Painting: Finish paint shall be RAL-7032.

7.7.3. Termination

Cable box termination

Where cable boxes are specified, the cable box shall be air insulated type suitable for the type and number of cables specified. The size of cable box shall meet the minimum dimensional requirement of cable termination. Cable boxes shall be air insulated type with clearances as per specification. Non-magnetic gland plate shall be supplied for single core cables. Disconnecting links shall be supplied in the termination box. Cable box shall be of IP55 class, suitable to terminate:

- HV side - Single Run 3c x 300 Sq. mm cable.
- LV side – Bus Duct

Bushings: Bushings shall be suitable for atmosphere present in the place of setup. Total creep-age distance shall not be less than 25 mm/kV of highest network voltage and 50% of this shall be protected creep- age distance. Higher creep-age distances shall be supplied for polluted atmosphere, as per specification in engineering criteria. Current rating of the bushings shall be minimum 150% of transformer rated current.

Bushings Current Transformer: Where bushing CTs are specified, the same shall conform to the specification indicated in the data sheet. All secondary leads, including tapings shall be brought to a weatherproof terminal box. Rating and terminal marking plate of the CT shall be marked on the name plate of transformer. CTs shall be to the marshalling box.

Winding Temperature Indicator: Winding temperature scanner/controller with RS 485 port (for connectivity to DCS / PLC) shall be supplied in marshalling box and wired to RTDs. RTDs inserted in the hottest part of the inner winding. 2 no's / Ph RTDs shall be supplied.

7.7.4. Marshalling Box

The marshalling box shall be mounted on an easily accessible location and shall be completely assembled with glands as per specification in the requisition. The enclosure protection shall be minimum IP- 55.

The marshalling box shall consist of following:

1. Winding temperature scanner cum controller (WTI)
2. Terminal Block.
3. Anti-condensation heater.
4. A 240V AC switched lamp with holder.
5. Emergency push button with minimum 2 N0+2NC contact.

7.7.5. Earthing

Earthing pad shall be supplied on transformer enclosure body and cable termination box. All metal parts of the transformer with the exception of individual core laminations, core bolts and associated individual clamping plates shall be maintained at some fixed potential by earthing.

Where coil clamping rings are metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of the transformer as main earth connections.

The magnetic circuit, the framework, top and bottom clamping arrangement and all internal metal parts of the transformer, with exception of individual laminations, core bolts and their individual clamping plates shall be suitably earthed.

7.7.6. Accessories

Transformer shall be supplied completely assembled with all accessories deemed essential for proper operation plus those which are mandatory specified in this specification or the requisition. All components make shall be as per Owner's approved vendor list.

7.7.7. Neutral CT

The neutral "CT" if specified on the data sheet shall be supplied in the earth connection box. CTs shall be of Resin cast only.

"CT ratio and parameters" are indicative only. Shall be finalized during detail engineering by EPC contractor.

7.7.8. Corrosion Protection

All metal parts shall be adequately protected against corrosion, based upon the environmental conditions specified on the site and utility data sheet. Surface preparations and painting shall be seller's standard for the environmental conditions specified on the site and utility data sheet. Seller shall submit in his quotation his standard surface preparation and painting systems for buyer's review. Colour of the topcoat shall be seller's standard unless a specific colour is specified on the data sheet.

7.7.9. Marking Rating Plates

Rating plates shall at least show the information as required per IS: 11171/2026 and shall be attached to the apparatus on a well visible place. Rating plates shall be of stainless steel and shall be fixed with corrosion resistant screws or rivets. A diagram plate shall be supplied and installed closed to the rating plate. An additional nameplate shall be supplied indicating the apparatus number and/or description. Sizes and letter heights for nameplates and apparatus number plates will be specified in detail in the requisition.

7.7.10. Inspection and Testing

All the routine tests & as per IS shall be witnessed as per approved QAP. Type test certification to be submitted. Transformers shall be routine tested in accordance with the IS: 11171 & 2026 standards. The intention of witnessing the tests and eventual supplementary inspection items will be specified in the requisition.

Heat run test on one transformer to be conducted.

7.7.11. Warranty

Manufacturer shall give warranty for at least 5 years the apparatus with lifetime support of spares and accessories.

7.8. 110V DC BATTERY CHARGER

7.8.1. Life

Battery charger shall have minimum life of 25 years.

7.8.2. Service Conditions

The battery will be installed in an enclosed building in a non-hazardous area where service conditions shall be specified in project data sheets/job specification. If not specifically mentioned therein, engineering ambient temperature of 27°C and altitude not exceeding 1000m above MSL.

Battery setup shall be suitable for seismic zone.

The minimum ambient temperature for batteries shall be as per site conditions.

7.8.3. Technical Requirements

- The batteries shall be of VRLA type.
- The batteries shall be suitable for 60 minutes back-up time.
- The battery stand shall be of metal type with RAL 7032 shade. The height of Battery rack shall not exceed 1800 mm.
- The rated AH capacity of the cell/battery shall be at 27°C, constant current discharge at 10 hours rate (C10).
- Construction of the battery shall confirm to IS 15549.
- Battery shall be supplied with all accessories including but not limited to the following: Battery stand
- Inter cell, inter row & Inter tier connectors. These shall be made of copper and able to withstand the short circuit current.
- Shrouds for all the battery terminals.
- Stationary VRLA cells shall be designed to withstand the mechanical stresses encountered during normal transportation & handling.

- The float and boost charger offered shall be static type with silicon-controlled rectifiers and diodes, completely assembled with resistor/capacitor network for surge protection, connected in three phase full wave bridge circuit.
- Charger shall have provision for manual control if the auto mode fails. Load limiting features shall be supplied.
- The chargers shall be supplied with automatic voltage regulation in float mode and automatic constant current regulation in boost mode.

The charger shall essentially comprise the following items:

- One (1) moving coil DC voltmeter and ammeter of suitable range for float and boost chargers. Necessary shunts for local and remote metering shall be supplied.
- One (1) moving coil centre zero ammeter, with shunt to read discharge / charge current of the battery.
- Fault indicating lamps shall be supplied on the charger cubicle and following initiating contacts shall be supplied for remote alarm for each of the float and boost chargers.
- Main AC source-1 failure
- Main AC source-2 failure
- AC input fuse blown.
- DC output fuse blown.
- U/V and current limit protection
- Over voltage protection
- Over current protection
- Filter condenser fuse blown.
- Rectifier fuse blown.
- DC Positive earth fault
- DC negative earth fault
- The external cooling fans shall be supplied to dissipate the heat developed within the panel, if required.
- Battery Charger shall be supplied with a separate compartment consisting of DC MCBs: EPC contractor to detail the same during detail engineering.
- Manufacturer shall give warranty for at least 5 years the apparatus with lifetime support of spares and accessories.
- The Batteries shall be supplied completely assembled with consumable like electrolyte, vent plugs, connectors, shrouds, mounting bushings required for setup and daily operation and maintenance.

7.9. APFC PANEL

Capacitor panel shall have minimum life of 25 years. Capacitor panel shall be fabricated from CPRI certified panel fabricators. Refer single line diagram for details. All substations shall be supplied with automatic power factor improvement of required capacity as per the single line diagram. The panel shall be totally enclosed, free standing floor mounting dust and vermin proof minimum degree of protection of IP31 completely assembled with a hinged lockable door indoor cubicle type with provision for capacitor mounted inside the panel with adequate Ventilation network and air inlet filter unit shall be supplied for the capacitor banks to facilitate better heat dissipation. The ventilation fan shall be operated by two numbers of thermostats set at desired temperature respectively. and powder coated with approved shade. Constructional criteria and busbar rating shall match with the main LT panels inside the substation.

Each of the switchboards shall incorporate a power factor improvement capacitor setup which shall be housed in a separate dedicated enclosure forming an integral part of the switchboard.

