

**TENDER DOCUMENT**

**FOR**

**DEVELOPMENT OF SHIP DOCKING AND REPAIR**

**INFRASTRUCTURE IN PATHFINDER CREEK**

**AT VADINAR**

**VOL. I**

**SPECIFICATION FOR CIVIL AND MARINE WORKS**



**DEENDAYAL PORT AUTHORITY**


**ADMINISTRATIVE OFFICE BUILDING,**

**POST BOX NO.50, GANDHIDHAM (KUTCH)**


**GUJARAT – 370201.**

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## **1. GENERAL CONDITIONS RELATING TO SITE AND WORK**

### **1.1 Project Information**

Deendayal Port Authority (DPA) intends to develop a ship docking and repair infrastructure at Vadinar jointly with Cochin Shipyard Limited. The Ship Repair facility shall include two numbers of 300m length floating dry dock and one number of 150m length floating dry dock with necessary onshore facilities. The facilities shall include the following.

- Floating dry docks
  - 2 Nos of 300m x 55m x 15m x 12m
  - 1 No of 150m x 32m x 12m x 10m
- Floating dock berthing Jetties of
  - Outfitting jetty-1 (325m x 20m)
  - Outfitting jetty-2 (325m x 20m)
  - Outfitting jetty-3 (200m x 20m)
- Guide pin piles for Floating Dry Docks (6 x Nos)
- Berthing fenders and bollards for ships and crafts at Jetty
- Approach Trestle to land ~ 231.1m
- Crane rails for ELTT cranes and end stoppers.
- Electrical Power Supply including substation facilities.
- Cable trenches including cable reaving slots.
- Desalination plant and Potable Water supply facilities
- Firefighting water pump house and facilities
- Navigational Aids


In the view of above, Deendayal Port Authority (DPA) appointed Department of Ocean Engineering, IIT Madras to prepare design and detail for the offshore facility.

### **1.2 Contractor's Responsibility**

The information supplied hereinafter and provided elsewhere is given in good faith, but the Contractor shall satisfy himself regarding the weather, wind, waves, tides, currents, geological ground and other conditions and no claim will be entertained due to inadequacy or any error in the information provided.

### **1.3 The Site**

Vadinar proposed jetty is located at the west coast of India, in the state of Gujarat. Vadinar is a natural harbour located path finder creek at the mouth of Gulf of Kutch. The proposed jetty for the Floating dry dock project is located south of existing Nayara Oil terming Jetty and close the existing berthing jetty for berthing small crafts belonging to DPA.

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#### **1.4 Safety of Adjacent Structures to Works**

In pursuance of the conditions of contract the contractor or his representative shall provide and erect to the approval of the Employer's Engineer such supports as may be required to protect efficiently all structures or works in the vicinity of working area or otherwise take such permanent measures to protect the structures or works. Any damage to the structures shall be made good by the contractor without delay as directed by the Employer's Engineer at his cost.


#### **1.5 Use of local labourers**

- 1.5.1 The contractors shall preferably engage only local labourers available for unskilled work.
- 1.5.2 The contractor shall make his own arrangement to obtain immigration, or any other approval required for his expatriate personnel. A fresh domicile certificate of individual issued from the concerned district authority with photograph affixed on to be produced on arrival at worksite for verification of his character and antecedents from the concerned police station.
- 1.5.3 The contractor shall submit the names of the workers employed by him to the Employer's Engineer. No workers, employees of Government department shall be employed by the contractor without production of discharge certificate from the department concerned.
- 1.5.4 The contractor shall make his own arrangement for the transportation of HSD, Petrol, etc. required for this project.

#### **1.6 Shipment and Landing Charges Customs Duty Etc.,**

The contractor shall bear all expenses in connection with the shipment and landing of any plant, materials or other things imported or brought for the purpose of the contract. The rates quoted by the contractor shall also include the cost of customs duties, royalty charges, Excise duty, Sales Tax, import duties, Tolls, Quarry fees, etc. on any plant, materials or things imported into by him for the contract whether for permanent or temporary works. No claims will be entertained on this account.

The contractor may be allowed to use the area of 12,000 Sq.m for casting yard/storage yard will be provided free of cost at Prince's Dock, Haji Bunder and Mallet Bunder including waterfront there at. However, the water conveyance charges for barges etc. shall be paid to the port. The contractors shall be allowed to anchor their floating vessels in the vicinity of the site free of charge. However, they shall intimate the DPA VTS and seek approval of the Marine Department in this regard.

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## **1.7 Unauthorized Persons**

No unauthorized persons will be allowed at the site. The contractor shall take steps to prevent trespass and prevent unauthorized persons from entering and / or being on the site. All the personnel will be required to wear their security passes as per the requirements of local / defence authorities. Access shall be limited to the area they are working in and allowed by local / defence authorities. Such passes shall be arranged sufficiently in advance both for men as well as vehicles and shall be renewed as and when required. Non-availability of passes or personnel to carry out the job within the stipulated time shall not be considered as a plea for extension of time or extra cost.

## **1.8 Fire Fighting Arrangements**

The contractor may be subjected to periodic fire prevention inspections by local fire prevention authorities. Deficiencies or unsafe conditions shall be corrected at the cost of the contractor and the approval of the Employer's Engineer and the DPA Fire Department.


These fire prevention inspections will include but are not limited to the following:

- i) Proper handling, storage and disposal of combustible materials, liquids and waste.
- ii) Work operations, which can create fire hazards.
- iii) Access to firefighting equipment.
- iv) Type, size, number and location of fire extinguishers or other firefighting equipment.
- v) Inspection and maintenance of records for extinguishers.
- vi) Type, number and location of containers for the removal of surplus materials and rubbish.
- vii) General housekeeping.

While carrying out alteration works inside the DPA area, the contractor shall isolate the zone under his occupation in consultation with the Fire Department. Smoke from welding etc., should be kept to a minimum to ensure that false alarms are not raised.

## **1.9 First Aid Facilities**

The contractor shall provide and maintain upon the work sufficient proper and efficient lifesaving appliances and first aid equipment to the approval of the Employer's Engineer and in accordance with the requirements of International Labour Organisation (I.L.O.) Convention No.62. The appliances and equipment shall be available for use at all times. For work carried out within the site area or in the vicinity of any wharf or quay, the contractor shall abide by all the provisions of the site Workers (Safety, Health and Welfare) Scheme, 1961. The contractor's particular attention is drawn to the above said Regulation in respect of

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erection and maintenance of staging. The contractor shall indemnify the DPA from the cases booked by the Labour Enforcement Officer (L.E.O.) for his (contractor's) negligence.

The contractor shall, at his own expense, provide adequate First aid services on the site including trained first aid staff during all working hours. The contractor shall also make necessary arrangements with a local hospital and with doctors so that his sick or injured persons may receive the best available medical treatment with a minimum billing at any hour of the day or night. For this purpose, he shall provide a suitably equipped ambulance.

### **1.10 Communication**

Communications between parties which are referred to in the conditions are effective only when in writing or online mode. A notice shall be effective only when it is delivered (in terms of Indian Contract Act 1872).

### **1.11 Site Register**

For the purpose of quick communication between the Employer's Engineer and the contractor, site register shall be maintained at site in the manner as described below:

Any communication relating to the works may be conveyed through records in the Site Registers, such as communication from one party to the other shall be deemed to have been adequately served General Conditions of Contract. Each Site register shall have machine numbered pages in triplicate and shall be carefully maintained and preserved by the contractor and shall be kept in the office of the Employer's Engineer. Any instruction or order which the Employer's Engineer may like to issue to the contractor may be recorded by him in the Site Register and two copies thereof taken by him for his record.

### **1.12 Construction Records**


#### **1.12.1 Daily Progress reports**

The Contractor shall record; submit to the Employer's Engineer daily, progress report for the preceding day showing up to date progress and progress during the previous day on all items of each section of the works in relation to and in consideration of the detailed CPM schedule. In addition, the Contractor shall submit on the second day of every fortnight a detailed progress report giving the progress of the works during the preceding fortnight and also indicating the up-to-date progress of the work.

#### **1.12.2 Progress Photographs**

The Contractor shall submit (two copies one each for Employer's Engineer/ Employer) at monthly intervals or as otherwise directed sufficient numbers of progress photographs in



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colour with printed date taken, to cover all areas and stages of the Works spread over in previous month. The photographs shall be half plate size and shall be mounted in albums and suitably inscribed. Wherever necessary the Employer's Engineer or his Representative shall indicate the subject matter of the photographs.

The Employer's Engineer shall select the required important photographs from those received each month for inclusion in the progress report to be submitted to the Employer. The Contractor shall supply six 200x250mm size prints of each selected photograph suitably mounted, labeled and suitable for incorporation in the report. Alternately digital photos also may be supplied by Contractor. The cost of albums, developing to the required sizes etc. shall be deemed to be included in the rates quoted in the tender.

#### 1.12.3 Digital Films

The Contractor shall make Digital films of the works as it progresses. The duration of such digital films shall be about three hours. At the end of the Contract, the film shall be edited to make a digital recording with adequate commentary and sound effects of approximately three-hour duration. Two copies of the film in VCD/DVD form shall be handed over to the Employer's Engineer and Employer at the completion of the Works. All charges for making and editing such a video film shall be deemed to be included in the rates and prices quoted by the Contractor and shall not be paid separately.

#### 1.12.4 Submission of Information and Records


All reports, statements, returns, drawings, diagrams, programs, etc., which the Contractor shall be required to submit during the progress of the Works to the Employer's Engineer or his Representative are to be furnished in triplicate unless otherwise directed.

#### 1.12.5 As-Built Drawings

On completion of the Works the Contractor shall prepare and submit within 15 days a complete set of 'as-Built ' drawings in duplicate. The drawings shall give all the details showing the changes made with respect to the construction drawings (to be shown in cloud) in different colours / notations, the sections. Once approved by the Employer's Engineer the Contractor shall provide five sets of the drawings (hard copies) and two Auto-Cad (latest Version) copies of set-in soft form of 'as-made' drawing.

#### 1.12.6 Site Books

For the purpose of quick communication between the Employer's Engineer and the contractor, site books shall be maintained at site office /on dredger in the manner as described below:

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Any communication relating to the works may be conveyed through records in the Site Books, such as communication from one party to the other shall be deemed to have been adequately served. Each site book shall have machine numbered pages in triplicate and shall be carefully maintained and preserved by the contractor and shall be kept in the Office of the Employer's Engineer. Any instruction or order which the Employer's Engineer may like to issue to the Contractor may be recorded by him in the Site Book and two copies thereof taken by him for his record.

### **1.13 Temporary Access**

Access shall be provided to the site by the contractor, if necessary, from the nearby main road at no extra cost as directed by the Employer's Engineer or his representative. The contractor shall be responsible for proper maintenance of this access road and take all care to see that the existing services, if any, are maintained in working order.

The contractor shall provide temporary access / approach, if necessary, otherwise shall maintain the existing roads being used by him.

### **1.14 License and Permits**


The contractor shall make his own arrangements for obtaining all necessary licenses, permits etc., for his crafts and also for the procurement of any spares that he may require during the progress of the works. The contractor shall have an adequate supply of necessary spares from the very beginning to ensure that no serious delay or hold-up occurs in the execution of works.

### **1.15 Existing Services**

The contractor's attention is drawn to the possibility that there might be existing underground or overhead services & service line i.e., within the site of the proposed works. It is the contractor's responsibility to work cautiously and carefully so that these are not damaged. Any damage to the services shall be repaired and restored immediately as directed by the Employer's Engineer without any extra cost. The contractor is required to ascertain and allow in his cost for any rerouting of the services that may be necessary for the due execution of the contract and any claim resulting from his failure to do so will not be admitted.

### **1.16 Maintaining Utility and Services**

The contractor shall not damage, close or obstruct any utility areas, roads, traffic or other property until permits thereof have been obtained. If facilities are closed, obstructed, damaged or rendered unsafe by contractor's operation, the contractor shall, at his own cost,

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make such repairs and provide such temporary guards, lights and other signals or as necessary or required for safety and as will be acceptable to the Employer's Engineer and / or the Employer of the utility, highway, road or other property.

### **1.17 Facilities, Attendance Etc., on Nominated Sub - Contractors**

The contractor shall allow for the provision of facilities, attendance etc., for the nominated subcontractors.

These facilities, attendance etc., include:


- a) Storage facilities for plant and equipment and products and materials.
  - i) The contractor shall make his own arrangement for sanitary facilities for his employees and workmen engaged on this work by providing Sewage treatment Plant. Arrangements for storage of water should be made by the contractor at his own cost.
  - ii) The labourers engaged for the work should be provided with fuel by the contractor and cutting of trees shall not be permitted.
- b) Watching and lighting and protection of their work as necessary.
  - i) The contractor shall be responsible for the watch and ward and safety of the materials, Tools & Plant, Machineries. The contractor shall facilitate the inspection of cement going down by the Employer's Engineer at any time.

### **1.18 Limitation of Operations**

The contractor shall refrain from entering the area of the site not allocated to him unless he obtains the prior written approval of the Employer's Engineer and appropriate authorities. Should the contractor wish to make use of any adjoining or property of offices or halls, he shall first obtain the written clearance / consent of the Employer's Engineer and then shall apply to the appropriate authority for permission to use the area. If such permission is granted, the contractor may make use of the area thus permitted to use, but on completion shall clear away and make good any damage at his own expense and pay all costs and charges in connection therewith.

The contractor shall be solely responsible to obtain required permits / authorization from other agencies / Departments for the due performance of the contract and delay if any arising thereof shall not be quoted as reason for extension of time and consequent additional cost.

The Contractor has to comply with all operational procedures set forth by DPA Authorities as and when required at his own cost.

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### **1.19 Work Program for Areas with Restricted Access**

- i) The work to be carried out inside the DPA shall be programmed to ensure that the time period required to carry out all the activities is minimum. All advance preparations with regard to approvals, procurement of all materials, plant, personnel etc., shall be made to achieve the targets, this may call for working continuously or at unscheduled hours as directed and approved by the Employer's Engineer.
- ii) The contractor shall submit a detailed CPM / PERT chart showing detailed program and diagram in an approved form showing the estimated dates of commencement and completion of the various parts of the temporary and permanent works, including anticipated dates and arrangements for delivery, erection etc. of materials for the various sections of the works.
- iii) The sequence in which the work is to be carried out shall be as approved by the Employer's Engineer. A program of work is to be submitted to the Employer's Engineer for review and approval and this has to be periodically updated and modified as per actual progress of work to enable timely completion. The program should essentially show the key days for important operations and shall contain full and complete details. The contractor shall submit a progress report regularly for the period of working as per the format specified by the Employer's Engineer showing up to date progress of all the important activities.

### **1.20 Stoppage of Works**

Contractors may be instructed to stop the work from time to time due to security reasons, movement of ships or any other reasons as per the instruction of DPA Authorities.


### **1.21 Noises and Dust Control**

The contractor shall take all necessary precautions in reducing noise and dust caused by Plant to minimum acceptable level by means of mufflers, silencers, screens and the like.

### **1.22 Working Condition**

#### **1.22.1 Access to the Site**

The Proposed work site for "Ship docking and repair facility" is located in Pathfinder creek adjacent to the existing berthing jetty. The men and material for the project shall be brought from land by barges since the approach and limits posed by the traffic and capacity of the existing approach trestle.

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#### 1.22.2 Port Requirement

The existing berthing jetty operations will be continued throughout the progress of the works and the contractor shall carryout their works without any hindrance to the port activities.

The contractor shall obey orders and directions given by the Employer's Engineer or his authorized representative in the course of the discharge of his duties. The contractor shall cease work whenever and for as long as the Employer's Engineer may consider it essential to do so. It shall be noted that the contractor shall be given only time extension and shall not have any financial claims on account of the stoppage of work on such occasions.

#### 1.22.3 Provision of materials, stores, equipment, and craft

The contractor shall be responsible for the provision of all materials, stores, equipment and craft necessary for satisfactory execution and completion of the work.

#### 1.22.4 Wrecks and other obstructions

Unless the Employer's Engineer directs otherwise all wrecks and other objects encountered during the execution of work shall be lifted, removed and disposed of by the contractor.

#### 1.22.5 Interruptions of work and idle time charges

The contractor shall allow in his rates for any loss of working hours due to weather and shifting of plants and other equipment from one area to another area depending upon the traffic operations or for maintenance.

Any claim for idling of the contractor's plant and machinery or any other inputs shall not be entertained by the DPA for reasons whatsoever including non-availability of working area and therefore the contractor may consider all such events including the normal Port operations and submit their offer accordingly.

For the reasons stated or for any other reasons, no claim on idle time charges should be entertained by the Port.

#### 1.22.6 Clearance of site on completion

- i) After completion of the contract the contractor shall remove at his own cost all chains, wires and any other equipment, plant or materials introduced by him.
- ii) After the completion of the work, the contractor should clear all the residual materials belonging to the contractor within 15 days and prior to the final bill payment.

### 1.22.7 Environmental Considerations

The contractor shall refrain from using plants which make excessive noise, particularly during the hours of darkness, which shall be limited to 45db (A) at a distance of 100 m from the working area and other plants.

The information furnished hereinafter and provided elsewhere is given in good faith, but the Contractor shall satisfy himself regarding the weather, tides, etc., and no claim will be entertained due to any error in the information supplied.

## 1.23 Site Condition

### 1.23.1 Tidal Information

The tidal data with respect to chart datum for Vadinar site is summarized in Table 2.1. The tide at Vadinar is semidiurnal.

**Table 1.1 Tide Levels**

Description	Tidal levels (m) with respect to CD
Mean High Water Springs (MHWS)	+5.549
Mean Sea Level (MSL)	+3.159
Chart Datum	0.0
Lowest Low water	0.0
Mean Low Water Springs (MLWS)	+0.769

### 1.23.2 Wind


The average wind speed is 8 kmph during the period 2019-2021 and the maximum wind speeds are observed in the range of 30 - 34 kmph during the months of May and July for the years 2019-2021.

Coastal wind speed varies during the year. Design wind speed for Gujarat region specified in IS 875 for coastal region is 50 m/sec (50 years return period). However, as per OCIMF guidelines, the wind speed of 60 knots shall be used for the design of mooring system and associated structures. Hence the design wind speed used for vessels and crafts and Floating Dry dock shall be taken as per the wind speed summarised in table 1.2.

**Table 1.2 Wind Speed for mooring design**

Description	Moored Vessels and crafts (m/sec)	Floating Dry Dock (m/sec)
Wind Speed	30	50

**However, the structures shall be designed for the direct wind pressure due to storm wind speed of 50 m/sec.**

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### 1.23.3 Cyclones

These may occur in the period of May/June or October/November. The storms are mostly confined to the months of June and September, and the months of July and August are almost free of storms. The last severe cyclonic storm having winds of above 48 knots was experienced in 1982. Occasionally, sudden high winds also occur during the fine weather periods from NE.

### 1.23.4 Wave and Currents

Offshore waves are not expected to enter the pathfinder creek except for local wind generated waves.

The currents are of monsoon origin and flow predominantly north-westward in December and January and south westward for the rest of the year, rates up to 1.5 knots may be met during the SW monsoon and up to 1 knot at other times.

**The wave and current are negligible at the proposed jetty location. Hence, wave and current is not considered for structural design.**

### 1.23.5 Relative Humidity and Temperature

Regarding humidity and temperature may be obtained from the Meteorological Department. The temperature range between 16°C to 36°C the relative Humidity is about 80%.

### 1.23.6 Visibility

At Vadinar, throughout the year the visibility is good, as the fog is infrequent at the sea in all seasons. However, a minimum of 10 to 15 days can be considered as foggy days.

### 1.23.7 Rainfall

The rainfall in Gujarat is scanty and low. Most of the rainfall is received during the months of June- September (South- West Monsoon). The average number of rainy days during the period 2019-21 are 50 days.

### 1.23.8 Cyclones

These may occur in the period of May/June or October/November. The storms are mostly confined to the months of June and September, and the months of July and August are almost free of storms. The last severe cyclonic storm having winds of above 48 knots was

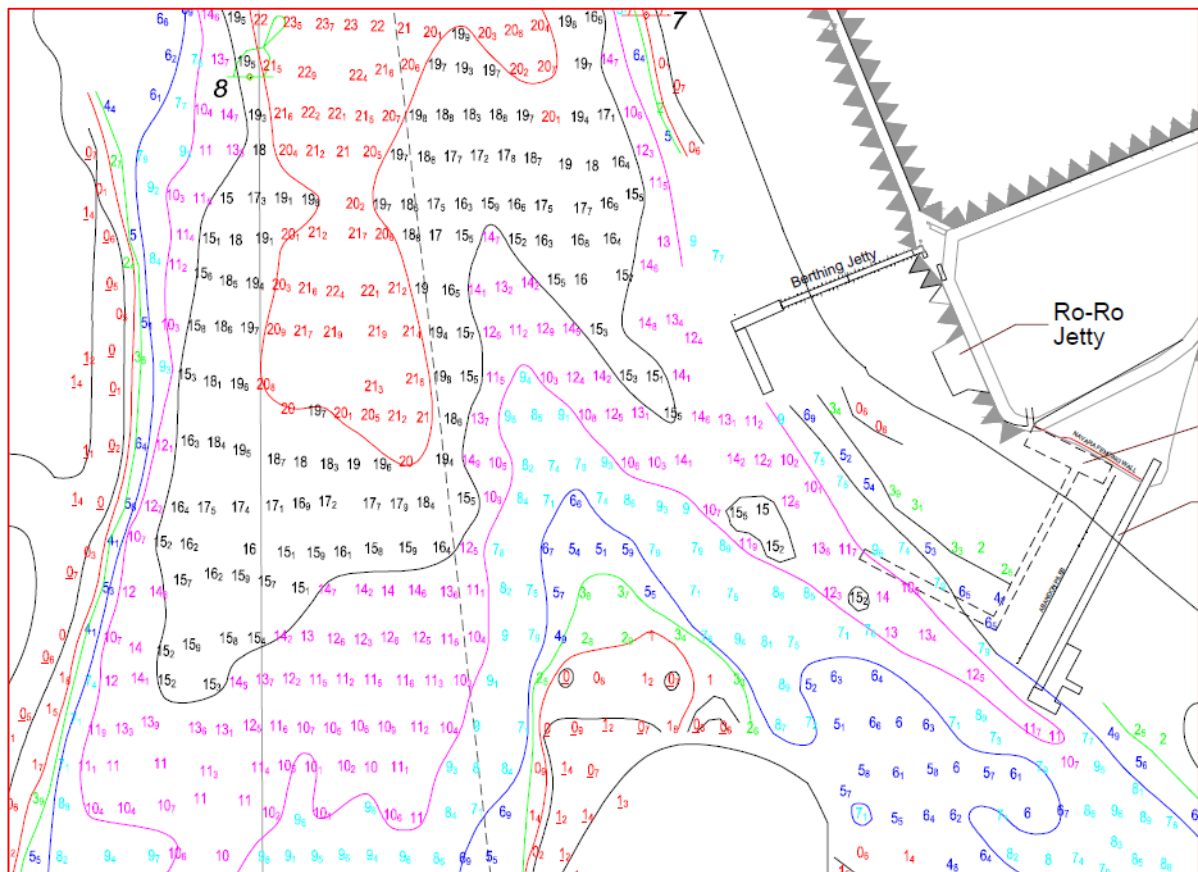


experienced in 1982. Occasionally, sudden high winds also occur during the fine weather periods from NE.

### 1.23.9 Bathymetry

The bathymetry at the existing Vadinar berthing jetty face is varying from -8m to -14m and the existing seabed level at the approach channel is varying from -14m to -22m with respect to chart datum. Bathymetry of the area is shown in figure 1.1. The bathymetry is extracted from a chart provided by DPA bearing No. H. S. 3719 and the survey was conducted between 14.12.2021 to 25.12.2021. Hence latest bathymetry shall be carried out prior to finalising the tender.

Topography survey details were not available for the proposed jetty landfall point location. Topography survey shall be conducted prior to finalising the tender.




**Figure 1.1 Bathymetry – Vadinar jetty location**

### 1.24 Temporary Works

The Contractor may, at his own expense, and subject to the approval of the Employer's Engineer and statutory authorities, construct offices, stores, workshop in the area allocated to



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him and remove the same as per the orders of the Employer's Engineer, on completion of the Contract. Whenever required the Contractor shall furnish such details of his temporary works as may be called for by the Employer's Engineer and the Contractor shall satisfy the Employer's Engineer as to their safety and efficiency.

The Employer's Engineer may direct those temporary works which he considers unsafe or inefficient to be removed and replaced in a satisfactory manner. The Contractor shall follow Employer's Engineer's directions/instructions, The Contractor shall maintain all the equipment and shall ensure that they are suitable for the work and maintained in such a manner to ensure their efficient working. The Employer's Engineer, may if he deems fit, direct the Contractor to remove from site any equipment which are not efficient and/or prejudicial to the quality of the work to be replaced by equipment to their satisfaction.

### **1.25 Contractor's working area**


The Employer's Engineer shall allow the Contractor to use of Port Land for the purpose of setting up of his Site Office, workshop, storage and fabrication area etc for a period not exceeding the duration of the project. An area up to maximum of **1.2 hectare** will be made available free of cost based on availability. However, no labour camp shall be permitted inside the harbour area of the Port for security reasons. This working area shall be available on an "as is where is" basis. Levelling, constructing approach roads, laying water and power lines, if required, shall be the responsibility of the Contractor.

The cost of all such works shall be deemed to have been included in the rates and prices quoted for the works and no extra payment shall be made on this account.

On completion of the Contract, Contractor shall remove all his temporary structures thereon from this area, level it and hand over the same back to the Employer in a neat and clean condition. Upon failure of the Contractor to comply with the same, the Employer shall get the work done at the cost of Contractor and debit the same from the Contractor's Final bill.

### **1.26 Returns of labour and equipment**

The Contractor shall supply to the Employer's Engineer or his Representative, by noon every working week, a return of the men employed the previous day and of the work on which they were engaged, specifying also the numbers employed in each trade. He shall also supply monthly any other return which may be required as to the number of men and construction equipment employed and the nature and quantity of the work done.

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### **1.27 Sanitary conveniences**

Sanitary conveniences for the use of persons employed on the Works shall be provided and maintained by the Contractor to the extent and in such a manner at all such places as shall be approved by the Employer's Engineer and the authority concerned, and all persons connected with the Works shall be obliged to use them exclusively. The Contractor shall make all temporary arrangements for the proper discharge of sewage and drainage from or in connection with the Works and shall maintain the same to the satisfaction of the Employer's Engineer and the authority concerned as long as they may be required.

### **1.28 Temporary fencing of contractor's area**

The Contractor shall at his own expense erect and maintain in good condition temporary fences and gates along the boundaries of the area free of any rental charges.

The Contractor shall except when authorized by the Employer's Engineer, confine his men, materials and plant within the Site of which he is given possession. The Contractor shall not use any part of the Site for purposes not connected with the works unless prior written consent of the Employer's Engineer has been obtained. Access shall be made to such areas only by way of approved gateways. The Contractor shall maintain sufficient watchmen at site to the satisfaction of the Employer's Engineer and shall provide lights at nighttime to the fencing provided for the area.

### **1.29 Supply of Materials by the Contractor**

It will be the responsibility of the Contractor to make timely procurement of all materials for both temporary and permanent works.


### **1.30 Taking over / handing over of the completed works**

All the work until handed over to the Employer's Engineer shall stand at the risk of the contractor who shall be responsible to make good at his own cost. Contractor shall hand over the work in good order and conditions and in conformity in every respect with the requirements of the contract.

### **1.31 Availability of infrastructural facilities:**

#### **1.31.1 Water Supply**

The Employer will not provide water for construction purposes. The Contractor is required to make his own arrangements for supply of water for construction purposes. The Extra Water Charges & Sewerage Charges levied, if any, by the Municipal Corporation for use of water

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for construction purposes shall be paid by the Contractor and it will be deemed to have been covered in the rates quoted in the tender.

The Contractor shall be allowed to make use of the existing water supply system of the Port for his offices, stores, workshop, staff & labour accommodation on payment of charges as per the tariff of the Port. However, the storage of the water supplied shall be the responsibility of the Contractor.

Contractor shall bear all the costs towards laying of any pipeline, providing storage tanks, pumps, water meters etc. to meet his requirements.

#### 1.31.2 Power Supply

Contractor shall be required to make its own arrangements for the provision of electric power from the available sources.

#### 1.31.3 Telecommunications

The Contractor shall make his own arrangements for suitable telephone/internet connections / wireless communication system for intercommunication between base office, dredging spread and transport barges.

In addition, the Contractor shall provide a radio room at Contractor's base office and adequate radio communication sets on the vessels, dredgers, survey and inspection boats, and shore control points. An adequate number of walkie-talkie sets are to be provided for key personnel to be contacted on VHF channel.

#### 1.31.4 Bunkering and Water Supply Services for Contractor's craft


The Contractor shall make his own arrangements for bunkering and water supply for all his craft.

#### 1.31.5 Welding or hot work

Welding/gas cutting/hot work near berths or any floating plant/vessels shall be done only with the prior permission of the DPA fire department and at such times and in locations as approved by him, subject to compliance with the conditions imposed.