The PFC section shall contain a main ACB a multistage power factor relay controlling specified kVAr capacitor stages as per SLD. Each capacitor stage shall include a three-phase capacitor unit of the required rating, a three-phase triple pole capacitor duty contactor with inrush limiting pre-connection reactors, illuminated ON/OFF lamps and stage fault protection comprising appropriate MCCBs. Current density of busbars shall be 0.8A/sq.mm. and phase and neutral shall have same area of cross section. Higher bus bar ratings, if required, based on short circuit and fault level of the panel and due to any engineering factors shall be supplied.

The reactor insulation shall be Class “F” or above. The maximum temperature of the reactor at maximum continuous RMS amperage shall be no higher than 145°C at a 50°C ambient.

Capacitor units shall be dry designs for heavy duty MPP-H A protection network shall be fitted to each element which shall comprise an over-pressure disconnect device and an appropriate cartridge fuse per element. Each unit shall also be fitted with an integral discharge resistor for the safe and automatic discharge of the capacitor bank. The reactors used shall be copper wounded only. The power factor capacitors systems shall having connected in a delta configuration. The power capacitors shall have a minimum rated voltage of 415V and designed to accommodate without harm a reasonable degree of harmonic content in the loads connected to the switchboard, typically that which would arise from the use of electronic soft start or variable speed motor control apparatus / electric welding apparatus / discharge lighting.

The power factor cubicles containing the capacitors shall incorporate suitable safe venting of any potential explosion of capacitors. The venting of potential gases and or heat from the capacitors shall be either safely discharged so as not to cause harm or danger to persons that may be within the switchgear room or the vent location.

The power factor cubicles containing the capacitors shall incorporate interlocks on the access doors, such that the capacitor is automatically discharged through resistors to earth to reduce the voltage to below 50 volts in 1 minute before the access door is allowed to be opened.

The APFC panel shall be suitable for its intended application. Any control transformer required for control supply shall be supplied. The power factor controller shall/ be able to shall be able to sense the reactive current requirement of the network and shall switch ON / OFF the required stages of a capacitor bank. The power factor controller shall/ be able to any stage size by automatic recognition and the switching sequences should be user defined. Detect the capacitor bank size if in case the present capacitor is replaced by a new capacitor of different rating.

The switchboard is to be supplied with an earth bus bar (copper) and individual switchgear units are to be earthed to the earth bus using right size copper strip. The earth bus taken out at both ends shall have provision to earth it to the network earthing and having same area of copper as per the earthing schedule. Any control transformer required for protection, indication and measurement shall be supplied.

The inspection at manufacturers work also includes physical verification for compliance with PO, specs, extent, approved drawings and BOM. The inspection at Manufacturer's works also includes dimensional checks, components checking, operation inspection, etc. The contractor shall give at least 15 days advance information to client about the manufacturing and tests plan so that DGNP can attend the same. Costs associated with inspection at manufacturer's works and at site are under the extent of the contractor. ACBs and relays shall be set at site. Tests reports shall be submitted for Engineer for review and records.

All type tests shall be carried out in accordance with the IS 16636 (Equip IEC 61921) and IEC 61439 completely assembled Capacitor banks equipped with detuned reactors. The following type tests shall include:

1. Verification of Temperature Rise limits at 130% of nominal current (with allowable temp rise values considering 50degC as the base ambient temp)
2. Verification of dielectric properties
3. Verification of the short-circuit withstand strength
4. Verification of the effectiveness of the protective circuit
5. Verification of clearances and creepage distances
6. Verification of mechanical operation
7. Verification of the degree of protection

7.10. GMU PANELS (GENERAL MAINTENANCE UNITS)

The GMU panels shall have minimum life of 25 years. Contractor shall include for the detailed engineering, supply, manufacture, assembly, delivery to site, erection, inspection, activation and setting to work of the 415V, 50Hz ac low tension switchboards. Each main

switchboard will receive an incoming power supply from a dedicated transformer which will be supplied from a circuit breaker on the local 22,000 kV switch gear. The switchgears/LT panels are intended for powering the vessels or other loads with 3 phases and neutral.

The switchboards shall be supplied with the quantities and ratings of circuit breakers and busbars together with all protection devices specified herein and as per single line diagram.

The panels shall be fabricated from CPRI approved manufacturers (Certificate in this regard shall be furnished) Each 440V, 415V or 380 V switchboard shall consist of a metal enclosed, containing an incoming air circuit breaker, Aluminium bus bars, outgoing circuit breakers and power factor improvement apparatus. The proposed switchboards shall include an incoming circuit breaker and the outgoing circuit breakers indicated on the drawings.

The switchgear shall be installed on a network of the three-phase pattern with nominal voltage between phases of 440/480V for 60Hz network and 415V / 380V for the 50Hz network. The network neutral will be solidly earthed via the switchgear. Current density of busbars shall be 0.8A / sq.mm. Higher bus bar ratings, if required, based on short circuit and fault level of the panel and due to any engineering factors shall be supplied. All electrics of 440V/480V panel shall be suitable for its indented voltage and frequency of 60Hz.Bus bars shall be rigidly fixed to the supports, of SMC/DMC solid block type base. Busbars shall be firmly held within the slots in sheet type supports, which in turn shall be rigidly fixed to the chamber.

The switchgear shall be required to operate Outdoor on jetty and shall be rated for a minimum of 45 deg. C ambient air temperature, The atmosphere is saline in nature. Panel IP rating shall be selected as per outdoor conditions. These environmental operating conditions shall apply for all apparatus within the substation, no specific risk of earth tremors or other vibrations due to causes external to the switchgear have been identified.

The switchboards shall be of an Outdoor type, metal enclosed, floor mounting unit construction, air insulated bus bar, extensible type. It shall be equipped with air break circuit breakers, moulded case circuit breakers and SDFU‟S as per specification in the single line diagram. Unit mounting relays, instruments, transformers and auxiliary devices essential for operation, control, protection or measurement purposes also shall be supplied. All normal components, fittings and accessories required for safe and proper operation of the switchgear shall be supplied whether specifically mentioned herein or not.

7.11. SHIP SHORE UNITS (415V COPE POINTS)

The SSU (COPE POINT) panels shall have minimum life of 25 years. Design, supply and setup of SS-316 grade outdoor cope box in the jetty with proper mounting arrangement. The cope box shall be supplied with essential hardware for easy connection and disconnection of vessel power supply cable.

The item shall be surface mounted receptacle combination enclosure with stainless steel grade of 316 suitable for marine environmental use. The panel is for use in the marine

environments and shall have grater resistance to pitting. The item shall be compact austenitic chromium – nickel stainless and heat resistance steel with superior corrosion resistance. Hinged lockable doors with door switch interlock will be supplied for all feeders/panels, door opening in front and canopy and having IP 55 degree of protection for enclosure. The receptacles/ sockets shall be high resistance polycarbonate material. The panel shall be fitted with 12 W LED lamp fittings with switch, MCB for getting outside illumination for working purpose. The item shall be of branded and reputed make having manufacturing facility according to DVE, TUV, Lloyd 's, or equivalent. Relevant certificate shall be produced for approval. Makes Hensel, Menekes or equivalent reputed/ branded make having experience in marine field application. For other makes, approval from the Employer has to be taken and discretion of the Employer is final. Tentative rating and quantity of the cope box is given below. However, contractor has to supply the item as per the detailed engineering requirement.

Cope box on suitable foundation, bolts, connect test and activation independent, floor mounted fabricated of 2 mm stainless steel sheet including electrolytic copper 3 phase bus bar of suitable current ratings as per Single line diagram.

7.12. HT SWITCHGEAR

The HT Switchgear shall have minimum life of 25 years. With a rated Voltage of 22kV and Rated frequency of 50Hz with 3 Phases. Rated current is as per detailing by EPC contractor.

The switchgear shall be of CRCA steel / corrosion proof aluminium-zinc construction with sheet not less than 3 mm thickness for load bearing section and not less than 2mm thickness for non-load bearing and shall totally dust and vermin proof.