### 1.32 Employment of Skilled Labour

During the execution of work the contractor shall employ only such persons who are careful, perfectly skilled and experienced in his field of work. The Employer's Engineer shall be at

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liberty to object and ask the contractor to remove from the work any person employed by the contractor for execution of work, in the opinion of Employer's Engineer, misconducts or he is found negligence in the proper performance of his duties as such persons shall not be again employed on the work without permission of Employer's Engineer.

### **1.33 Sub- Soil Conditions**

The data and findings from the sub-soil investigations carried out earlier for the Port Craft Jetty in 1990 by Kandla Port Trust and the Coast Guard Jetty in 2021 by M/s. Paresh Construction and Foundations Pvt. Ltd. is provided with the tender under **Volume IV – Geotechnical Investigation Reports**. There are no other records available for anticipated settlement of the loose bed materials. This information is for the guidance of the contractors and contractor have to carry out new bore hole investigations at the locations proposed in the tender drawings prior to commencement of works and shall be completed within three (03) months from the date of work order/ notice to proceed. The detailed specifications for conducting geotechnical investigation and proposed locations for the new boreholes to be considered for the geotechnical investigation are provided in Section 2 of this Specification.


### **1.34 Contractor to Submit Mooring Proposals**

The contractor shall submit, every week, to the Employer's Engineer a statement showing the proposals for mooring the floating crafts during the ensuing fortnight. The contractor shall also submit for approval to the Employer's Engineer his proposals for mooring his small craft and floating plant.

### **1.35 Navigable Channel to be Kept Free**

Throughout the period of the contract, the contractor shall ensure that the work is carried out without causing any obstruction or interference to the normal traffic in the approach channel and basin as specified elsewhere in the contract agreement. The contractor's craft and personnel shall at all times adhere to the established Rules of Port Authorities and comply with any directions in respect of navigation in the basin in waters that may be issued from time to time by the Employer's Engineer and Deputy Conservator. The contractor shall also conform in every way to the requirements in respect of making, lighting and watching and structure, craft or equipment employed in the execution of the contract.

The contractor shall seek permission from the Port Authorities for all his floating crafts plying in the execution of this contract and no floating craft which has not been so registered shall be allowed to be employed in the execution of this contract. No exemption whatsoever shall be granted in this regard.

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### **1.36 Survey and setting out.**

The contractor shall at his expense's carryout all the necessary surveys, measurements and setting out of the works and shall for this purpose engage qualified and competent surveyors whose names and qualifications shall be submitted to the Employer's Engineer for his approval.

The contractor shall provide for the purpose of checking the survey and setting out to the Employer's Engineer. All the assistance, which he may require, the Surveyor shall be selected having appropriate experience and as far as possible the same Surveyor shall be provide throughout the contract period.

Before commencing any work at any location, the contractor shall give the Employer's Engineer not less than two days' notice of this intention to set out or give levels for any part of the works in order that arrangements may be made for inspection.

The contractor shall provide for the use of the Employer's Engineer and his nominee all necessary survey instruments and other equipment and all technicians, labour and attendants which the Employer's Engineer or his nominee may require for checking the setting out and making of the works.

The contractor shall maintain in good working order at all times during the period of contract the instruments provided by him for the proper setting of the works.


The contractor shall make available, at his own expense, any poles, pegs, staging, templates or profiles required by the Employer's Engineer or his representative for inspection and / or measurements of the works.

### **1.37 Programme of work**

The Contractor shall submit to the Employer's Engineer within 14 days of the award of the Contract eight copies of detailed Construction Planning and Management (CPM) schedule showing in approved form the estimated dates of commencement and completion of the different parts of the works including expected dates for completion of the various sections of the works. In addition, eight copies of the bar chart derived from the CPM schedule shall also be submitted. The detailed CPM schedule shall be such as it can be updated quarterly or as directed by the Employer's Engineer and eight copies of the revised CPM schedule shall be supplied to the Employer's Engineer.

### **1.38 Standards - General Provision**

Unless otherwise specified in the Contract, the relevant provisions of the appropriate bureau of Indian Standards shall apply for all materials and workmanship. Where relevant BIS

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Standards do not exist, the latest version of the relevant British Standard Specification or Standard of the American Society for Testing Materials shall apply.

Equivalent standards from other countries may be used provided they are demonstrated to be equal to or more onerous than the standard quoted. In such a case, the standard shall be provided with an acceptable translation.

IS / BIS	:	Indian Standards
BSS	:	British Standard Specification
Cp	:	British Standard Code of Practice
ASTM	:	Standard of the American Society for Testing Materials

The goods or materials to be supplied by the contractor shall be of the quality or sort specified and, in every respect, equal and answerable to the pattern or samples submitted by him for approval of the Employer's Engineer or his nominee.

All materials used shall be new and no material shall be used on the work without the prior approval of the Employer's Engineer or his nominee.


The decision of the Employer's Engineer or his nominee regarding the quality of any materials used on the work will be final and binding on the contractor. He shall remove from the site of work any material rejected as unfit for use on the work at his own cost as soon as he is ordered to do so, failing which the Employer's Engineer or his nominee shall remove such materials from the site of work and shall deduct the cost incurred by such removal by the DPA from the site of work from any moneys due to the contractor.

### **1.39 Standard Products**

If specific mention of a brand or product is made in the Contract individual manufacturers, indicates that the standard or type and workmanship of goods, are satisfactory to the Employer's Engineer.

The Contractor may substitute similar Products of at least equal quality and suitability, subject to the approval of the Employer's Engineer provided that the Contractor has submitted with his Tender proposals for such substitution with full particulars of the proposed alternative products; otherwise, the Contractor's proposals may not be considered.

Proposals by the Contractor for the supply of manufactured products shall be accompanied by certification that the manufacture's products are approved by the relevant standards authority.

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#### **1.40 Test Certificates**

Where specified, each consignment of materials or products intended for use in the Permanent works shall be accompanied by a manufacturer's test certificate showing that it conforms in all respects to the appropriate standards and specifications.

If no such certificates are enclosed, the Employer's Engineer shall have the materials or products tested in any of the approved laboratories approved by ISI / PWD / Govt. approved Laboratory. The costs of such tests shall be borne by the Contractor.

#### **1.41 Works to be Kept Dry**

If certain parts of the Works or Temporary works are liable to flooding at any stage, the Contractor shall be responsible for preventing such flooding and for promptly rectifying any damage to the works or Temporary works so occasioned by flooding.

#### **1.42 Quality management / assurance**

The Contractor shall document and operate Quality Assurance System as approved by the Engineer/Employer.

In addition, the Contractor shall prepare a Quality Assurance Plan for the execution of the works. The plan shall be submitted within 21 days of receipt of the Letter of Acceptance. The Quality Assurance Plan shall be reviewed, updated and resubmitted for approval as necessary throughout the Contract period.


The Quality Assurance Plan shall specifically address:

- i. The procedures for maintaining the project quality requirements with respect to the use of subcontractors, vendors and suppliers.
- ii. The structure of all correspondence between the Contractor and the Engineer

The Contractor shall cooperate with the Employer's Engineer and provide all the necessary works and records to enable the Employer's Engineer to assess the Contractors quality plan and associated procedures.

The Contractor shall not commence works until he has submitted to the Employer's Engineer a written statement of his proposed procedure for his own inspections of the items, recording such inspection and obtaining the Engineer's written approval thereof. Every statement shall identify the individuals on the Contractor's or sub-contractor's staff who are responsible for inspection, the stages at which inspection and tests are to be made and the detailed aspects to be verified or measured in each inspection. Each inspection shall be recorded.



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The record shall identify the inspector, the place, the date and time when the inspection was completed, the section of the works inspected or part of the materials, and its state of completion. Reference shall be made to the relevant drawings and the specific aspects or properties which were checked or measured.

The record of inspection and tests shall be stored in an orderly fashion on the site by the Contractor until the issue of the Taking Over Certificate for whole of the works or such earlier times as Employer's Engineer may instruct, and Employer's Engineer shall have the right of access to them at all times.


After the issue of Taking Over Certificate for whole of the works or such earlier time as Employer's Engineer may instruct the Contractor to either dispose the records or deliver them as directed.

### **1.43 Environmental management plan for execution**

The Contractor shall prepare an execution plan of the EMP and submit it for the approval by Engineer/Employer within 3 weeks of the receipt of Letter of Acceptance. The execution of the Environmental Management Plan (EMP) shall meet the following requirements:

- (i) The contractor shall refrain from using plant which makes excessive noise, particularly during the hours of darkness, which shall be limited to 65db (A) at a distance of 100 m from the dredging and other plants.
- (ii) In addition, the contractor shall at his cost make necessary noise control measures.
- (iii) All works shall be undertaken in such a way as to ensure that these operations do not deteriorate the surface water quality, which must be maintained within the prescribed standards. Water quality parameters viz. turbidity, dissolved oxygen, ammoniacal nitrogen and other nutrients in water should be measured at regular intervals to monitor water quality.
- (iv) Monitoring of the water quality parameters in the dredge areas and in dumping locations on weekly basis or as determined by Engineer.
- (v) Suspended sediment concentrations in mg/l concurrently with current measurements at frequency of once in a week during dredging period or as determined by the Engineer. The water samples shall be collected at surface, mid depth and 1 m. above sea bed by adopting the standard methods of collection of water samples.
- (vi) Dissolved Oxygen measurements
- (vii) Toxicity test on dredge material to determine the quality of heavy metals in accordance with approval methods and standards.
- (viii) Spillage of any mineral oil products shall be prevented and immediately mitigated in the exceptional occurrence of the spillage. The Floating barges shall comply with MARPOL Regulations as regards on board oil spillage equipment.



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- (ix) The Contractor should take adequate anti-pollution measures and shall ensure that the dredging parameters are maintained well within the prescribed norms.
- (x) Maintain clean wharf to avoid garbage, leakage / spillage of dredged materials and other wastes.
- (xi) Maintain their project offices neat and tidy taking all precautions against land/ sea pollution.
- (xii) Setting up of Environment monitoring group.
- (xiii) Monitor various other parameters including land, air and water pollution in the working areas.

The EMP submitted by Contractor shall meet the stipulations as laid down by Ministry of Environment and Forests (MoEF), India.

The Contractor shall also abide by all the relevant environmental stipulations during the progress of the work.

The Contractor shall submit the test results regularly to the Employer/Employer's Engineer for information and approval.

As the execution plan of the EMP is a management tool for the Contractor's use, it shall present in detail how these measures shall be operated, the resources required and the schedule of implementation. This plan should contain sections dealing with the individual environmental aspects.


The Contractor shall respect and obey the restrictions and safety rules as applicable and as imposed by the authorities concerned.

The detailed outline of the proposed EMP for execution shall be submitted in Schedule-N of the Tender.

The EMP of the Contractor shall be monitored through reputed Environmental agency approved by Employer's Engineer/Employer and Contractor shall be responsible to adhere to and satisfy all the requirements related to EMP. The cost towards the EMP including monitoring through any approved reputed Environmental agency shall be borne by the Contractor.

On completion of the works, the Contractor shall demolish and remove from the Site all temporary structures leaving the area in clean and tidy condition to the approval of the Engineer/Employer.

No claim for extra payment or for extension of time in the removal of such items and the like will be entertained and the Contractor shall allow in his rates for all the cost of removing any

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items of the type or types listed above and the like which may be encountered in the course of the dredging which he is required to execute.

All oil and greasy wastes on board the “Contractor’s Equipment”, floating vessels, crafts, etc. shall be collected in containers and disposed away on land as directed by the Employer’s Engineer and shall not be let into the sea. Before starting the Work, a scheme shall be worked out in consultation with the Employer’s Engineer which will be acceptable to the Environmental Control Cell of DPA.

#### **1.44 Relocation of Navigational Buoys**

It is the responsibility of the Contractor to shift, place and reposition the existing navigational aids such as buoys laid for marking the Channel which are creating obstructions to the Contractor’s dredging activities as per the instructions of Engineer. The Contractor shall take utmost care and precaution in shifting and repositioning of the navigational buoys at no extra cost. Damages if any, during the course of repositioning shall be borne by the contractor.

#### **1.45 General – Survey**

The Contractor shall make suitable provisions for calibration of all survey equipment including the tide gauge whenever directed by the Engineer. Because of the extent of tidal range the Contractor shall place special stress on the accurate reduction of sounded depths. The survey launch, survey equipment, automated survey system software etc. require the approval of the Employer’s Engineer before being imported to Site. Software HYPACK/PDS 2000 should be used for survey purpose.

#### **1.46 Data from Surveys**


All raw data on recording paper and/or Compact Disc of echo sounder and tide gauge shall become property of the Employer after the surveys and drawings have been completed.

#### **1.47 Breakdowns**

The Contractor shall inform the Employer’s Engineer forthwith of any breakdown, irregularities or otherwise, affecting the positioning of his dredger, vessels or other equipment. Delay incurred in the dredging operation due to malfunctioning of the Electronic Positioning System shall not be reimbursed under the Contract.

#### **1.48 Fire-fighting arrangements.**

The contractor shall provide suitable arrangements for firefighting. For this purpose, he shall provide requisite number of fire-extinguishers and adequate number of buckets, some of

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which are to be always filled with sand and some with water. This equipment shall be provided at prominent and easily accessible places as directed by the Employer's Engineer and shall be properly maintained. If at any time during the currency of the work, the firefighting services are carried out by Employer, the same will be on chargeable basis.

The contractor may be subjected to periodic fire prevention inspections by local fire prevention authorities/Port Fire Department. Deficiency or unsafe condition shall be corrected at the cost of the contractor and the decision of the Employer's Engineer, and the Port Fire Department shall be binding on the Contractor.

These fire prevention inspections will include but are not limited to the following:

- (i) Proper handling, storage and disposal of combustible materials, liquids and waste.
- (ii) Work operations which can create fire hazards.
- (iii) Access to firefighting equipment.
- (iv) Type, size, number and location fire extinguishers or other firefighting equipment.
- (v) Inspection and maintenance of records for extinguishers.
- (vi) Type, number and location of containers for the removal of surplus materials and rubbish.
- (vii) General housekeeping.

While carrying out alteration works inside the Port area, the contractor shall isolate the zone under his occupation in consultation with the Fire Department. Smoke from welding etc. should be kept to minimum to ensure that false alarms are not raised.


Welding/hot works in close proximity of Oil Jetty/berth during discharge of POL and other inflammable liquid cargo is prohibited and the fire safety regulations of the Port shall be strictly followed.

#### **1.49 Assistance to the employer/ engineer**

##### **1.49.1 General**

The Contractor shall render such assistance with facilities, labour, motor vehicles, boats and materials as at any time may be required by the Employer/Employer's Engineer directly or indirectly, in connection with the works. The costs of such assistance shall be borne by the Contractor, if such assistance is intended by or provided for or specified in the Contract; if any assistance is required by the Employer/Employer's Engineer which is not so intended and not provided or not specified, then the cost of such assistance shall be borne by the Employer. The assistance to the Employer/Employer's Engineer includes, but not by way of limitation the items in the following clauses.

The contractor shall provide the Employer's Engineer at all times during the contract period sufficient and qualified personnel to assist the Employer's Engineer in his duties to carry out

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or check any work and / or measurement of works. The contractor is also to provide the Employer's Engineer with necessary survey instruments, computers, any gadgets, ladders, gangways etc., as directed for inspection or measurement of the works by the Employer's Engineer.

#### 1.49.2 Facilities / Services provided by Contractor.

The contractor shall provide the following facilities for the exclusive use of Employer, Employer's Engineer or their representatives at no extra cost to the Employer for their respective projects:


- a) Furnished Air-Conditioned site office of at least two forty feet portacabins i.e. cabin for Employer's Engineer or Employer's staff along with one conference room with Executive tables, chairs for about 10 staffs including pantry arrangements.
- b) Xerox and scanning facility.
- c) 2 Nos Desk Computer and 1 Laptop (min 100 GB hard disk capacity) of latest generation including the licensed software ( office 365 and Autocad) with 2 printers separately.

The facilities under Sr. No. (a) to (e) shall be returned back to contractor after completion of the project.

#### 1.49.3 Protective & safety items

The Contractor shall provide for the use of Employer/Employer's Engineer and his principals, employees and agents and such other persons as the Employer/Employer's Engineer authorizes, the following protective items throughout the duration of the Works.

- Safety Boots (20 number- various sizes as agreed with the Engineer)
- Wellington Boots with Steel Toe caps (20 number- various sizes as agreed/required by the Engineer)
- Water proof top coats (20 number)
- Hard Hats (20 number)
- Life Jackets (20number)
- Gloves (20 number)
- Ear Protection (20 number)
- Hi-Visibility vests (20 number)
- Eye protection (20 number)
- Any other safety equipment as required by Employer's Engineer in connection with Contract.

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#### 1.49.4 Provision of Vehicle

The Contractor will have to provide two Air-Conditioned Vehicles (Innova /Tavera /Xylo/Ertiga) with driver throughout the contract period for the use of Employer / Employer's Engineer on twenty-four hours basis. This vehicle will be used for the duties related to the works of this contract. Vehicle must be in very good condition and to the satisfaction of the Employer. Necessary fuel/oil/driver/maintenance etc will have to borne by the Contractor. During the contract period, in case the Contractor does not provide the Vehicle the employer will engage a vehicle and actual charges incurred by him will be recovered from the contractor's bill.

### 1.50 Definition of Terms

Following definitions apply to these specifications.

**"Employer"** means Board of Trustees of Deendayal port, a body corporate under the Major Port Trust Act, 1963, issued by Government of India (as amended) acting through its Chairman, Deputy Chairman or the Chief Engineer (Civil Department) or any other officers so nominated by the Board.

**"Employer's Engineer"** means the Team Leader of the Project Management Consultant (PMC) and he shall be resident at the project site and act as representative of the Engineer.

**"Design Consultant"** means Consultant appointed by the employer to finalise the design of jetty including civil and marine structures and issue Good for Construction (GFC) drawings for the civil and marine work and modify the same to suit site conditions as and when required. IIT Madras has been appointed as consultant.

**"Contractor"** means the successful bidder for this project.

**"Vendor"** Means the specialized agency supplying equipment and material.

## 2. GEOTECHNICAL INVESTIGATION

### 2.1. Scope

In connection with the existing available data of the bore hole at locations mentioned in Drawing No. IITM-DPA-VAD-DWG-003-02 (Rev. B), it is proposed to take additional 06 nos. of new boreholes along the proposed Approach and Outfitting Jetties.

The scope of geotechnical investigation includes the following for the purpose foundation design for proposed Outfitting and Approach Jetties at Vadinar.

- Conducting 06 Nos of deep offshore geotechnical bore holes at the location of Jetty for an elevation of (-) 40m in water depth of approximately 20m.

The location of proposed bore holes is shown in Drawing No. IITM-DPA-GHOGHA-DWG-003-02. The co-ordinates of new bore hole are provided in Table 2.1 below,


**Table 2.1 Co-ordinates for New Bore Hole**

Point	Latitude (m)	Longitude (m)
NBH-01	569263.14	2481799.47
NBH-02	569062.99	2481716.81
NBH-03	568935.77	2481794.52
NBH-04	568896.21	2481895.36
NBH-05	568817.06	2482097.09
NBH-06	568777.48	2482197.93

The detailed scope of work for each bore includes the activities as specified in Table 2.2.

**Table 2.2 Scope of work activities for geotechnical investigation**

S. No.	Scope of work Activity
1	Mobilization of jack up barge or other suitable floating structure, drilling rig, other rig, other drilling tools and accessories including personnel for carrying out Geotechnical investigation work with a water depth of 20m (approx.).
2	De-mobilization of barge, Drilling rig, other drilling tools & accessories and personnel after carrying out Geotechnical investigation work.
3	Setting up of barge at each borehole location as per the location co-ordinates provided by client
4	Boring through soils of various strengths
5	Drilling through all kinds of weathered rock, and hard rock
6	Collection of 90mm / 100mm dia meter, 450mm long undisturbed samples (UDS) from bore holes and sealing the tube with molten wax.
7	Conducting standard penetration test (SPT) in soil
8	Laboratory Experiments and studies
9	Preparation and submission of factual report during the progress of boring and testing in draft form for preliminary review.
10	Preparation and submission of final geotechnical investigation report including detailed results of laboratory studies, recommendation for foundation design etc for comments and incorporating the same and final submission.

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## **2.2. Borehole locations**

Bore holes are located at the proposed jetty and approach trestle location. The tentative locations of the proposed new bore holes are specified in the tender drawings, and the contractor shall position them with co-ordinates based on the pre-construction survey during setting up of the site.

## **2.3. Duration for Geotechnical Investigation**

The Contractor shall carry out detailed geotechnical investigation for the proposed six (06) new boreholes, including mobilization, demobilization, deployment of all required equipment, sampling, field testing, laboratory testing, preparation of bore logs, and submission of geotechnical reports complete in all respects, in accordance with relevant IS codes and approved methodology.

The entire borehole investigation work shall be completed within a period of **three (03) months** from the date of issuance of work order/ notice to proceed. The Contractor shall submit the final Geotechnical Investigation Report, including all field and laboratory test results, interpretations, recommendations, and design parameters, to the Engineer-in-Charge within fifteen (15) days from date of completion of the investigation works.

## **2.4. Equipment and Manpower requirements**

The minimum manpower the successful execution of the geotechnical investigation is given in this section. Minimum equipment and accessories to be deployed is given below.


- Hydraulic self-elevating jack-up platform for water depth of 20m (approx.).
- Boats for personnel transfer, soil samples and equipment
- Hydraulic rotatory drilling rig
- Boring & drilling accessories
- Other necessary equipment as required to execute the work.

Minimum manpower to be deployed during the execution of boreholes is given below.

- Geotechnical Expert with minimum 10 years post graduate experience: 1
- Supervisor: 1
- Barge Master: 2
- Drilling Crew: 4

Marine spread proposed for the project shall be having experience of previous similar operations. The support for drilling operations shall be provided using hydraulic operated



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jack-up platform. The drilling crew shall be experienced to handle the hydraulic rig and boring operations.

## 2.5. Technical Requirements

### 2.5.1 Boring / Drilling and Rock Coring

The activities comprise of borehole drilling and either


- (a) In-situ testing in borehole and
- (b) Sampling and sample handling.

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

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

- a. Drilling equipment: Any equipment that provides a suitable clean open hole before insertion of down hole sampling and / or testing apparatus and ensures that sampling and / or testing is performed in undisturbed ground.
- b. Drill Rig: Machine capable of providing rotation, feed and retraction, to drill pipe casting and or auger. Drill fluid pumping capacity shall be as required to promote return of drilling fluid.
- c. Drill casing: cylindrical pipe with one or more of the following purposes:
  - To support the sides of the boreholes.
  - To support drill pipe above ground surface in case of over water drilling
  - To promise return of drilling fluid.
- d. Drill pipe: Cylindrical pipe connecting drill rig and drill bit.
- e. Drill Bit: Device attached to drill pipe and used as cutting tool to drill into the ground.
  - Core drilling is a ground investigation technique comprising simultaneous drilling and sampling.
  - Core bit: Device attached to the core barrel and used as a cutting tool to drill the ground.
  - Core catcher: Device that assists retention of core in the core barrel.
  - Core Box: Box with longitudinal separators for the protection and storage of core.



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### 2.5.2 Sampling

The description of the sampling apparatus is as follows.

- a. Push sampling will be undertaken in highly sensitive clays or is the clay encountered is soft to firm is accomplished by
- b. Sampler insertion equipment: apparatus providing relatively rapid continuous penetration force.
- c. Reaction equipment: reaction for the sampler insertion equipment.
- d. Sampling rods: Rods that connect the sampler insertion equipment to the sampler head.

### 2.5.3 Conducting standard penetration test (SPT)

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

### 2.5.4 Sampling Requirement

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

- a. Class 1: undisturbed: Strength, stiffness, and consolidation.
- b. Class 2: undisturbed: permeability, unit weight, boundaries of strata – fine.
- c. Class 3: disturbed: sequence of layers
- d. Class 4: disturbed: particle size analysis, Atterberg limit, boundaries of strata – broad.
- e. Class 5: disturbed: sequence of layers.
- f. The higher class includes laboratory tests of the lower class.
- g. This is to assist in Geotechnical classification, identification, and description of strata.

### 2.5.5 Factual Report

The factual report shall include an introduction outlining the objectives of the investigation, description of the procedures followed for carrying out the various field and laboratory works, equipment used, ground conditions encountered, and the generalized soil profile obtained from findings of field and laboratory investigations. Engineering properties of soils

shall be described in detail along with specifications, codal provisions and some engineering practice.

## 2.6. *Laboratory tests*

The minimum laboratory tests to be conducted on soil and rock samples collected at each bore hole shall be as per Table 2.2.

**Table 2.2 Laboratory Tests on soil and rock samples**

S. No.	Laboratory tests
1	Particle size distribution
2	Atterberg's limits
3	Specific gravity / particle density
4	Bulk density
5	Sedimentation / hydrometer analysis
6	Chloride content, soluble sulphates, carbonate content
7	Natural moisture content
8	Tri-axial compression test – (Consolidated Un-drained)
9	Tri-axial compression test – (Unconsolidated Un-drained)
10	Direct shear test
11	Uniaxial compression test – rock sample
12	Point Load Test – rock sample

## 2.7. *Deliverables*


Following shall be minimum deliverables.

- Daily Field report including calibration of the devices and duly signed by Field Engineer's Representative and Engineer's Representative or his representative.
- Actual executed bore hole shall be plotted on the bathymetry chart with coordinates and submitted separately both in hard and soft copy in AutoCAD format.
- Geotechnical Investigation report including interpreted data including all laboratory results.


## 2.8. *Report format*

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

- Descriptive geology of the area
- Bore hole data (raw) and interpreted based on relevant Indian Standards
- Description of each soil strata indicating colour, consistency, grading in accordance with Indian Standards for soil classification.

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- Laboratory test results
- Geotechnical soil profile at the proposed location.
- Soil characteristics including design strength for each bore hole strata.
- Soil strength includes SPT value, angle of internal friction, density, subgrade lateral soil modulus, modulus of elasticity of soil, undrained shear strength etc shall be provided for each soil layer either by direct testing or by interpretation from relevant literature.
- Pile (Bored cast in-situ RC pile) axial capacity chart prepared for 1200mm piles based on IS 2911, IRC 78 and IS 14593 as deemed appropriate.

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### **3. BORED CAST-IN-SITU PILES**

#### **3.1. General**

##### **3.1.1. Standard Specification**

Bored cast-in-situ piles shall be carried out as per the requirements of IS 2911 (part 1/section - 2). All materials shall be as specified under relevant clauses as applicable. Concrete shall be of the grade indicated on the drawings.

The design loads for the piles are shown in contract drawings.

##### **3.1.2. Scope**

This Section of the Specification includes the provisions for the following types of piles:

- (i) Bored cast-in-situ piles supporting the Approach trestle Jetty. These piles are designed by the Consultant with respect of:
  - Pile diameter.
  - Axial and lateral specified working load
  - Minimum embedment
  - Minimum amount of reinforcement.

The Contractor shall be responsible for establishing the final pile toe level for the jetty structure based on the working load specified on the contract drawings.

The permanent casing specified for these piles is necessary to provide protection to the piles during the operations. The detailing of the permanent casing shall be subject to the Engineer's approval prior to procuring the permanent casing elements.


All elements of Contractor's design shall be subject to proving by full-scale in-situ pile tests and subject to the Engineer's approval prior to installation of piles.

##### **3.1.3. Materials**

Materials failing to comply with the Specification shall be removed promptly from the site at no cost to the employer.

##### **3.1.4. Ground Conditions**

The available Soil Investigation data has been provided with the Tender Documents. This shall be fully assessed by the Contractor prior to using any data or recommendations in his work.

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The Contractor shall report immediately to the Engineer any circumstance which indicates that in the Contractor's opinion the ground conditions differ from those reported in or which could have been inferred from the ground investigation reports or preliminary pile results.

#### 3.1.5. Equipment, accessories and Piling Method

The equipment and accessories used for bored cast-in-situ piles shall depend on sub soil strata, type of founding material and penetration etc. General requirement of boring equipment shall be in accordance with IS 2911 (part 1/section 2). However, boring in hard strata should be carried out by advanced rotary drilling/ RCD.

The Contractor shall submit with his Tender all relevant details of the method of bored cast-in-situ piling, the plant and the monitoring equipment he plans to adopt.

#### 3.1.6. Piling Programme

The Contractor shall submit a provisional programme for the execution of the Works at the time of Tender and a detailed programme prior to commencement of Works. He shall inform the Engineer each day of the intended programme of piling for the following day.

#### 3.1.7. Supervision and Control of the Works

The Contractor shall keep upon the Works a competent site supervisor to be in charge of pile construction and installation.

The site supervisor shall be experienced in bored cast-in-situ type of pile construction. Curriculum vitae of the site supervisor shall be submitted with the tender. The whole time of the site supervisor shall be devoted to the piling works. The supervisor shall not be removed from the Works without the Engineer being notified at least one week in advance.


#### 3.1.8. Damage to piles.

The Contractor shall ensure that during the course of the Works, displacement or damage which would impair either performance or durability does not occur to completed piles.