However, if vendor has standardized the thickness of enclosure other than above mentioned and it meets the performance criteria and the engineering has been established through type test, the same shall be accepted. The panels shall be rigid without using any external bracings. The switchboard panels should comply with relevant IS / IEC and revision thereof and shall be designed for easy operation maintenance and further extension. Each circuit shall have a separate vertical panel with distinct compartments. Bus bar, metering, circuit breaker chamber, cables and cable box chamber should have proper access for maintenance and proper interlocks should be supplied. All instruments (Except the Relays) shall be non-draw out type and safeguard in every respect from damages and supplied with mechanical indicator of connection and disconnection position. The switchgear shall be completed with all essential wiring, fuses, auxiliary contacts, terminal boards etc.

The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction, comprising of row of freestanding floor mounted panels. The adjacent panels shall be completely separated by steel sheets except in busbar compartments where insulated barriers shall be supplied to segregate adjacent panels. The switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position SERVICE,

ISOLATED, TEST or removed, and all doors and covers closed. All doors, removable covers and glass windows shall be gasketed all round with synthetic rubber or neoprene gaskets.

The arcing contacts and bus bar should be rated as per EPC contractors engineering. Bus bars shall be capable of connecting one switchgear panel to other through proper insulated arrangement. The panels shall be modular in engineering.

The breakers should be able to be drawn out in horizontal position at ground level [with vertical/horizontal isolation]. When breaker is drawn out in horizontal position none of the live components inside the 22KV switchgear panel should be accessible. The safety shutters shall be robust and shall automatically cover the live components when the breaker is drawn out. The switchgear shall have completely assembled interlocking arrangements at the fully inserted and fully drawn out and test positions. Withdrawal of the breaker should not be possible in ON position, it should not be possible to close the circuit breaker in service unless the entire auxiliary and control circuit are connected.

Circuit breaker shall be vacuum; draw out type housed in a separate cubicle of the switchboard and shall be enclosed from all sides. A sheet steel hinged lockable door shall be at the front. It shall be possible to withdraw the circuit breaker to 'Test' and "Isolated' position with the door closed. Door interlock shall be supplied such that the door can only be opened after withdrawing the breaker to 'Isolated' position and the breaker cannot be racked into the 'Service' position unless the door is closed. A visual indication as to show when the breaker is in 'Service', 'Test' or 'Isolated' position shall be supplied in front of the door.

Switchgear construction shall have a bushing or other sealing arrangement between the circuit breaker compartment and the busbar / cable compartments, so that there is no air communication around the isolating contacts in the shutter area with the truck in service position.

The breaker and the auxiliary compartments supplied on the front side shall have strong hinged doors, busbar and cabling compartments supplied on the rear side have bolted compartment covers with self-retaining bolts. Breaker compartment doors shall have locking facility.

Built-in / separate trolley mounted earth switches for incomer (busbar earth) and outgoing (feeder cable earth) shall be supplied.

All the high voltage compartments shall have pressure discharge flap for the exit of gas due to internal arc to ensure operator safety. All the HV compartment engineering shall ensure conformity to IEC-60298 and shall be type tested for IAC classification and duration as per IEC As per IEC 62271-200 clause A. 4.5 (AFLR).

Two separate earthing terminals shall be supplied in each panel and shall be connected to the earth bus within the panel. The earth bus shall be of copper and shall have adequate cross-sectional area.

The bus PT/relay compartments shall have degree of protection not less than IP:52 in accordance with IS:2147. However, remaining compartments can have a degree of protection of IP:42. All louvers if supplied shall have very fine brass or GI mesh screen, IPH-2 degree of protection as per IS: 3427 to all live parts shall (whether isolated or removed from panel) even when the breaker compartment door is open. Tight fitting garments / gaskets are to be supplied at all openings in relay compartment.

Total height of the switchgear panels shall not exceed 2600 mm. The height of switches, pushbuttons and other hand-operated devices shall not exceed 1800 mm and shall not be less than 700mm.

Suitable base frames made of steel channels shall be supplied along with essential anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and levelled when the flooring is being done, welding of base frame to the insert plates shall be as per approved setup drawings.

The switchboard shall have the facility of extension on both sides of Adapter panels and dummy panels required to meet the Busbar.

7.12.1. Bus Bars and Connectors

Bus bars and all other electrical connection between various components shall be made of electrolytic copper of rectangular / tubular cross sections, as per the type tested and ratified engineering. The bus bars section should have ample capacity to carry the rated current of minimum 1250 Amps in panel current rating at an ambient temperature of 45 deg. C, continuously without excessive heating and for adequately meeting the thermal and dynamic stresses in the case of short circuit in the network up to full STC rating of 26.3 kA for 3 sec. The Current density of 1.6Amps/sq. mm shall be considered for the bus bars.

All bus bars connections shall be firmly and rigidly mounted on suitable insulators to withstand short circuit stresses and vibrations. ‘Self-supported busbar’ engineering will be acceptable if the same is ratified by type tests for the specified rating and busbar support drawings approved during type tests shall be furnished with the offer.

All fasteners (Nuts Bolts) used for bus bar connections shall be of non-magnetic stainless steel.

Adequate clearance between 11 kV point and earth and between phase shall be supplied to ensure safety as per provision in Indian Electricity Rule 2003 and its amendment thereof and, in accordance with the relevant Indian standard specification and the same shall be capable of withstanding the specified high voltage tests as per IEC 62271-200 / IS 13118 and amendment thereof.

Sharp edges and bends either in the bus bars or bus bar connections shall be avoided as far as possible. Wherever such bends or edges are un-avoidable, suitable compound or any other insulation shall be supplied to prevent local ionization and consequent flashover.

The bus bars along with their supporting insulators etc. shall have a short time current rating of 26.3 KA for 3 sec. Test certificate of bus bar for rated STC rating shall be submitted, along with the bid. This shall be confirmed by the tenderers in their technical offer. These insulators shall be of solid core porcelain or epoxy resin cast, with suitable petticoat engineering. Insulators shall have a cantilever strength of not less than 1200 KgF.

The Bus Bar should be colour coded.

7.12.2. Circuit Breaker

The vacuum circuit breaker shall be draw out type suitable for setup in the switchgear cubicles (indoor). The breaker shall comply with IEC 62271-100 / IS- 13118 (1991) for circuit breaker and IEC 62271-200 for the switch gear and latest amendment thereof. Construction of breaker shall be such that the points, which require frequent maintenance, shall be easily accessible.

The circuit breakers shall be spring operated, motor/manually charging of the spring feature, manually released. VCB shall have spring closing mechanism for 3 pole simultaneous operation. The speed of closing operation shall be independent of the speed of hand operating level. The indication device shall show the OPEN and CLOSE position of breaker visible from the front of cubical.

The circuit breakers shall be type tested as per IEC 62271 for compliance with the following criteria:

1. E2 class: The circuit breakers shall not require maintenance of the interrupting part of the main circuit during its expected operating life.
2. C2 class: The circuit breakers shall have very low probability of restrike during capacitive current breaking.
3. M2 class: The circuit breaker should require very limited maintenance and should be tested for endurance for 10,000 close – open operations.
4. The breakers shall be capable of making and breaking the short time current in accordance with the requirement of IEC 62271-100 / IS 13118 (1991) and latest amendment thereof and shall have three phase rupturing capacity of 26.3KA for 3 second at 11 KV. The continuous current rating of all current carrying parts of breaker shall be 1250 Amps for all items. The total break / make time shall be not more than 4 cycles for break and 6 cycles for make time for all breakers.
5. Circuit breaker shall be suitable for rapid reclosing cycle O-0.3 sec-CO-30 sec-CO.
6. The spring release coil for VCB close and VCB trip coil shall both be rated for continuous energization at the rated close / trip voltage. Trip and close coil shall be suitable for 110 V DC.
7. The vacuum circuit breakers shall ensure high speed extinction and adequate control of pressure during breaking of current and designed to limit excessive over voltages.

8. Comprehensive interlocking network to prevent any dangerous or inadvertent operation shall be supplied. Isolation of circuit breaker from bus bar or insertion into bus bar shall only be possible when the breaker is in the open position.
9. Vacuum Circuit Breaker shall have completely sealed interrupting units for interruption of arc inside the vacuum. The vacuum interrupter sealed for life.
10. Vacuum interrupter should have an expected life of 30000 operations at rated current and should be capable for operating at least 100 times at rated short circuit current.
11. The circuit breaker shall be supplied with motor for spring charging operation. Spring charging motor shall be suitable for 240V, 50 Hz, single phase AC and 110 V DC Supply. Suitable rating starter/fuse shall be supplied for Motor protection. Provision shall be available for charging the springs manually as well, and to close circuit breaker mechanically.