The sequence and timing for installation of piles submitted to the Engineer for approval shall be prepared having regard to the avoidance of damage to adjacent piles.

#### 3.1.9. Tolerances

Immediately prior to construction of the piles, the pile positions shall be checked by the Contractor.

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The maximum permitted deviations shall be as required in accordance with IS: 2911. In particular:

For a pile within a pile group, with a specified cut-off level at or above the working level, the maximum permitted deviation in any direction of the pile centre from the location specified in the Contract Documents shall not exceed the greater of 75mm or 10% of the pile diameter for piles whose diameter is greater than 600mm.

- The Contractor shall be responsible for all additional costs arising from the necessity to adjust the structural details in case this tolerance requirement is not met.
- The deviation from the true axis shall not be more than 1.5% for vertical piles. Forcible corrections to concrete piles to overcome errors of position or alignment shall not be made.


### 3.1.10. Records

The Contractor shall keep records as indicated by an asterisk in Table 2-1 or as directed by the Engineer for the construction/ installation of each pile and shall submit two signed copies of these records to the Engineer no later than noon of the next working day after the pile was installed.

Any unexpected boring or drilling conditions shall be noted in these records.

**Table 2-1: Table: Records to be kept (indicated by an asterisk)**

Description	Bored cast-in- place
Contract	*
Pile reference number and location	*
Pile type	*
Nominal cross-sectional dimensions	*
Date and time of installation from start to finish	*
Date of concreting	*
Sea bed level at pile position at commencement of installation	*
Working level on which piling machine base stands	*
Depth from Sea bed level at pile position to pile toe	*
Toe level	*
Pile head level as constructed	*
Pile cut-off level	*
Length of Sacrificial casing	*
Soil samples taken and in-situ tests carried out during pile formation or adjacent to pile position	*
Cover to the reinforcement	*
Concrete mix	*
Volume of concrete supplied to pile	*
All information regarding obstruction delays and other interruptions to the sequence of works	*

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Pile forming equipment, including rig number	*
Depth from commencing surface to changes in strata and any fluctuations	*
Level of top of reinforcement cage as constructed	*
As constructed positional records vertical and horizontal	*

## **3.2. Bored Cast-in-place Piles**

### **3.2.1. General**

Construction of bored cast-in-place piles shall be carried out in accordance with IS:2911 (Part I/Sec 2), including all up-to-date amendments, and this Specification.

### **3.2.2. Setting out**

The Contractor shall check the casing position of each pile during and immediately after placing of the casing. Any independent checks by the Engineer shall not relieve the Contractor from his responsibility.

### **3.2.3. Diameter of Piles**

The diameter of a pile shall not be less than the specified diameter for the piles designed by the Engineer.

The auger/ drilling bit dimensions shall be checked as necessary and recorded for each pile to ensure the specified diameter is achieved.

### **3.2.4. Boring**


#### **3.2.4.1. Boring near recently cast piles**

Piles shall be bored in an order and in such manner that no significant damage is sustained to previously cast piles.

#### **3.2.4.2. Permanent casing**

Permanent casing shall be required for the piles.

Permanent casing shall be designed by the Contractor taking into account all details of his proposed method of piling and the ground conditions on the site. The permanent casing shall be installed to such level that the embedded portion of the permanent casing shall not be shallower than 0.5m to 1.0m below rock level with 25% RQD. The depth to which the permanent casing is installed may be increased if in the Contractor's opinion such increase is

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required to maintain the stability of the bore. No reductions in the depth of permanent casing shall be permitted without a prior written approval by the Engineer.

Where the use of permanent casing is specified, the Contractor shall submit full details of the type of casing and the method of installation at the time of tender.

### 3.2.5. Continuity of construction

The pile shall be bored, and the concrete shall be placed without such delay as would lead to impairment of the performance of the pile.

The time period for the concrete after the termination of piles is completed and the reinforcement is placed shall not exceed 12 hours.

The time period shall start after the reinforcement cage is placed in pile.

Where the construction sequence is such that the time period of 12 hours will be exceeded even if no delays are taken into account, a realistic time period for the pile construction shall be stated in the Contractor's method statement submitted at tender stage. The Contractor shall advise on the likely effect of extension of the pile construction period on the performance and the capacity of the pile.

In case of pile construction delays due to unforeseen conditions the Contractor shall submit for Engineer's approval a method for restoring the pile capacity. This may include re-drilling the pile bore at a larger diameter, lengthening the pile, etc.

### 3.2.6. Cleanliness of pile bases

On completion of pile boring, all loose, disturbed or softened material shall be removed from the bore using appropriate methods approved by the Engineer, which shall be designed to clean while at the same time minimising ground disturbance below pile bases.


### 3.2.7. Reinforcement

Except where reinforcement details are prescribed on the contract drawings for the piles designed by the Engineer the reinforcement shall be designed and installed in accordance with the requirements of IS:2911 (Part I/Sec 2).

### 3.2.8. Concreting

The concrete mix shall be designed in accordance with the relevant IS Code and sections of this Specification, taking into consideration the potential soil aggression against concrete.



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Concreting shall generally be carried out in accordance with IS: 2911 (Part I/Sec 2).

The workability and method of placement of the concrete shall be such that a continuous monolithic concrete or grout shaft of the full cross-section is formed. Concrete shall be transported from the mixer to the position of the pile in such a manner that segregation of the mix does not occur.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of concrete in a casing. No soil, liquid or other foreign matter shall be permitted to contaminate the concrete. Bi-polar Concrete Penetrating Corrosion inhibiting admixture shall be provided for all RCC works.

The concrete shall be produced in floating batching plant for carrying out piling.

### 3.2.9. Placing & workability of concrete in pile bores

The method of placing and workability of the concrete shall be such that a continuous concrete shaft of the full cross-section is formed.

The concrete shall be placed without such interruption as would allow the previously placed batch to have hardened. The method of placing shall be approved.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a temporary casing. No soil, liquid or other foreign matter that would adversely affect the performance of the pile shall be permitted to contaminate the concrete.

Slump of the concrete mix, measured at the time of discharge into the pile bore, shall be in the range of 125mm to 175mm.


The concrete shall be of the workability approved when in its final position and shall remain sufficiently workable for all pile construction procedures to be completed safely.

Internal vibrators shall not be used to compact the concrete.

### 3.2.10. Placing concrete under water or support fluid

Before placing concrete, a check shall be made to ensure that there is no accumulation of silt or other material at the base of the boring.

Concrete to be placed under water shall be placed by tremie and shall not be discharged freely into the water. Pumping of concrete may be approved wherever appropriate. A tremie shall have a hopper at the top that empties into watertight tube at least 150

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millimetres in diameter running down to the base of the bore hole. If a pump is used, a watertight tube shall be used with a minimum diameter of 100 millimetres.

The hopper and pipe of the tremie shall be clean and watertight throughout. The pipe shall extend to the base of the bore and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the tremie and the water. The pipe shall at all times penetrate the concrete that has previously been placed and shall not be withdrawn from the concrete until completion of concreting. A sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water in the pile bore. The internal diameter of the pipe of the tremie shall not be less than 150 mm for concrete made with 20 mm aggregate and not less than 200 mm for concrete made with 40 mm aggregate, allowing the tremie to pass within reinforcing cages without causing damage. The internal face of the pipe of the tremie shall be free from projections.

For piles cast under water or drilling fluid, the pile heads shall be cast to a level above the specified cut-off so that after trimming to remove all debris and contaminated concrete, a sound concrete connection with the pile can be made. The amount to be cut off shall be at least 1 metre.


If more than one tremie pipe are used in the same pile, it shall be ensured during the pouring of concrete that contamination of concrete does not occur by mixing of slurry. To achieve this, level of concrete in all the tremie pipes should be kept at the same level. The concrete pours shall be completed in such a manner that concrete above the foot of tremie remains workable until the casting of pile is complete.

#### 3.2.11. Obstruction

If any obstruction to boring or driving is encountered, the Contractor shall notify the Engineer and submit for the latter's approval his proposals for overcoming the difficulties. Notwithstanding any such approval the Contractor shall be entirely responsible for ensuring that the piles are bored or driven to the required lines, position and depth.

#### 3.2.12. Finishing Pile Heads

The top of the pile shall be brought up sufficiently above the finishing 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. The reinforcement in the pile shall be exposed for a sufficient length to permit it to be adequately bonded into the pile cap. The concrete pile cap shall not be constructed until all piles in the group are bored.

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### 3.2.13. Cutting off pile heads

When cutting off and trimming piles to the specified cut-off level, the Contractor shall take care to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and the pile repaired in an approved manner to provide a full and sound section at the cut-off level.

Contractor shall have his method for cutting off the pile heads approved by Engineer prior to commencement of works.

### 3.2.14. Disposal of pile muck and other waste material generated during piling

This material is to be collected properly and disposed off the site without any extra cost to the employer.

## 3.3. Dynamic Load Testing Piles

### 3.3.1. Scope

The tests shall be carried for concrete cast-in-situ working piles shall be tested to ensure their integrity and load carrying capacity as per the BOQ. Contractor should provide all the information of the possible specialist sub-contractor for pile integrity test in Annexure 5 of the tender document.

### 3.3.2. Method of testing

The method of load / integrity test to be adopted shall be one of the following:

- a) Impulse method
- b) Sonic Echo, Frequency Response or Transient Dynamic steady state vibration method
- c) Sonic logging method


Other methods may be proposed subject to satisfactory evidence of performance and Engineer's approval.

### 3.3.3. Age of piles at time of testing

Dynamic Load testing / Integrity testing shall not be carried out until the cast-in-situ pile concrete is at least 28 (twenty-eight) days old.

### 3.3.4. Preparation of pile heads

Where method of testing requires the positioning of sensing equipment on the pile head, the head shall broke down to expose sound concrete and shall be clean, free of water, laitance,

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loose concrete and blinding concrete and shall be readily accessible for the purpose of testing.

### 3.3.5. Post-construction integrity testing of damaged piles

If based on the post-construction survey the Engineer reasonably concludes that a pile or several piles could have been damaged, post-construction integrity testing shall be carried out. Such testing shall generally be carried out using the sonic logging method through conduits installed by coring vertically through the piles to the depth approved by the Engineer for testing in order to ensure the pile performance within the structure including the seismic conditions.

### 3.3.6. Low Strain Pile Integrity Testing


As part of the verification of quality of construction, pile integrity testing shall be carried out on piles selected by Employer's Engineer. Before commencing the piling work, the contractor shall have on site suitable equipment and trained personnel to carry out dynamic integrity testing of piles of each diameter.

The principle of the dynamic integrity testing method to be used shall be based on the application of impacts on the prepared pile head and measurement of the response of the pile by means of equipment capable of recording and processing the pile strain versus time, acceleration versus time and velocity versus time. Unless the contractor himself has proven experience, he shall employ a specialist firm with proven experience in this kind of work.

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

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

A complete report of each pile test, including a description of the equipment used and an evaluation or judgment as to the accuracy of the results shall be submitted not later than two

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weeks after the completion of the test. Intermediate or tentative results shall be communicated to the Employer's Engineer or his nominee as soon as it is available.

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

### 3.3.7. High Strain Dynamic Load Tests


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

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

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

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

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

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### 3.3.8. Interpretation of tests

The interpretation of tests shall be carried by competent and experienced specialists. As a rule and unless approved otherwise by the Engineer prior to commencement of the Works, the specialist integrity testing firm carrying out the tests shall also interpret the results and produce the overall report.

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

### 3.3.9. Reporting

Preliminary results of the tests shall be submitted to the Engineer within 24 hours of carrying out the tests.

The test results and the interpretation shall be reported to the Engineer within ten days of the completion of each cycle of testing (i.e. for all tests done during one visit or one day of work of the specialist testing firm).

The report shall contain a summary of the method of interpretation including all assumptions, calibrations, corrections, algorithms and derivations used in the analyses. If the results are presented in a graphical form, the same scales shall be used consistently throughout the report. The units on the scales shall be clearly marked.


### 3.3.10. Anomalous results

In the event that any anomaly in the acoustic signal is found in the results indicating a possible defect in the pile the Contractor shall report such anomalies to the Engineer immediately. The Contractor shall demonstrate to the Engineer that the pile is satisfactory for its intended use or shall carry out remedial works to make it so or shall install a replacement pile as directed by the Engineer at no additional cost to the Employer.

Sonic logging tubes, if used, shall be grouted up after the Contractor has demonstrated that the pile is satisfactory.

### 3.3.11. Specialist Sub-Contractors/ Agency

The contractor should appoint specialised agency for pile integrity test with the approval of the Engineer.

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### **3.4. Static Load Testing of Piles**

#### **3.4.1. General**

Initial Static load testing (Vertical and lateral pile load test) on test pile shall be carried out in accordance with IS:2911, including all up-to-date amendments, and this Specification. Following tests are planned.

- (a) Vertical load test (compression)
- (b) Vertical load test (tension or uplift)
- (c) Horizontal load test

Load tests on piles shall be carried out only after 4 weeks from the time of casting the pile.

#### **3.4.2. Design of a vertical compression test pile and reaction system**

Vertical Test pile shall be designed by the contractor using the relevant codes and standards. Following guidelines shall be used.


- a) The test pile shall be treated as free cantilever unless a lateral rotational restraint at the top is provided. Effective length of pile shall be taken from point of fixity to the top of cut of level. Effective length factor of 2.1 shall be considered. For reduced effective length factor lateral support against rotation shall be provided at the top of pile without restraining against vertical movement.
- b) The spacing between test pile and the reaction pile shall not be less than 2.5 times the test pile diameter.
- c) Test pile shall be designed for the test load with a suitable load factor of 1.5 as per IS 456 in addition to the test factor of 3.0. Slenderness moment shall be considered in accordance with IS 456.
- d) Design of steel kent ledge frame and arrangement shall be in accordance with IS 800.

The design of kent ledge frame for supporting test setup shall include 4 nos of temporary liners or piles installed around the test pile and also to secure the displacement reference frame. The reaction system shall be designed using vertical reaction piles or vertical anchor system or combination of the above and shall be connected to the test frame. Symmetry in such arrangement shall be maintained to avoid undue to results during testing.

#### **3.4.3. Design of a vertical pullout test pile and reaction system**

Horizontal Load Test pile shall be designed by the contractor using the relevant codes and standards. Following guidelines shall be used.



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- a) The test pile shall be treated as free cantilever.
- b) Pullout load test pile shall be designed for the test load with a suitable load factor of 1.5 as per IS 456 in addition to the test factor of 3.0. Design shall be considered in accordance with IS 456.
- c) The spacing between test pile and the reaction pile shall not be less than 2.5 times the test pile diameter.
- d) The reaction pile(s) system for pull out test shall be designed such that the vertical compression settlement shall be less than 1mm.