All circuit breakers shall have mechanical ON/OFF indicator and spring charge indicator. These shall be visible from the front without opening the panel door. Also, there shall be provision for mechanical (manual) tripping and for manual charging of the springs.

7.12.3. Current Transformer

The Current Transformers shall have class of accuracy of 0.5 S for metering, 5P for protection for Incoming and outgoing feeders and PS for differential protection.

Primaries shall be wound or bar or window type, rigid, high conductivity grade copper conductor. Unavoidable joints on the primary conductor shall be welded type, preferably lap type. The current density at any point shall not exceed 1.6 A/sq. mm.

The Insulation level of all the CTs shall be: 12/28/75 kV and the Class of Insulation shall be “E”.

Short time current rating of CTs shall correspond to 26.3KA faults for 3 seconds of 11kv network. CTs shall be triple / double core and dual ratio. Instrument safety factor for metering core shall not exceed 2.5.

The designed accuracy should be available even at the lowest ratios.

The secondary terminal of the current transformers shall be such that effective and firm wire terminations are possible. Shorting links of adequate capacity shall be supplied at the terminal blocks for sorting of the leads from secondary terminals of current transformers. The secondary terminal of the CTs shall be earthed at one point.

CTs shall confirm to IS 2705 with latest amendment and relevant IEC standard, if any in all respect and will be subjected to all routine and type test specified in the IS/IEC.

The CTs shall be resin/epoxy cast. Contact tips on primary terminals shall be silver plated. Correct polarity shall be invariably marked on each primary and secondary terminal.

The designed accuracy should be available even at the lowest ratios.

Secondary terminal studs shall be supplied with at least three nuts, two plain and two spring washers for fixing leads. The stud, nut and washer shall be of brass, duly nickel plated. The minimum outside diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads. The space clearance between nuts on adjacent studs when fitted shall be at least 10 mm.

7.12.4. Potential Transformer

1 No. 3 phase resin cast, draw out type, bus bar connected, potential transformer of 5-limb construction, ratio 22000/110 volts, class 0.5 accuracy at 50 VA output per phase, completely assembled with HT HRC fuse and Triple Pole & Neutral MCB, rated 1 Amp, with monitoring contacts on PT LV circuit. Primary and secondary neutrals of the PT shall be brought out and earthed. If required, the busbar connected P.T. may be housed in a separate cubicle. PT mounted on top of the panel will not be acceptable.

H.V side shall be connected in star formation and L.V. side in star/open delta formation.

PT may be supplied in a separate compartment. The primary and secondary contacts (moving & fixed type) shall have firm grip while in service. Service position locking mechanism shall be supplied and indicated by bidder in relevant drawing. Rigidity of primary stud point with earth bus in service position shall be confirmed.

Contact tips of primary/secondary contacts shall be silver plated. Correct polarity shall be distinctly marked on primary and secondary terminal.

Secondary terminal studs shall be supplied with at least three nuts, two plain and two spring washers for fixing leads. The stud, nut and washer shall be of brass, duly nickel plated. The minimum outside diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads. The space clearance between nuts on adjacent studs when fitted shall be at least 10 mm.

Details of PTs:

- IS: 3156 and relevant IEC standard.
- Ratio: 11KV/√3/110V/√3
- No. Of phases: 3 Phases / star – star connected.
- Insulation level: 12/28/75 kV
- Class of Insulation: Class E
- Rated voltage factor: 1.2 continuous & 1.5 for 30 Sec.
- Rated Burden: 100 VA per phase.
- Class of accuracy: 0.5
- Purpose: Metering
- Primary wiring of the PTs shall be protected by suitable H.R.C. fuse.

- Each secondary core will be protected by suitable MCB. Two sets of 22 KV/110 V PTs shall be supplied.

7.12.5. Protection Relays

All relays shall conform to the criteria of IS: 3231 / IEC-60255/ IEC 61850. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear. The relay for entire project shall be of same type. The relays shall be numerical protective & communicable type.

Composite relay unit having O/C, E/F & directional element etc. shall be preferred. Relays should have USB / ethernet communication port and RS485 / RS232 serial communication port for communication through IEC 61850 Ed II (with high-speed GOOSE communication and certified by KEMA/CPRI certificate level A for IEC 61850 compliance). Licensed version of the relay software should be supplied as per user's requirement.

7.12.6. Measuring Instruments

All instruments shall be switchboard type, back connected, suitable for flush mounting and shall comply with the criteria of latent issues of relevant Indian Standards. The instrument cases shall be dust proof, watertight, vermin proof and specially constructed to adequately protect the instruments against damage or deterioration due to high ambient temperature and humidity.

All instruments shall be access adjustable and calibrated before dispatch and shall have means for calibration check and adjustment at site.

All ammeters shall be digital type with direct reading scales. The scale value of ammeters shall be as per the primary current ratings of the associated current transformers. The rated current of ammeter elements shall be 5 Amperes and Accuracy class 1.0 as per IS: 1248.

All voltmeters shall be of digital type with direct reading scales. The maximum scale value of voltmeters shall be 50% in excess of the primary voltage of associated PT.

The rated voltage of the voltmeters shall be 110 volts A.C., and accuracy class shall be as per IS: 1248.

Indicating wattmeter shall be of digital type of accuracy class 1.

7.12.7. Cubicle

The switchgear cubicle (panel) shall be free standing floor mounting indoor type. There shall be sufficient reinforcement to have level surfaces resistance to vibration and rigidity during transportation & setup.

Design & construction of the switchgear panel shall be of the highest order. All sheet steel work shall be treated as per the seven-tank process before applying primary coating. For the final coat (stowed) epoxy paint colour shade of light admiral grey to shade No.695 as per IS:5 shall be used. Alternatively, powder coating may also be accepted. The panels after

final painting shall present an aesthetically pleasing appearance, free of any dent or uneven surface.

Cable compartment shall be suitable for Incoming and outgoing cable runs of minimum 240 sq. mm three runs of 3 core cable.

7.12.8. Cable Glands And Clamping Arrangement for Holding Suitable Cable Boxes

Two nos., brass, wiping glands for each incomer and one no. Brass wiping gland for each outgoing panel of adequate dimension for XLPE cable of 3 cores up to 400 sq. mm size shall be supplied along with panels. For bus coupler no cable glands should be supplied.

Suitable cable boxes as per requirement of cable shall be arranged by the purchaser at his end. The panel shall however provide a flat of size 50X6 mm2 with suitable clamp made of 50X6 mm2 flat along with Nuts Bolts and Washers for holding the cable boxes. The flat should be fitted at a suitable height with allotted arrangement for adjustment of height from 300mm to 500mm at site. The clamp and flat shall have suitable stud type arrangement for earthing cable and cable box.

All control cable / wire entries shall be by means of suitable cable glands, such glands shall be of brass and tinned.

7.12.9. Auxiliary and Control Wiring

All the secondary wiring in the panel shall be 1100 volts grade single core; multi- strand flexible tinned copper wires have high quality PVC insulation and the same shall have conductor size of not less than 2.5 mm2 of copper. Colours of the secondary/auxiliary wiring should confirm to IS 375/1963 and latest amendment thereof if any. All wiring shall be neatly run, and group of wiring shall be securely fixed by clips so that wiring can be checked without necessity of removing the clamps. Wiring between fixed and moving portion of the panel shall be run in flexible tubes and the same shall be so mounted to avoid any damage to them due to mechanical movements. Ferrules with number shall be supplied on both end of the wiring.

All front mounted as well as internally mounted items including MCBs shall be supplied with individual identification labels. Labels shall be mounted directly below the respective apparatus and shall clearly indicate the apparatus designation.

Terminal blocks shall be of screw type engineering made from non-trackable insulating material of 1100 V grade. All terminals shall have all current carrying and live parts made of tinned plated brass. The washers, nuts, etc. used for terminal connectors shall also be of tinned plated brass.