Reaction system for pullout load test shall be by means of vertical reaction piles only suitably designed to reduce the compression settlement of reaction system.

#### 3.4.4. Design of a horizontal test pile and reaction system

Horizontal Load Test pile shall be designed by the contractor using the relevant codes and standards. Following guidelines shall be used.

- a) The test pile shall be treated as free cantilever.
- b) Horizontal load test pile shall be designed for the test load with a suitable load factor of 1.5 as per IS 456 in addition to the test factor of 2.0. Design shall be considered in accordance with IS 456.
- c) The spacing between test pile and the reaction pile shall not be less than 2.5 times the test pile diameter.
- d) The reaction pile(s) system for horizontal load test shall be designed such that the lateral deflection at the test load shall be less than 1mm.

Reaction system for horizontal load test shall be by means of vertical reaction piles or inclined anchors suitable designed to reduce the lateral deflection of reaction system.

#### 3.4.5. Construction of a test pile(s)


Each initial test pile shall be constructed in a manner similar to that to be used for the construction of the working piles, and by the use of similar equipment and materials. Extra reinforcement and concrete of increased strength will be permitted in the shafts of initial piles, provided prior notification is made and design calculation is submitted for approval.

#### 3.4.6. Location of test piles

The location for the initial test piles shall be as per the location shown in drawings or approved by the Engineer prior to installation of the test piles.

Initial static pile load test shall be carried out on pile constructed for this purpose as



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identified by the Employer's Engineer. The test pile location shall be selected such that it represents the soil conditions of the working pile but at the same time it does not interfere with the working piles. The test piles, anchor piles if any projecting above the seabed shall be cut and removed after the completion of test. The spacing between the test pile and the anchor pile shall be at least 2.5 times the diameter.

Contractor shall compute the pile load carrying capacity in accordance with the nearest borehole and compare the same with the tested capacity.

#### 3.4.7. Notice of construction

The Contractor shall give the Engineer at least 48 hours' notice of the commencement of construction of any initial test pile.

#### 3.4.8. Boring or driving records

For each initial test pile which is to be tested and for each reaction pile a detailed record of the conditions experienced during the installation shall be made and submitted daily, not later than noon of the next working day. Where the Engineer requires soil samples to be taken or in-situ tests to be carried out, the Contractor shall present the results without delay.

#### 3.4.9. Concrete test cubes

Test cubes for test piles shall be made, cured and tested in accordance with the requirements of IS:2911 and IS:456. Extra cubes may be required to monitor the concrete gaining strength and to ensure the requirement of minimum concrete strength at the time of loading the pile for testing.


The pile test shall not commence until the strength of the cubes taken from the pile exceeds twice the average direct stress in any pile section under the maximum required test load and the strength of the cubes taken from the pile cap exceeds the average stress at any point in the cap under the same load.

#### 3.4.10. Preparation of working pile to be tested

The detail of preparation of working piles for routine testing shall be subject to the Engineer's approval prior to installation of the test piles.

#### 3.4.11. Supervision

The setting up of pile testing equipment shall be carried out under competent supervision and the equipment shall be checked to ensure that the setting up is satisfactory before the

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commencement of load application.

All tests shall be carried out under the direction of an experienced and competent supervisor conversant with the test equipment and the test procedure. All personnel operating the test equipment shall have been trained in its use.

#### 3.4.12. Safety precautions

Design, erection and dismantling of the pile test reaction system and application of the load shall be carried out in accordance with the requirements of the Statutory Regulations and shall safeguard operatives and others who may from time to time be in the vicinity of the test from all avoidable hazards.

Throughout the test period all measurement equipment shall be protected against adverse effects of sun, wind and precipitation. Temperature reading shall be taken at the start, end and at the maximum load of each loading cycle.

Construction activity and persons who are not involved in the testing procedures shall be kept at sufficient distance from the test to avoid disturbance to the measuring apparatus. Field records shall be kept of any unavoidable activity and its effects.

The Contractor shall ensure full-time security and supervision of the test site to ensure safety and protection of the installation against vandalism.

#### 3.4.13. Reaction Piles


Reaction system shall be robust enough to provide reaction to the test load without large deflection or settlement preferably such settlement of reaction piles shall be less than 1mm. Working piles shall not be used as reaction piles for static load testing purposes.

Reaction system shall consist of reaction piles, vertical anchors with suitable kentledge frame supported on additional temporary piles before testing. Failed piles from other tests shall not be used for reaction piles.

Alternate scheme such as O-cell method, inclined guy ropes or other alternate methods shall not be used for supporting the test piles or anchorages.

#### 3.4.14. Notice of Test

The Contractor shall give the Engineer at least 24 hours' notice of the commencement of the test. No load shall be applied to the test pile before the commencement of the specified test procedure in accordance with IS:2911 and this Specification.

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#### 3.4.15. Presentation of Results

During the progress of a test all records taken shall be available for inspection by the Engineer. The results shall be submitted as follows:

- i) A preliminary copy of the test records to the Engineer within 24 hours of completion of the test, which shall show:
  - a. For a Maintained Load Test: for each stage of loading – the period for which the load was held, the load and the maximum pile movement against time;
  - b. For a Constant Rate of Penetration (CRP) test – the maximum load reached and a graph of load against pile movement.
  - c. For a Lateral Pile Load Test: for each stage of loading – the period for which the load was held, the load and the maximum pile movement against time;
- ii) The completed schedule of recorded data, as specified below, within ten days of completion of the test.

#### 3.4.16. Test Compliance

The test compliance assessment shall be as set out in IS:2911.


#### 3.4.17. Schedule of Recorded Data

The Contractor shall provide information about the test in accordance with IS:2911 and the following list:

- (i) General
  - Site location
  - Contract identification
  - Proposed structure
  - Main contractor
  - Piling contractor
  - Engineer & his representative
  - Employer & his representative
  - Date and time of test
- (ii) Pile details
 

All types of piles

  - Identification (number and location)
  - Specified Working Load (SWL)
  - Design value of Negative Skin Friction (NSF)
  - Test load
  - Working surface level at pile position
  - Pile head at which initial test load was applied
  - Type of pile

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- Vertical or raking, compression or tension, etc.
- Shape and cross-section dimensions of pile, levels at which any changes of cross-section occur (including levels of changes in reinforcement detail)
- Shoe or base details (if applicable)
- Head details (if applicable)
- Length in the ground
- Level of toe
- Dimensions of any permanent casing
- (iii) Installation details
  - Dates and times of boring and concreting of test pile and reaction piles if applicable
  - Difficulties and delays encountered
  - Date and time of casting concrete pile cap (if applicable)
  - Type of rig used and method of boring
  - Full log of pile borehole
  - Method of placing concrete
  - Volume of concrete placed
- (iv) Test procedure
  - Mass of Kent ledge
  - Reaction pile or ground anchorage detail
  - Plan and test arrangement showing position and distances of Kent ledge supports, rafts, reaction piles, ground anchorages and supports to pile movement reference system
  - Jack capacity
  - Method of load measurement
  - Method of measurement of pile movement
  - Calibration certificates for loading and measurement equipment
  - Temperature readings
  - Test results
  - All results in tabular form
  - In graphical form – load plotted against pile head movement and load plotted versus time
  - Ambient temperature records during test

#### 3.4.18. Completion of Test

On completion of test all reaction piles, anchorages and initial test piles shall be cut off upto seabed level.

Unless instructed otherwise by the Engineer all routine test piles shall be cut off restored as required for incorporating into the Permanent Works.

## 4. CONCRETE

### 4.1. General Specifications

#### 4.1.1. National Specifications

Unless otherwise stated in these Specifications, the materials and construction of the Works shall comply in all respects with the latest edition of I.S. 456 and I.S. 13920, other relevant IS codes together with the latest editions of all relevant Indian Standard Specifications and Codes of Practice.

#### 4.1.2. Concrete for the Works

Concrete for the Works shall be produced on Site using floating batching plant for piling and all in situ works. For precast concrete work concrete produced at site or ready-mixed concrete plants located in the vicinity of the Site can be used.

For Site produced concrete, the Contractor shall provide details of his quality control procedures to the Engineer for approval prior to the preparation of the trial mixes. Once design mix is approved, the Engineer will monitor the operation of these procedures during the course of the Works and any deviations from those procedures will be corrected by the Contractor at his own expense.

The Contractor shall provide a field material testing laboratory including such assistance as may be necessary. The laboratory shall be equipped to carry out all routine tests on concrete making materials and concrete as per relevant Indian Standards and any other standards referred to in this Specification. The material testing laboratory shall be maintained in a clean and efficient manner throughout the currency of the Contract by the Contractor at their own cost. The rates quoted by Contractor shall be inclusive of all the costs related to sampling, testing and maintaining the testing laboratory at site with requisite qualified personnel.

#### 4.1.3. Definitions

Cement	Hydraulic binder that sets and hardens by chemical interaction with water and is capable of doing so under water.
Characteristic Strength	That value of strength below which not more than 5% of the test results of all possible strength measurements of the specified concrete are expected to fall. Cement Content Mass of cement contained in a cubic metre of fresh, fully compacted concrete, expressed in kg/m <sup>3</sup> .
Free Water/Cement Ratio	Ratio of the mass of free water (that is, excluding the water absorbed by the aggregate to reach a saturated surface dry

condition) to the mass of cement in a concrete mix.

**Certified Average Alkali Content** The average of 25 consecutive determinations of equivalent alkali content, expressed as the sodium oxide equivalent, carried out on samples each of which is representative of a day's production.

**Declared Mean Alkali Content** The mean alkali content, expressed as the sodium oxide equivalent, which will not be exceeded without prior notice from the manufacturer. This is the certified alkali content plus a margin that reflects the manufacturer's variability of production.

**Guaranteed Alkali Limit** The alkali limit, expressed as the sodium oxide equivalent, which the manufacturer guarantees will not be exceeded by any test result, on any spot sample.

## 4.2. Site Specific Requirements

### 4.2.1. Permitted Types of Cement

Type	Standard Specification
Portland Slag Cement (PSC) with compressive strength satisfying the requirement of OPC grade 53	I.S. – 455(1989)

### 4.2.2. Cement Properties


Property	Maximum Permissible Value	Test
Alkali Limit (as Na <sub>2</sub> O equivalent)	0.6 per cent	I.S.- 4032

### 4.2.3. Permitted Aggregates

Type	Standard Specification
Natural	I.S. – 383

### 4.2.4. Aggregate Properties

Property	Maximum Permissible Value	Test
Flakiness Index	15% (in case of Pumped Concrete, use of flaky aggregate shall be avoided)	I.S. 2386 Part I
Elongation Index	25%	I.S. - 2386 Part I
Water Absorption	2% by weight	I.S. - 2386 Part III
Aggregate Abrasion Value	30%	I.S. - 2386 Part IV


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Property	Maximum Permissible Value	Test
Aggregate Crushing Value	45%	I.S. - 2386 Part IV
Magnesium Sulphate Soundness loss over 5 cycles	18% for coarse aggregate 15% for fine aggregate	I.S. - 2386 Part V
Sodium Sulphate Soundness loss over 5 cycles	12% for coarse aggregate 10% for fine aggregate	I.S. - 2386 Part V
Limits of deleterious materials in coarse and fine aggregate	As per I.S. - 383, Clause 3.2.1 Table I	I.S. - 2386 Part II
Chloride Content (expressed as chlorine)	0.02% by weight of aggregate dried at 105°C	I.S. - 2386 Part VII/ DIN 4226 Part 3, Clause 3.6.5
Sulphate Content (SO <sub>3</sub> )	0.5% by weight of aggregates dried at 105°C	I.S. - 2386 Part VII/ DIN 4226 Part 3 Clause 3.6.4

#### 4.2.5. Concrete Mix Schedule

Concrete Grade	M 20	M 40	M 40	M 20	M40	M30
Usage	Mass Concrete (above water)	Reinforced Concrete (above water)	Reinforced Concrete (Precast)	Mass Concrete (under water)	Reinforced Concrete (under water)	Reinforced Concrete (above water)
Type of Mix	Design Mix	Design Mix	Design Mix	Design Mix	Design Mix	Design Mix
Cement Type	As specified above					

Nominal max aggregate size	20 mm	20 mm	20 mm	20 mm	20mm	20 mm
Concrete characteristic strength N/mm <sup>2</sup>	20	40	40	20	40	30
Min. Cement content kg/m <sup>3</sup>	280	400	400	350	450	350
Sample rate m <sup>3</sup> /sample	As specified below.					
Workability Slump (mm)	75-100	75-100	75-100	150-200	150-200	75-100
Max. free	0.45	0.45	0.45	0.45	0.45	0.45

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water/cement ratio							
Max. cement content kg/m <sup>3</sup>		500	500	500	500	500	500
Total Drying Shrinkage strain		0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Admixtures	Specified	No	No	No	No	No	No
	Permitted	See Note 1	See Note 1	See Note 1	See Note 1	See Note 1	See Note 1
	Amount	As per manufacturer's recommendations and approved by the Engineer					
Air content		Zero	Zero	Zero	Zero	Zero	Zero
Air Temperature on Placement °C	Maximum	38	38	38	38	38	38
	Minimum	5	5	5	5	5	5
Density of Concrete kg/m <sup>3</sup>	Minimum	2400	2400	2400	2400	2400	2400
Fibres	Kg/m <sup>3</sup>	Permitted	Permitted	Permitted	Permitted	Permitted	Permitted
Max. Temperature of Concrete at time of placing		40°C	40°C	40°C	40°C	40°C	40°C

Notes:


1. Water reducing admixtures, retarders, plasticizers all of approved make, will be permitted. 2.
2. Bi-polar Concrete Penetrating Corrosion inhibiting admixture shall be provided for all RCC works

#### 4.2.6. Concrete Mix Properties

Property	Value
Total water-soluble sulphate content, expressed as SO <sub>3</sub>	4.0% max by mass of cement in the mix in accordance with IS 456

Total acid-soluble chloride content of the mix expressed as chloride ions	0.6% max by wt of cement for unreinforced concrete 0.3% max by wt of cement for reinforced concrete 0.1% max by wt of cement for prestressed concrete or in accordance with IS 456
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#### 4.2.7. Information to be submitted to the Engineer

Certificates of Conformity
Personnel, Foreman, Mixer Operators, Vibrator Operators.
Approval of Cement Supply
Manufacturer's Cement Test Certificates
Sources of Aggregates
Aggregate Test Certificates
Site Processing of Aggregates
Source of Water
Approval of Admixtures
Approval of Corrosion Inhibitor
Prior Approval of Mix Proportions
Proposals for Minimising the Risk of Damaging Alkali-Silica Reaction
Approval of Batching Methods
Mixing Plant
Position & Form of Construction Joints

#### 4.2.8. Personnel, Foremen, Mixer Operators, Vibrator Operators.

Personnel: 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, details of qualifications and experience of the personnel to be engaged in the work of concrete and quality control.