At least 20% spare terminals shall be supplied. All terminals shall be supplied with ferrules indelibly marked or numbered and identification shall correspond to the designations on the

relevant wiring diagrams. The terminals shall be rated for adequate capacity which shall not be less than 10 Amps for control circuit. For power circuit it shall not be less than 15 Amps.

All fuses used shall be of HRC type. The fuse base and carrier shall be plug-in type moulded case KitKat of Bakelite/DMC. All current carrying and live parts shall be of tinned/nickel plated copper. No fuse shall be supplied on DC negatives and AC neutrals. Tinned copper links shall, however, be supplied on DC negatives and AC neutrals.

All MCBs as per IS:8828/2006 (amended up to date) of adequate rating shall be used.

7.12.10. Name Plate and Panel Details

All apparatus shall have weatherproof and non-corrosive metal plates fixed in suitable position with full particulars engraved thereon with white letters against black background.

The firm shall affix a name plate on each Switchgear panel having following information:

1. Panel Tag number
2. Voltage rating
3. Frequency
4. Fault kA
5. Year of manufacture

7.12.11. Painting

All metallic surface [except corrosion resistant aluminium-zinc material and enamelled. and bright parts] exposed to weather shall be given suitable primer coat and two coats of first quality paint of approved colour. The supplier shall also supply adequate quantities of paints, varnish etc. for use of finished cost and for use of patching up any scratches received during transport, handling erection inspection and activation. Instead of above proper powder coating after proper pre-treatment is acceptable.

7.12.12. Annunciation System

Alarm annunciation network shall be supplied in the control board by means of visual and audible alarm to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. All the Essential trips Alarms shall be available on Panel annunciation window.

7.12.13. Type Tests and Routine Tests

Type tests shall comprise of the tests listed below as a minimum.

1. Short time current withstand and peak current withstand test.
2. Single phase short circuit test
3. Temperature rise test
4. Impulse test
5. Internal arc test for the specified short circuit rating
6. Degree of protection

7. Routine tests shall comprise of following as minimum.
8. Design and Visual checks: designation of panels and apparatus rating plates, component verification, etc.
9. Power frequency voltage test
10. Partial discharge test
11. Insulation resistance test
12. High voltage of auxiliary circuit
13. High voltage of main circuit
14. Contact resistance measurement.
15. Interchangeability test on breaker
16. Measurement of resistance of the main circuit
17. Dielectric strength
18. Electrical function test: dielectric strength of auxiliary devices, Verification of correct wiring, test of auxiliary device, Protection operation by primary injection of current and voltage, Verification of availability and correct operation of all protection and control functions of all protection relays and control circuits.
19. Mechanical operation test: Operational (electrical and mechanical) tests on all components
20. Painting thickness test
21. Test on earthing truck including interlock.
22. Torque tightening method for bolted connection.

7.12.14. Packing and Storage

Preparation of shipment shall be made after all inspection and inspection of apparatus has been accomplished and apparatus has been released for shipping by the Buyer.

Switchboard shall be shipped in sections to suit ease of handling for transportation and setup.

Each shipping section shall be supplied with supports in the form of suitable steel sections, lifting eyes etc. to maintain alignment of parts during shipping, handling, hoisting and setup. Location of lifting points shall be clearly marked on shipping containers and on drawings. Each shipping section shall have its weight and centre of gravity clearly marked on the container.

7.13. LIGHTING

Contractor shall provide and install area lighting to the site including luminaries, supporting masts/towers, columns, brackets, cable support systems and control apparatus, control gear/apparatus enclosures, lamps and miscellaneous components to completely assembled the lighting schemes for the Outer Harbour and outer areas as described herein

The area lighting and associated apparatus shall be designed in detail, manufactured, supplied, delivered, installed, tested, commissioned and set to work as described herein.

Lighting to the various areas of the Outer Harbour shall be supplied by a combination of luminaries mounted on high mast, columns, buildings structures located at the Harbour area.

It is of considerable importance to the Employer that the lighting of the Harbour areas is carried out in an effective manner. Only LED lights shall be used for lighting. A high-quality lighting setup is required to serve the area and the following objectives are of significance:

- Provision of the minimum adequate levels of artificial lighting commensurate with safe and efficient working and compliance with the Employer's obligations
- Achievement of good uniformity levels of illumination across the areas are served.
- Minimum practicable energy consumption commensurate with the achievement of the remaining objectives given in this Employer's Requirements.
- Minimization, or elimination so far as is practicable, of glare generally and as experienced by personnel working within the area.
- The final location may vary based on site requirement.
- Contractor shall further develop the area lighting engineering to suit the operational criteria of the Harbour areas including jetties and buildings outer areas. Contractor shall specifically consider the height of the cranes.
- The area lighting shall be designed to illuminate all areas of the Jetties and building outer areas of harbour.
- Lighting engineering shall be as per Lux levels specified in IS 3646 for interior illumination and for industrial setup IS 6665.
- Buildings shall be supplied with external area lighting fixed to the building and shall not be taken account off in any area lighting calculations.

7.13.1. High Mast Lighting System and Equipment

The mast shaft shall be manufactured from high tensile steel plates confirming to BS EN 10025. Each mast shaft section shall have only one longitudinal weld and without any circumferential weld joint. Sections with more than one longitudinal weld shall not be accepted. The mast base flange shall be free from any lamination or incursion and supplied with supplementary gussets between the boltholes to ensure elimination of helical stress concentration. The welded connection of base flange shall be fully developed to the strength of the entire section. The dimensions including thickness of mast shall be decided based on engineering calculations, which is to be submitted for approval.

A door reinforced with welded steel section, vandal resistant, weatherproof with Allen bolts and pad locking facility of dimension of suitable size shall be supplied at a suitable height from the base of mast to provide clear access to base compartment apparatus winch, motor, cable, connector etc.

For the environmental protection of the mast from salt laden and corrosive atmosphere the mast and accessories shall be hot dip galvanized, internally and externally after fabrication

as per BS EN ISO 1461, the entire fabricated mast shall be hot dip galvanized internally and externally in single dip having a uniform average thickness.

These High masts are envisaged for Jetty and outer area. The work includes supply, Installation, inspection and activation of 35 meter mast shaft in two sections suitable for 50 m/sec wind speed, with raising lowering network comprising, head frame, luminaries carriage suitable to install luminaries as per schedule of price in asymmetrical arrangement, drum winch, Min 6mm diameter stainless steel wire rope, trailing cable, connector, all wiring materials from feeder pillar to high mast, integral power tool motor, manual handle, junction box, lightening finial, foundation bolts manufactured from special steel along with nuts, washers, anchor plate and common template, equivalent to 500 W and 1000W LED Flood Light, LED type dual dome aviation lamp, outdoor stand mounted feeder pillar, 32A MCB incomer, single dial time switch, Min 25A TP contactor for the automatic switching of luminaries, power tool control with 2 no Min 9A contactors and raise lower push button, Wiring of luminaires with all wiring materials lugs, MCB, Installation of the mast feeder pillar by grouting the stand in concrete. The material of construction shall be S 355 grade as per BS-EN10025. The completely assembled engineering of the mast and associated foundation shall be such that mast is structurally and mechanically safe. Structural Design calculation for mast shall be submitted prior to manufacturing.

The electrical connections from base compartment to the junction box on the lantern carriage shall be made through special multicore trailing cable of minimum size 4 sq.mm copper conductor, EPR/PCP cable. Trailing cable shall be terminated for easy disconnection at the base compartment. The cable for connection to flood lighting fixtures /aviation lighting fixtures from junction box supplied on lantern carriage shall be through 3C x 2.5 sq.mm copper conductor, PVC insulated, armoured and overall PVC sheathed cable. The trailing cable at the lantern carriage shall be taken in flexible metal conduit. The suspension network shall essentially be without any intermediate joint and shall consist of only non- corrodible stainless steel of AISI 316 or better grade. Certificates shall be submitted in this regard. The stainless-steel wire ropes shall be of suitable size, the central core being of the same material. The overall diameter of the rope shall not be less than 6 mm and the same shall be determined by calculations and based on safety factors as per statutory criteria. The thimbles shall be secured on ropes by compression splices with twist &tie. Two continuous lengths of stainless-steel wire ropes shall be used in the network and no intermediate joints are acceptable in view of the required safety. No intermediate joints / terminations, either bolted or else, shall be supplied on the wire ropes between winch and lantern carriage.

7.13.2. Street Lighting Poles

The work includes supply, Installation, inspection and activation of 8m Octagonal pole sheet thickness min 3mm or as per engineering whichever is higher, including foundation and foundation bolts, MCB, connectors, etc. and 150W LED Street light of model equivalent to Bajaj Make BENP 11SL 150W LED. Contractor shall develop a network for automatic switching ON/OFF of these lights. The locations and number of street light poles shown are

indicative only and final location shall suit with site criteria. Refer particulars indicated in schedule of price.

7.13.3. Internal Building Lighting – General

All the buildings shall be well illuminated by using LED lights and minimum lux levels to be achieved as per IS standard for internal illumination.

Concealed conduits shall be supplied by using PVC conduits inside the buildings to route the lighting wires and cables.

The lighting network includes 100% Normal AC lighting. Normal AC Lighting shall be energized from 3-phase, 4- wire, 415 V distribution board. During Electricity Board power supply failure, it will take 15-30 seconds to change over to Generator power supply and vice versa, considering the above it is proposed to provide UPS back up for essential lighting (Emergency lighting) in all the areas and essential apparatus load such as server, Gates, Computer points etc. Illumination levels proposed at various places are listed below: Limiting values of glare index to be ensured as per area / location. Further engineering should ensure uniform lighting with no dark-spots and proper selection of fitting height etc.

Manufacturer shall give warranty for at least 5 years the apparatus with lifetime support of spares and accessories.

7.14. MAIN POWER AND SMALL POWER DISTRIBUTION BOARDS

Main Power and Small Power Distribution Boards shall have minimum life of 25 years.

Standard to be followed: IS 732- Electrical Wiring Installations

Contractor shall engineer in detail, supply and install Sub-Main Distribution Boards (SMDB"s) throughout the Substations for jetty areas to serve low voltage power using apparatus. These are fed directly from substation LT switchgear and are typically rated at 400A, 630A, 800A, 1250A, etc. (Refer single line diagram), switchgear shall be fully rated at 50oC.Refer single line diagram for details.

KA rating of ACBs and MCCBs shall be as per Single line diagram.

Where IP54 ingress protection is required (within industrial and facilities buildings etc.), enclosures shall be specifically designed and manufactured / assembled to achieve this level of protection completely assembled.

SMDBs shall be supplied completely assembled with top / bottom / side cable extension boxes as required to enable termination and connection of incoming and outgoing cables as required, extension boxes shall be supplied as required to accommodate meters, selector switches and associated current transformers etc. However, in the case of SMDB -01 separate cable chambers shall be used for lower and upper tier switchgear and shall be of two-tier construction. Cable termination spaces shall be available for spare feeders also.

SMDB"s shall incorporate incoming switch-disconnectors (if indicated in single line diagram) (with facility for locking off) for isolation and maintenance and shall afford protection against direct contact to IP2X and shall be type tested to Form 3b.

Steel Construction, busbar rating of switchboards, panel fabricators criteria &inspection of switchboards etc. required under this section is same that of main LT switchboards. Contractor shall provide all secondary support steelwork and framework / fixings to ensure that SMDB"s are solid and stable.

Any control transformer required for protection, indication and measurement shall be supplied.

7.15. CABLES

The following power cables shall be used:

- IS 7098 (Part I) : XLPE insulated FRLS PVC sheathed cables for working tensions up to and including 1100V.
- Conductor type: stranded copper and aluminium conductor (as per specification)
- Insulation: XLPE insulated, PVC sheathed, armoured and overall FRLS PVC sheathed, strictly as per IS: 7098 (Part I & II) amended up to date
- Resistant to water ingress and low halogen
- Armour: Galvanized Steel Flat Strip Armoured (2XFY, for Copper and A2XFY for Aluminium).
- Power cables for use on 415 V network shall be of 1100-volt grade, aluminium/copper conductor, XLPE insulated, extruded PVC inner sheathed, extruded FRLS PVC outer sheathed, GI flat strip armoured cables suitable for solidly grounded network, strictly as per IS: 7098 (Part I & II) amended up to date. Colour of the outer sheath shall be Black.
- The engineering and construction of 1.1kV XLPE Cable shall be of Cable Code A2XFY-2XFY.
- Cable sizes: 2.5, 4, 6, 10, 16, 25, 35, 50, 70, 95, 120, 150, 185, 240, 300, 400 sq. mm
- Cable life shall be minimum 25 years.
- The conductors shall be electrolytic grade high conductivity annealed Copper or electrolytic grade Aluminium as per specification elsewhere.
- IS: 7098 (Part II) - XLPE insulated FRLS PVC sheathed cables for working tensions from 3.3kV up to and including 33kV.
- Conductor type: 6600V and 22000V Stranded Compacted circular shaped Aluminium Conductor
- Insulation: XLPE Insulated Aluminium Conductor and confirming to IS 7098 Part 2 amended up to date. The engineering and construction of 6.6kV and 22kV XLPE Cable shall be of Cable Code A2XFY.The conductors shall be screened by extruded

compound and XLPE insulated. The cores shall be screened by extruded semi-conducting compound in combination with non- metallic tape. The inner sheath over laid up cores and outer sheath over the Armour shall be extruded black FRLS PVC compound type ST-2. The inner and outer sheath should be separated by armouring.

- Resistant to water ingress and low halogen
- Armour: Multi core cables shall be with armouring of galvanized flat steel strip.
- Cable sizes: 70, 95, 120, 185, 240, 300, 400sq. mm.

Approval to be obtained from Central Electricity Authority prior to starting procurement of cables and the same shall be informed to the Engineer and Employer. The cable proposed is fire retardant, low smoke, low halogen type with additional criteria as per specification above.

The cable sizing mentioned in the single line diagram and cable schedule are minimum size to be followed and the contractor shall confirm the same, additional criteria, if any, shall be incorporated. However, in the case of cables feeding power to mechanical machineries and pumps, the cable sizes shall be recalculated based on KW rating of apparatus selected and number of cores shall be increased, if found essential.in consultation with Engineer. In case of and discrepancy between cable sizes between cable schedule and single line diagram, the former would prevail.

Contractor shall engineer in detail, manufacture, supply, deliver, install, test, commission and set to work the cabling network associated with the power distribution (HT&LT), motor starting apparatus (MCCs) herein in order to provide a fully functional engineering.

The cable engineering shall be verified by inspection on site. The test results shall be recorded. The cables shall be identified in line with IEC 62491 Labelling of Cables and Cores.

All LT power and control cables, termination shall be with heavy duty tinned copper lugs only. Contractor shall consult available information and where essential shall liaise other apparatus suppliers to ensure that the correct cables and cable gland types are specified. Contractor shall drill holes for fixing glands wherever essential. Cable gland shall be earthed as a part of cabling.

Contractor shall identify where local junction boxes are required to connect the signals of local actuators and instruments; however, the use of junction boxes shall be kept to a minimum as direct cabling is preferred. The junction boxes shall be designed, supplied and installed. Terminal connection detail drawings shall be supplied for all local junction boxes. All junction boxes shall be labelled.

The engineering in detail, manufacture, setup, inspection and inspection of the cabling network shall comply with relevant Indian technical standards.

Ambient temperatures upon which cable ratings are specified shall be appropriate for setup in India.

IS: 1255 should be followed for Installation & Maintenance of Power Cables

Contractor shall provide the completely assembled cabling setup to provide fully functional systems as per specification herein.

Cable installations shall be coordinated with the pipe work and other installations forming the completely assembled works.

The setup of the cabling shall be coordinated for building services installations with respect to the following: -

Routing and fixing of cables to maintain segregation, clearance distances for differing voltage groups, prevention of mutual detrimental influence etc.