Foremen: Fully experienced foremen shall be in charge of all concrete placing gangs. Plant/  
Mixer Operators: Only approved experienced mixer operators shall be employed.

The operators shall be trained in the operation of the plant and shall be subject to checking and approval by the Engineer.


Vibrator operators: Mechanical vibrators shall be operated only by trained and experienced workmen who shall be named to the Engineer and tested and approved by him.

### 4.3. Cement

Cement to be used for civil, marine, and structural works shall be Portland Slag Cement only as per IS:455 with compressive strength not less than grade 53 Ordinary Portland Cement.

#### 4.3.1. Permitted Types of Cement

Changing of types and brands of cement within the same structure or part thereof will not be permitted. Change of brand will be permitted with prior approval of Engineer subject to re-design of concrete mix design.

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#### 4.3.2. Approval of Cement Supply

Supply of cement for the Works shall be arranged by the Contractor.

So far as is possible cement of a required type shall be supplied from only one source throughout the execution of the Works, and no variations in source of supply shall be made without the approval of the Engineer.

The approval of the Engineer to any type of cement shall not relieve the Contractor his responsibility and at any time the Engineer may give notice for removal of any consignment of cement from the Site if such consignment does not in every way comply with the requirements of this Specification.

Before any cement is ordered or brought on to Site, the Contractor shall submit to the Engineer for his approval a detailed list of the sources / manufacturers and manufacturer's brand names of all types of cement which he proposes to use in the Works, as per the Cement records contained in Appendix A (At the end of this section) to this document.

This shall be accompanied by full details of the composition and properties of cement, as set out in the Cement Properties Table. This shall be completed for each type of cement and for each proposed source / manufacturer, as per the Cement Properties Table contained in Appendix A to this document (Performa given at the end of this section).


#### 4.3.3. Manufacturer's Cement Test Certificates

Manufacturer's Works test certificates shall be furnished to the Engineer for all consignments of cement and no cement shall be used in the Works until the Engineer has been satisfied that it has been tested and complies with the relevant standard specifications.

#### 4.3.4. Sampling and Testing of Cement

Notwithstanding the submission by the Contractor of the information detailed above, the Engineer may at any time order any further tests which he considers necessary for the purpose of establishing the true quality of the cement proposed and the concrete produced there from, under actual Site conditions and with the aggregates proposed by the Contractor, before giving his approval to any cement.

Any consignment of cement delivered to the Site may be subject to testing, if directed by the Engineer. Cement in storage may also be subject to testing to check that it has not deteriorated. Cement which is not used within 90 days from its date of manufacture shall be tested. The Engineer shall take samples from different containers, and he will despatch them

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to a laboratory approved by him for testing.

The cement from the consignment from which the samples have been extracted for testing shall not be used in the Works before completion of testing and analysis and until it has been accepted as satisfactory by the Engineer.

Should the results of any of the tests provided for in this Clause show that any sample fails to meet the minimum requirements of this Specification, the whole consignment to which the sample belongs shall be rejected and be removed from the Site. No cement from any consignment shall be used in the Works without the approval of the Engineer.

#### 4.3.5. Failure to Supply Certificates or Carry out Tests

Failure to comply with either of the two requirements mention above, will render liable to rejection by the Engineer all work containing unapproved cement.

#### 4.3.6. Delivery of Cement

The cement shall be delivered to the Site in such consignments as shall ensure satisfactory progress of the Works.


Except where bulk delivery is approved, cement shall be packaged by the manufacturer in bags or containers that are so designed as to prevent any contamination and to minimise loss of Contents and the adverse effects of moisture and high humidity during transportation and storage.

All bags and containers shall be delivered sealed to the satisfaction of the Engineer. Each shall be adequately and permanently marked with the manufacturer's name, the name of the producing works, the cement type, the standard specification to which it was made, the date of manufacture or date code and batch number, so as to enable correlation to be made of every part of each consignment with the relevant test certificates and delivery notes.

Cement, when being conveyed to the Site in lorries, vessels or other vehicles, shall be properly protected from the weather and from contamination of any kind. Any cement which proves to have been damaged or contaminated in transit will be rejected upon delivery.

Cement delivered in split bags or containers will be rejected.

Where bulk cement deliveries are proposed the Contractor shall obtain the prior consent of the Engineer to the method of delivery and shall provide all information required by the Engineer concerning off-site storage and loading arrangements. He shall also provide reasonable facilities for the Engineer to inspect these arrangements for approval and routine

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inspection purposes. The temperature of cement delivered in bulk shall not exceed 65°C.

#### 4.3.7. Storage of Cement

From the time that a consignment of cement is brought on the Site and tested and approved by the Engineer and until such time as cement is used in the Works, the Contractor shall be responsible for keeping the same in sound and acceptable condition.

If cement is to be stored in bulk containers these shall be subject to the prior approval of the Engineer and shall be large enough to contain such quantities as may be required with sufficient reserve to allow for the likely frequency of supply.

Cement stored in bulk containers shall be, in the opinion of the Engineer, adequately protected against rain, humidity, dewfall and dust, and all charging and discharging points shall be properly sealed. Aeration equipment for the bulk containers, if available, shall incorporate dehumidifiers.


If packaged cement is stored in bulk containers it shall be charged into the containers through a 5 mm mesh screen which is welded or bolted to and covers the entire feed area of the charging hopper.

Cement other than that stored in bulk shall be kept in the bags or containers in which it was delivered until use and shall be stored in a Dry Store large enough to contain such quantities as may be required with sufficient reserve to allow for the likely frequency of supply. Cement in bags or containers shall be unloaded under cover. This store shall be dry, well ventilated, perfectly weatherproof and waterproof and shall be so situated as not to be liable to flooding and shall have a floor raised not less than 60 cm from the ground in order to protect the cement from moisture. An air space shall be left between the floor and the bottom layer of the bags. Cement bags shall be stored well away from outer walls of the store and not more than 12 bags shall be stacked in any tier. Each consignment shall be stacked separately therein to permit easy access for inspection and a record shall be kept so that each consignment may be identified by a serial number and date of delivery. Storage under tarpaulins shall not be permitted.

Each different type of cement approved for use and brought to Site shall be stored separately from one another.

All cement shall be used in the order in which the consignments are delivered to the Site commencing with the consignment which has been in the store for the longest period of time. In general it shall be used as soon as possible after delivery and in any event it shall not be used more than 12 months after manufacture, or when tests carried out on instruction of the Engineer show that the loss on ignition exceeds 4%.

Cement shall be adequately protected at all times from rain and spray. Cement which has set

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or partially set shall not be used in the Works.

Notwithstanding the above provision, any cement which the Engineer considers has become stale or unsuitable through absorption of moisture from the atmosphere or for other reasons shall be rejected and removed from the Site at the Contractor's expense. Any cement in containers damaged so as to allow the contents to spill or to be affected by atmospheric moisture prior to opening at the time of concrete mixing shall be rejected and removed from the Site at the Contractor's expense.

#### 4.3.8. Performance Characteristics

Notwithstanding apparent compliance with all other requirements of this Specification, the Contractor shall be responsible for satisfying himself that the performance characteristics of the cement used in the Works are not such as to necessitate the use of excessive cement contents or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete.

### 4.4. Aggregates

#### 4.4.1. Aggregates - Definitions

The term "Aggregate" shall mean all solid constituents of the concrete mix, other than cement or approved cementitious additives or approved admixtures, batched ready for charging into the mixers, whether such material is called "coarse aggregate", "fine aggregate" or "sand".


#### 4.4.2. Aggregates - Standard Specifications

Aggregates supplied to the Site shall generally be naturally occurring gravel, sands and/or crushed rock complying with the requirements of I.S. 383, except as otherwise stated in this Specification. Lightweight aggregates shall not be used without the written approval of the Engineer unless specified as a requirement.

Aggregate shall be of approved quality, chemically inert, hard, clean, sharp and free from injurious amounts of dust, silt, clay lumps, mica, shells, flaky particles, shales, alkali, organic matter, loam or other deleterious substances.

#### 4.4.3. Sources of Aggregates

The Contractor shall supply the Engineer with full details of his proposed sources of supply of aggregates for the Contract, together with test results carried out by an approved laboratory, as soon as possible after receipt of the order to commence the Works. The Engineer shall have the right to inspect all proposed quarries and other sources of aggregate.

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No aggregate shall be used in the Works until it has been approved by the Engineer and no change shall be made in any aggregate source without the prior approval of the Engineer.

The Engineer shall have the power to withdraw approval for any source of aggregate if the aggregate from that source fails to meet this Specification or for other reasons fails to produce concrete of required standard.

Any aggregate brought to Site which is not approved by the Engineer shall be immediately removed from the Site by the Contractor at his own cost.

#### 4.4.4. Information Required on Aggregate Sources

The Contractor shall supply full details of the proposed sources of aggregates as listed below for approval by the Engineer, together with the results of sampling and testing carried out in accordance with these specifications, at contractor's cost.

- Name and address of supplier
- Location of deposits
- Nature of materials and principal rock type present
- History of previous use
- Method of extracting and processing
- Details of producers, laboratory facilities and technical staffing
- Stockpiling, loading and supply arrangements


#### 4.4.5. Sampling of Aggregates

The following sampling of aggregates is required:-

- Each size of aggregate from each source shall be sampled as specified in I.S. 2430 at the discharge points on the production plant (i.e. conveyors or hoppers, NOT stockpiles) at three well-spaced time intervals during the course of each of three consecutive production days.

These samples shall be designated Production Samples.

- In addition selected samples shall be taken from producer's stockpiles or materials ready for loading which indicate any readily visible variations in physical characteristics, or appearance. These samples shall be designated Stockpile Samples.
- All samples shall be taken in the presence of the Engineer, if he so requires, and shall be tested as required below.
- Representative portions of the above samples which have been tested in accordance with these specifications, shall be taken for reference purposes and

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shall be split and retained on Site by both the Contractor and the Engineer to act as control samples for comparison with later deliveries.

#### 4.4.6. Testing of Aggregates

Each Production Sample shall be tested in the following respect:-

- Proportion of natural (uncrushed) material (% by weight)
- Gradings; deleterious materials including clay, silt and fine dust and organic impurities (% by weight), I.S. 2386 (Parts I & II)
- Specific gravity and water absorption, I.S. 2386 (Part III)
- Flakiness and elongation indices, I.S. 2386 (Part I)

Representative portions of equal weight shall be taken from each of the nine Production Samples of each size of aggregate, and then combined to provide Composite Production Samples for each size of aggregate. The Composite Samples shall be tested in the same respects as the individual Production Samples and shall also be tested as follows, unless otherwise directed by the Engineer. Stockpile samples shall be compared with production samples and if differences are observed the Engineer will require appropriate tests to be carried out on the Stockpile samples.

The Engineer shall also have the option to test composite samples as follows if he so wishes:

-

- Alkali Aggregate Reactivity tests. I.S. 2386 (Part VII)
- Soundness test: I.S. 2386 (Part V).
- Aggregate Crushing Value, I.S. 2386 (Part IV):
  - Test fraction in oven-dry condition
  - Test fraction in saturated surface-dry condition
- Aggregate Abrasion Value, I.S. 2386 (Part IV).
- Petrographic examination and description, including approximate composition, I.S. 2386 (Part VIII)

#### 4.4.7. Grading of Aggregates


##### **Coarse Aggregate:**

The maximum size of coarse aggregate shall be as specified. Coarse aggregate shall be delivered to the site and stored in single sizes and combined on batching to provide a graded aggregate all in accordance with the approved mix design. Where 10mm maximum size aggregate is required, 10mm single-sized grading shall be used.

##### **Fine Aggregate:**

Grading of fine aggregate shall be in accordance with Grading Zone II of Table IV of I.S. 383 and its fineness modulus shall not be less than 2.2 nor more than 3.2 Grading as well as



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fineness modulus shall be monitored regularly and continuously at source as well as at Site and if necessary sand from different approved sources shall be blended to achieve the desired grading and fineness modules.

**All-in aggregate:**

All-in aggregate and crushed stone sand shall not be used for reinforced concrete and shall only be used for un-reinforced concrete with the express written permission of the Engineer.

#### 4.4.8. Aggregate Properties

While the aggregate properties given in the fore-going clauses are maximum values, lower values may be required to satisfy the overall limits required for concrete mixes as specified in subsequent clauses.

#### 4.4.9. Staining

Aggregates shall not be composed of or contain inclusion of materials likely to cause staining or otherwise disfigure finished concrete surfaces.

#### 4.4.10. Washing of Aggregates

Aggregates shall be Sieved and washed with fresh potable water, free of all silt, dust, chlorides, sulphates, organic or other impurities in an efficient washing plant before delivery to Site. The Contractor shall carryout the tests to check the efficiency of the washing of the aggregates shall be made at regular and frequent intervals in presence of Employer's Engineer on site and the material for which the tests found to be unsatisfactory shall be rejected.


#### 4.4.11. Sampling and Testing of Aggregates

The method of sampling shall be in accordance with I.S. 2430.

Tests, including grading and tests for chemical, physical and mechanical properties of the aggregate and the presence of deleterious impurities, including but not limited to silt, sulphates and chlorides, shall be carried out as required by the Contractor as instructed by Engineer, in accordance with relevant parts of I.S. 2386 except as specifically provided otherwise in the Specification.

The Engineer shall have the right to require the Contractor at any time to test samples of aggregates drawn from locations as indicated by the Engineer. Sampling shall be carried out in the presence of the Engineer.



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#### 4.4.12. Shipping of Aggregates

Whilst being conveyed to the Site, aggregates shall be covered to prevent dust or other contamination and all necessary precautions shall be taken to prevent segregation of sizes or crushing of aggregates.

Aggregates shall be delivered to the Site at least one day before use in such consignments as shall ensure satisfactory progress of the Works.

Aggregates from separate bins or from separate stockpiles at the source of supply shall be delivered to the Site in separate vehicles. Different sizes and grading shall not be transported in the same vehicle simultaneously.

#### 4.4.13. Storage and Handling of Aggregates

Aggregates accepted for use in the Works shall be stored in accordance with I.S. 4082 in approved containers or on clean, hard, free draining paved areas draining away from the concrete mixing area, with adequate dividing walls of ample height and strength to prevent mixing of different types and sizes of aggregates. The surrounding areas where aggregates may be handled shall also be hard paved. All these areas shall not be liable to flooding. Details of the layout and siting of the storage areas shall be submitted to the Engineer for approval before they are constructed.