Provision of fire-stop cable transits and penetration sealing facilities generally.

Cables should not be fixed directly to internal walls but should mounted on cable ladder/tray or be enclosed within trunking or conduit systems as per specification. Cables shall not be bent to a radius smaller than that recommended in the relevant standard or as recommended by the manufacturer. If the figures are at variance the greater radius shall apply.

Protection against mechanical damage shall be supplied as appropriate. Particular attention shall be given to: -

- Cables rising from ground or floor level.
- Cables passing through elements of structures.
- The used of plastic cable ties shall not be accepted as a method of securing the cables to cable trays. Thermoplastic cable cleats shall be used for securing cables to cable trays.
- Surface Cable Installations

All cables, run on the surface, shall be supported and fixed by proprietary cable cleats, and accessories. The use of plastic or stainless-steel cable ties shall not be accepted as a method of securing the cables to cable ladder/tray. All cable cleats and accessories shall be suitable for the environment and where appropriate resistant to sunlight and extremes of temperature. The spacing of supports shall satisfy the criteria of the relevant Standards and the cable manufacturer's recommendations.

The contractor shall produce a cable schedule for all the cables to be installed on site during detailed engineering as per specification.

All cables shall be identified with a permanent numbering tag fitted at each end of every cable. This tag shall bear the cable reference number allocated to the cable on the cable schedule at every 30m and at every exit and entry point is trunking etc. Cable tags shall be supplied on all cables at each end (just before entering the apparatus enclosure), on both sides of a wall or floor crossings, on each duct entry; cable pits and at every 30 meter in cable tray runs. Cable tag shall contain size, runs, material, voltage, cable type, and cable

origin and cable destination. Cable identification is also required where number of cables enter together at gland plate.

Each end of the cable shall be identified using a trifoliate label. Lettering shall be coloured as above, and character height shall be no less than 4 mm.

Cable labelling shall be “Critchley type K” type, or equivalent, fitted to the cable by means of 2 of stainless-Steel core tie wraps. Critchley labels are to be supplied at twenty-meter intervals and either side of penetrations, cable chambers etc.

All as built drawings shall indicate the cable and cable core identification.

Cable Glands and Terminations

Standards to be followed: IS 2943- Brass Glands for PVC Cables

All cables shall be terminated onto apparatus by the use of glands, cable boxes, heat shrinkable encapsulations or other suitable terminations as per specification. All XLPE power cable up to 1.1 kV grade, shall be terminated at the panels/junction boxes etc. by means of suitable size double compression type heavy duty brass cable glands Armour of cable shall be connected to earth point. Heavy duty tinned copper lugs shall be used for termination in all the cases. Contractor shall drill holes for fixing glands wherever essential. Cable gland shall be earthed as a part of glanding using suitable Cu bare conductor and no additional payment is eligible in this regard. All metallic cable glands shall be earthed to the nearest earth conductor using 10SWG Cu in the case of LT and 25 x 3 Cu strip in the case of HT as a part of cable termination. Un-armoured cables shall be terminated with double compression polyamide, IP65, if specifically insisted by Engineer.

Cable Trays

Standards to be followed: IS 1255- Code of Practice for Installation & Maintenance of Power Cables.

Cable support systems shall generally comprise proprietary systems of trays, ladders, brackets, fittings and fixing components as required to suit the cable installations.

Cable support network major components where in exposed positions on Jetty for example, shall be manufactured from the following material: Material of cable trays shall be Hot dip galvanized type.

Cable support network in buildings shall be manufactured from G.I material. Mechanical protection is required for HT cable tray within the tunnel.

Materials generally shall be unaffected by exposure to ultra-violet radiation, water weathering and shall be suitable for setup and use, without deterioration, in temperatures from -5ºC to +50ºC.

Cable support systems shall have adequate mechanical strength for the load to be carried and shall have provision for the addition of a minimum of 25% of the initial installed cable load.

The engineering of cable support network installations external to buildings and generally exposed to prevailing weather conditions shall take account of structural loading arising from wind in addition to the effects of initial and future cables.

Earth continuity shall be reliably maintained throughout all cable support systems made of conductive materials.

All runs of cable support systems shall be continuous and shall be constructed of bends, tees and other purpose made fittings. Fixings and connections of network components shall be made using purpose made devices or those recommended by the manufacturer of the support network. All fixings and connecting devices shall be of non-corrodible standards similar to the network major components. Care shall be taken to ensure that fixing bolts, screws and similar do not introduce the possibility of damage to cable, either during or after their setup.

Contractor shall engineer in detail and provide all power distribution cables and associated terminations and support systems to completely assembled the installations specified herein. Contractor shall engineer in detail and provide all cable ducts, holes, etc. essential to ensure that cables are not fixed in exposed positions on working surfaces of structures.

Cable trays shall be prefabricated perforated and ladder types and associated accessories such as coupler plates, tees, elbow etc. fabricated from 14SWG (2.0 mm thick) steel sheet and then hot dip galvanized. Side flanges shall be as per schedule of price. All the cable trays shall be hot dip galvanized after fabrication and galvanizing thickness shall be minimum 70-micron thickness and average thickness 86 micron after fabrication.

All the HT cable trays within the tunnel shall be supplied with covers. Cable tray covers shall be fabricated from 14 gauge perforated (2.0 mm thick) MS sheet and then hot dip galvanized with Min. 70-micron thickness, average thickness 86 micron.

Cable trays shall be in standard length of 2500 mm and clear inside width of trays shall be as per schedule of price. Only Prefabricated bends, joints and reducers shall be used. The quoted price of trays shall be inclusive of these accessories and measurement is for running meter including bends, joints, etc. Any modifications, drilling, cutting, welding of GI tray at site is not allowed and same will be rejected. Any cost for addition and rectification, replacement shall be paid by contractor himself. Two lengths of Cable trays shall be fixed with twin coupler plates (inner & outer) at each joint. Erection with just one coupler plate shall result in rejection of the entire setup. Hardware (esp. bolts) for Joining of two lengths of cable trays shall be installed such that, not to damage the cables under any condition.

Earth continuity shall be maintained for cable trays. All cable trays shall be regularly earthed at every 10 meters. Intervals. The contractor shall engineer the earthing scheme of cable trays during detailed engineering utilizing available earth strips in tunnel.

GA drawings of cable trays showing supporting network, number of cables, earthing arrangement, etc. shall be prepared and submitted for approval.

All GI trays shall be tested at factory before dispatch. Specimen test, its costs of test at factory and controlled dispatch procedure is included in extent of contractor. All required tests shall be in accordance with IS 2629.

8. FIREFIGHTING

The system envisaged for firefighting purpose at port is a Single Hydrant service system. This system comprises of a network of above-ground piping throughout the port. For railway track & road crossings areas, the piping will be either buried with wrapping and coating or will be run through Hume pipes. Taping shall be considered in the hydrant header line for Sprinkler system. In order to meet the sprinkler system pressure requirement, booster pumps shall be considered near the port operational building and as well as in future area based on Hydraulic network requirement. For DG fuel station area extra 15m hydrant hose and hand appliances shall be considered. Hand Appliances selection basis and quantity shall be as per TAC recommendation.

For the proposed fire protection system, it is considered as ordinary Hazard with simple system of Hydrants at equal intervals of 45m and assuming that Mobile Fire Tenders (Tankers on Truck) will cater for peak demand. Capacity and number of Fire Protection System (FPS) Pump shall be decided w.r.to number of equivalent Single Hydrants and Water Monitors. Normally above Ground water storage is preferable with positive suction for FPS Pumps. But if U/G sumps are provided, then it is preferred to install the Pumps in Cellar with Positive suction.

The following are the specs for various components of the system

8.1. FIRE HYDRANTS

Each Hydrant Assembly shall conform to IS 5290. Landing Valve shall be double headed Stainless-Steel valve with 63 mm dia. outlets and 100 mm inlet conforming to IS 5290. Landing valve shall have flanged inlet and instantaneous female type outlets and mounted 1.0 to 1.2 m above the floor level. Instantaneous outlets for the hydrants shall be of standard pattern approved and suitable for 63 mm dia. fire brigade hoses.

Internal hydrants are provided to provide the dependable source of water to fire brigade for the firefighting works. The fire brigade will bring their hoses and nozzles in the enclosed area with them and hook up to the nearest hydrant of their choosing. The hydrants shall not be used by personnel for any reason. They are reserved for use by fire brigade only. If the hydrants were to be used it would trigger an alarm and the fire brigade would respond. Internal hydrants shall be installed inside the buildings in accordance with IS3844. Hydrants will be located near all exit doors. The branch lines shall be (down comers) shall be 100/150 mm in size and fire brigade connection shall be 63 mm.

External hydrants shall be located along the edge of the berth's backup area and the approach to the berth. External fire hydrants shall only be used by the fire brigade and not for the other industrial uses. Hydrants shall not be spaced further apart than 90 m (300 ft) or more than 45 m (150 ft) from dead end area as per NPFA 307. The external hydrants shall be marked to match the rest of the base's external hydrants for easy identification by the fire brigade as per IS13039. All hydrants shall be standpost type as per IS13039 All

hydrants shall be used for firefighting purpose only. If any hydrants are located near vehicular traffic they shall be protected on all sides from damage.

Each fire hydrant shall be provided with two numbers of 63 mm diameter, 15 m long, UL listed synthetic hose pipe with gun metal /with gun metal / with stainless steel male and female instantaneous type coupling, machine wound GI wire and SS branch pipe with nozzle.

8.2. HOSE CABINETS

Each hydrant shall be housed in a Hose cabinet of suitable size. The Hydrant Cabinet shall hold double headed hydrant, two numbers of 63 mm diameter, 15 m long, UL listed synthetic hose pipe with gun metal I with stainless steel male and female instantaneous type coupling, machine wound with GI wire and SS branch pipe with nozzle, set of extinguishers as required. The cabinet shall be of minimum 14 SWG thickness stainless steel grade 316 cabinets with spring lock or lever type lock, equipped with frangible type glass front panel (clear glass of 4-5 mm thickness) complete with lockable door. A metallic or plastic sticker shall be provided in the vicinity of each steel box for the purpose of breaking the glass front panel in case of emergency. The box shall have one coat of primer and two coats of finish paint, the finish shall be red. A common key shall be used for all the padlocks. Five sets of keys shall be provided.

Within the cabinet, the hose connection shall be located so that there are at least 2 in. (50mm) between any part of the cabinet, other than the door and the handle of the valve when the valve is in any position ranging from fully open to fully closed. The Cabinet shall be used for fire equipment only, and each cabinet shall be conspicuously identified.

The location and design of the extinguisher cabinets provided shall comply fully to the local fire authority requirements.

8.3. SPRINKLERS

Fire water sprinkler system shall be of the wet riser type. The buildings will be completely protected by an automatic wet pipe sprinkler system, except for areas with electric power distribution equipment.

The activation of any sprinkler head will initiate a fire alarm by a flow switch on the riser to each system. Sprinkler heads will activate individually only when activated by high temperature. The complete sprinkler installation shall comprise sprinkler control valve sets, sprinkler heads, pipework, pressure gauges, pressure switches, flow switches, sprinkler inlets etc.

The Control Valve shall be a double seated clapper type check valve.

The sprinkler control valve shall be mounted vertically, and the direction of water travel shall be indicated on the surface. It shall be rated to 12 Kg/cm^2 and tested to 25 Kg/cm^2 pressure.

A Bypass check valve shall be fitted to adjust minor and slow variations in water pressure for balancing to avoid any false alarm.

Each Control Valve shall have two sets of Pressure Gauges with ball valve type shut off.

A Water Motor Alarm shall also be provided. This shall be mechanically operated by discharge of water through an impeller. The drive bearing shall be weather resistant. A strainer shall be provided on water line before the nozzle.

Drainpipes connecting to the system shall be led to conspicuous positions as approved by the Engineer.

Sprinkler heads shall be of quartzoid bulb type with bulb, valve assembly, yoke, and the deflector. The sprinkler shall be of approved make and type with 15 mm nominal dia. outlets.

The bulb shall be made of corrosion-free material strong enough to withstand any water pressure likely to occur in the system. The bulb shall shatter when the temperature of the surrounding air reaches 68°C to 79°C. The temperature rating of the sprinkler head shall not less than 30°C above the highest expected temperature of the room and/or space.

The sprinkler shall be approved by UL/FM.

The metal parts of the quartzoid bulb sprinkler heads shall be chromium plated brass.

Upright sprinkler heads shall be similar to Pendent type in material construction and performance but designed to throw water Droplets upwards in umbrella fashion, to cool the underside of ceiling and extinguish any fire involving combustibles on the floor below.

Commissioning and testing of the sprinkler system will comply with NFPA guidelines

Concessionaire shall provide for Manual call points as per Code requirement whichever is stringent .

Portable skid for foam making branch shall be included in case of storage / bunkering of oil / fuels.

In the buildings and other structures, provision shall be made for hose reels at ease f access points.

All types of portable fire extinguishers and trolley mounted fire extinguishers shall be ensured.

8.4. PORTABLE FIRE EXTINGUISHERS

Portable fire extinguishers shall be installed in accordance with IS: 15683 and NFPA 10.

Portable fire extinguishers are to be used by personnel to try to control a fire until the fire brigade arrives on scene.

Two dry powder extinguishers of 6 kg each are required for every 200m2 of floor area, or within 15m travel distance whichever is less. Extinguishers are required for the enclosed

lower level of the jetty and the exterior top level of the jetty. The extinguishers shall be rated for ABC fires.

Each extinguisher shall have a tag or label securely attached that indicates the date of inspection and maintenance was performed and shall identify the person and organization performing the service. The same record tag or label shall indicate if recharging was also performed and when the next pressure test is to be conducted. The date of inspection and maintenance shall be within one month prior to the date of handing over.

Operating instructions in accordance with the local code shall be located in front of the extinguisher. The extinguishers shall not suffer from corrosion at the interface between the cylinder body and nozzle assembly due to galvanic action between dissimilar metals. The Contractor shall carry out the coordination in order to provide the right location of recess, access doors and signage for this purpose to the approval of the local fire authority. Where extinguishers are required to be installed exposed on the jetty deck (i.e., non-recessed), they shall be housed within stainless steel grade 316 cabinets.

The location and design of the extinguisher cabinets provided shall comply fully to the local fire authority requirements.

Extinguishers shall be conspicuously located in positions where they will be readily accessible and immediately available in the event of fire. Extinguishers shall be installed at a height of 1 meter above the floor level and shall be placed in a manner such that the extinguisher operating instructions face outward

8.5. ELECTRIC MOTOR

The motors should be of the squirrel cage induction type. They should be classified as IP-65, non-flameproof, ensuring protection against dust and water ingress. The motors shall be mounted using a flange configuration.

The power supply for the motors should be 415 volts, operating at a frequency of 50 Hz, and should have a three-phase connection. The motor power, enclosure rating, and voltage will be determined based on the vendor's specifications to suit the given operating conditions and flow rate.

The motor insulation class will be at least Class F temperature raised to Class B.

9. WATER SUPPLY

The Freshwater/potable water system is designed to meet the requirements for ship bunkering and various water requirements of buildings and make up to flushing. Toilets flushing water for the building areas shall be from the treated sewage water.

The freshwater system consists of raw water tank, raw water pumps, water treatment plant, potable water tank, potable water pumps to feed distribution network to buildings tie in and jetties cope points.

For meeting the requirements of buildings on shore and offshore, individual water tanks shall be provided on the terrace to have gravity flow for various water consumptions. The cumulative storage capacity of the same will be minimum one day's requirement of potable water demand for the buildings in their respective areas.

Requirement for landscaping and green areas is primarily met by reuse of treated water from the sewage system/ effluent treatment system.

Fresh water will also be used to cater to the demand for sprinkler system inside the service galleries, buildings and enclosed areas subjected to hazard. An automatic wet pipe sprinkler system shall be installed as per NFPA -13 and IS 15105. Sprinkler pumps to be provided to meet the requirement.