Containers and storage areas shall be self-draining. Particular care shall be taken in the construction and maintenance of such containers or storage areas and in the handling of materials to ensure that contamination by extraneous material such as air-borne dust, leaves or clay, organic and other deleterious matter or by harmful salts in the ground is prevented.

During delivery to and handling from the stockpile, care shall be taken to avoid crushing the aggregates or contamination with extraneous matter.

The general or localised build-up of fines or segregation of sizes in aggregate stockpiles shall not be allowed. If the Engineer is not satisfied that such segregation or build-up of fines has been prevented, he may instruct the Contractor to turn over the contents of any stockpile or to remove all or part of the contents of any stockpile and either reprocess or dispose of such material.

The Contractor shall also employ such methods as may prove necessary to ensure effective cooling of the aggregates prior to batching for concrete (such as provision of sunshades), subject to the approval and/or discretion of the Engineer. Spraying the aggregates with water will not be permitted.

#### 4.4.14. Silt, Clay, Dust & other Deleterious Materials

The quantity of silt, clay, dust and other deleterious materials present in the aggregates for concrete at the time of use shall not exceed the limits laid down by I.S. 383. These shall be determined in accordance with the appropriate method given in I.S. 2386 (Parts I & II).

### 4.5. Water for Concreting

#### 4.5.1. Water for Concreting

All water used for the mixing of concrete, grouts or mortar shall be clean fresh potable water. Potable water shall also be used for the curing of concrete and for the washing down of construction joints, removal of laitance, etc. It should not produce any stains or unsightly deposits on the concrete surface. The presence of tannic acid or iron compounds is objectionable. It shall have pH value of between 6.8 and 7.8. The water shall be free from deleterious matter in solution or suspension and shall meet the requirements of I.S. 456, in all respects. The permissible limits are given below: -

	Material	Maximum Limit (mg./litre)
a)	Suspended	2000
b)	Organic	200
c)	Inorganic	3000
d)	Sulphates (as SO <sub>4</sub> )	400
e)	Chlorides (as Cl)	2000 for plain cement concrete
		500 for reinforced cement concrete

However, the sulphate and chloride contents of the water shall be of such a level that, taking into account the sulphate and chloride contents of the other constituent materials, the overall sulphate and chloride contents of the various concrete, grout or mortar mixes do not exceed the limits laid down elsewhere in this Specification.


The Contractor shall make adequate arrangements to store sufficient water at the Site for use.

#### 4.5.2. Source of Water

As soon as possible after receipt of the order to commence the Works, the Contractor shall supply the Engineer with full details of his proposed source or sources of water for use in the Works. These details shall at least include results of analysis listed below.

The Engineer's approval to use of a proposed source shall be obtained before water from that source is used for the Works.

Once the Engineer has approved any source of water this shall not be varied without his prior approval.

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The Engineer shall have the power to withdraw approval for any source of water if the water from that source fails to meet this Specification.

#### 4.5.3. Testing of Water

Tests on the purity, soluble sulphate, chloride or other chemical content, sediment and pH value shall be carried out generally once a month or at such times as the Engineer may direct. The Contractor shall arrange for the despatch of samples of water to an approved testing laboratory and for the testing required. Sampling and testing shall be witnessed by the Engineer.

### 4.6. Admixtures & Additives

#### 4.6.1. Approval of Admixtures


No materials of any description shall be used in concrete mix other than aggregates, cement and water, except where specifically required by the Concrete Mix-Schedule without the written instruction or approval of the Engineer in each case. If more than one admixture is proposed for use in the same concrete mix, their interaction shall be checked by trial mixes by the Contractor to ensure their compatibility.

The Contractor should note that the description of any proposed admixture by trade or brand name will not be sufficient when proposing such admixture for the approval of the Engineer. In order to save delay, the Contractor should submit the fullest possible description of the chemical composition of any admixture, together with its 'shelf life' and details of storage and handling requirements. He should also submit details of its anticipated effect on the particular mixes in which its use is proposed. The Contractor shall also submit details of how long the admixture has been used in India / abroad and details of the projects on which it was used and copies of independent test reports giving the effects of use of the admixture. If appropriate, the Contractor should also provide details of how the mix proportions are to be varied to produce the required characteristic strength and rate of strength gain.

The Contractor shall submit manufacturer's test certificates and technical literature of the admixture proposed to be used. If directed by the Engineer, the admixture shall be tested at an approved laboratory at no extra cost.

The Engineer will, wherever appropriate call for trial batches of concrete to be prepared to demonstrate the effect of the proposed admixtures both on the fresh concrete and on the hardened concrete before giving his approval. He may also lay down additional requirements for the control of the use of such admixtures.

Admixtures shall not be used which produce concretes that are less durable, more porous, have inferior surface structure, or are more susceptible to humidity or temperature movement

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than the corresponding concrete grade made without admixture. Admixtures that affect the density of the concrete, such as air-entraining agents, shall not be permitted.

Notwithstanding any previously given approval, the Engineer may withdraw such approval at any time with respect to any mix containing admixtures if, in his opinion, the performance of the particular admixture under actual Site conditions is not completely satisfactory.

#### 4.6.2. Supply and Storage of Admixtures

Accelerating, retarding, water reducing admixtures shall conform to I.S. 9103, integral cement water proofing admixture to I.S. 2645, any other admixtures to B.S. 5075 if it is applicable, unless otherwise specified or agreed.

All admixtures to be used in dose forms shall be supplied in containers or packages marked with the recommended dosage for each type of mix in which they are to be used. Admixtures shall be stored strictly in accordance with manufacturers' recommendations and precautions shall be taken during delivery and storage to prevent damage to or adulteration of admixtures. This may include cleaning off sediment from the bottom of a storage tank, regular stirring, etc.

Any cement containing admixtures shall be supplied in bags or containers clearly marked to show the nature and quantity of such admixtures and shall be stored separately from any other type of cement.


#### 4.6.3. Use of Admixtures

Any admixture used in any concrete mix shall only be used at the rate of dosage or in the proportions previously approved by the Engineer, method of mixing etc. all in accordance with the manufacturer's instructions and within the manufacturer's recommended ambient temperature range.

In general, the dosage of retarders, plasticisers and super plasticisers shall be restricted to 0.5, 1.0 and 2.0 per cent respectively by weight of cement unless a higher value is agreed upon between the Engineer and the Contractor based on performance tests. Bi-Polar ...

Any batch of concrete which has received an incorrect dose of an admixture, or which shall show deterioration after placing as a result of incorrect use of admixtures, shall be broken out or otherwise replaced without charge to the Contract.

The relative density of liquid admixtures shall be checked for each drum containing the admixture and compared with the stated / specified value before acceptance. Liquid admixtures or powder admixtures that are to be used as solutions shall be dispensed by an

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appliance fixed to the mixer, which measures weight, volume or dosing time and is provided with a recorder. This appliance shall be accurately calibrated, and the calibration and dosage shall be checked at regular intervals or as directed by the Engineer. All such admixtures shall be dispensed with the mixing water.

All admixture dispensers shall be thoroughly cleaned before commencing each day's work and at every interruption to the work.

Where admixtures are to be used in bulk form, these shall be weigh-batched as is provided in this Specification for the batching of cement.

Powder admixtures to be used in dose form shall only be allowed if premixed and used as solutions and then only if the premixing procedure has been previously approved by the Engineer.

Trial mixes shall be undertaken as described below, together with additional trial mixes showing the effect of overdosing and underdosing of the concrete mix.

#### 4.6.4. Chlorides

Under no circumstances shall calcium chloride or chloride-based admixtures be used in any concrete mix, grout or mortar. The chloride content of admixtures shall be independently tested in an approved laboratory for each batch of admixture before acceptance by the Contractor at no extra cost.

### 4.7. Mix Requirements

#### 4.7.1. Concrete Grades


The concrete grades used in the Works shall comply with the requirements given in the Design Mix Schedule.

#### 4.7.2. Sulphate and Chloride Content of Concrete Mixes

The requirements laid down in this Specification for Sulphate and Chloride contents of the constituent materials of the concrete mixes, shall apply to all concrete mixes used in the Works and shall be calculated as the total of the various constituents of the mix.

#### 4.7.3. Prior Approval of Mix Proportions

As soon as practicable after the commencement of the Contract, the Contractor shall produce in writing, for the Engineer's approval, his proposals for all concrete mixes of the grades set out in this Specification including mix design calculations in triplicate, stating proportions of all constituent materials, including admixtures, Sieve analysis of aggregates, workability, etc.

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The Contractor must note that ample time should be allowed for testing and obtaining the approval of the Engineer for all mixes, as provided below, before commencing the mixing of concrete for the permanent works on the Site. Notwithstanding any approval by the Engineer to any mix, the Contractor shall not be relieved of any of his responsibility to use in the Works at all times only concrete meeting the requirements of the Specification in all respects to the satisfaction of the Engineer.

#### 4.7.4. Trial Mixes

Prior to the use of any concrete mix in the Works the Contractor shall either:

- (A) Prepare trial mixes for each different concrete mix to be used including the proposed admixtures. The trial mix shall be designed according to I.S. 456, I.S. 10262 and SP:23


Preparation and testing of trial mixes shall be carried out in the presence of the Engineer. The Contractor shall afford facilities to the Engineer to enable the Engineer to make independent tests, if he so desires.

For each trial mix three separate batches of concrete shall be made using the materials approved for use in the Works and, unless otherwise approved, under full-scale production conditions. If for any reason it is not possible to make any trial mix under full-scale production conditions, then it may be made in a laboratory but only with the express permission of the Engineer and under such conditions as he may lay down.

Particular attention shall be given to the water/cement ratio and workability of these trial mixes. The free water content of all the aggregates used shall be accurately determined according to IS 2386 (Part III) by drying or other approved means before the mixing begins in order to give an accurate measure of the free water/cement ratio.

The consistency of each trial mix concrete batch shall be measured by the Slump Test using the equipment and method given in I.S. 1199. The target slump of the trial mixes shall take into account the ambient temperature conditions expected at Site and shall be such that the slump of the production concrete when received at Site is as specified. The target slump shall have a tolerance of + 15 mm or + 1/5 the required value, whichever is greater. In hot weather conditions graphs of slump v/s time since adding the water to the mix and slump v/s concrete temperature shall be prepared for use in production testing.

If the target slump is not within the permitted tolerance specified, the proportions of the mix shall be adjusted accordingly, and new trial batches shall be made. Both the ambient temperature and the temperature of the fresh concrete shall be noted when each slump test is made.

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For two of the trial mix batches a total of six 150mm cubes shall be made. These test cubes shall be made, cured and tested in accordance with the provisions of I.S. 516. Unless otherwise directed by the Engineer, three of the six test cubes shall be tested for compressive strength at 7 days and three at 28 days. The third trial mix batch shall consist of twelve cubes, three cubes being tested at each of 3, 7, 14 and 28 days.

**OR**

- (B) If ready-mixed concrete is used, the Contractor may submit if approved by the Engineer, appropriate existing data as evidence of satisfactory previous performance for target mean strength with the proposed admixtures, current margin, workability, water/cement ratio and rate of gain of strength. In addition to what is specified in (A) above, the target slump of the trial mixes and concrete production mixes produced at the plant shall take into account the workability loss for the expected delivery time together with the concrete temperature at the time of delivery. The concrete mixes shall be so designed that due to any unforeseen problem they should be able to cope up with delays due to longer delivery period than expected.

Alternatively, if required by the Engineer, the Contractor shall carry out trial mix testing as specified in (A) above, at the ready-mix concrete plant.

Requirements of ready -mixed concrete specified in I.S. 4926 shall be followed except if and to the extent modified in this Specification.

#### 4.7.5. Compressive Strength Requirement for Trial Mixes

The compressive strength of a trial mix shall be considered satisfactory if the following requirements are met: -

- a) The six cubes from the three batches of a trial mix that are tested at 28 days age shall have an average compressive strength not less than
- b)  $f_{cu} + (1.65 \times S)$

where:  $f_{cu}$  is the required characteristic strength in  $N/mm^2$


S is standard deviation as per table 8 of IS 456.

For all cubes tested for strength, the density of the concrete represented by the cube shall first be determined before testing for strength.

#### 4.7.6. Workability

Concrete shall be cohesive so that it does not segregate and of such consistency as to ensure full compaction by the means being used and such that it can be readily worked into the



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corners and angles of the formwork and around reinforcement without segregation of the materials or bleeding of free water at the surface. On striking the formwork it shall present a face which is uniform, free from honeycombing, surface crazing, or excessive dusting, and which shall not, in the opinion of the Engineer, be inferior to the standard specified.

To satisfy the Engineer that the workability of the proposed mixes is adequate for the requirements of the Specification, the Contractor shall carry out a series of workability tests on the preliminary trial mixes. The tests shall be carried out in accordance with I.S. 1199, or such other procedure as may be approved by the Engineer. The samples to be tested shall be obtained from the batches used for the preliminary test cubes.

In addition, the Contractor shall supply for each of the grades of concrete a section of formwork complete with reinforcement fixed in position and generally representative of the sections commonly to be employed in the Works. The capacity of this trial section of formwork shall be at least half a batch of concrete, but in any case, not less than half a cubic metre. The formwork shall comply with the requirements specified. The moulds shall be filled in the presence of the Engineer with concrete of the same mix and batch from which the preliminary test cubes are made and shall be compacted in the same manner and with the same equipment as are proposed for the Works. This procedure shall, if necessary, be repeated with modified mixes until the appearance of the concrete after striking the mould is acceptable to the Engineer, after which it shall be used as the standard for that grade.

Workability of production concrete mixes shall also be checked at the place of concrete deposition for each pour.


#### 4.7.7. Alteration of Mix Proportions

If during the period of the Contract the Contractor wishes to alter the proportions of any mix or any constituent of the mix or the source of any constituent, he shall obtain the prior permission of the Engineer in each case. Additionally, if experience shows that any previously approved mix when used in the Works is inconsistent with satisfying the requirements of this Specification, then the Engineer may withdraw approval for this mix and direct the Contractor to produce an alternative. In either case the Engineer will require that additional trial mixes for the altered mixes be made and tested, all-in accordance with the requirements of the preceding Clauses.

#### 4.7.8. Minimising the Risk of Damaging Alkali-Silica Reaction

The Contractor shall submit to the Engineer for approval his proposals for minimising the risk of alkali-silica reaction which shall include the results of tests on the aggregates he proposes to use, the test being carried out according to I.S. 2386 (Part VII) - Alkali aggregate reactivity, using the cement proposed to be used in the Works. Generally, basalts are of low reactivity.



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Aggregates which are chemically reactive with alkalis of cement shall not be used.

#### 4.7.9. Temperature of Concrete

The strengths specified to be reached at 28 days or other earlier ages refer to test cubes tested at the temperatures specified in I.S. 516. In order to allow for the effect of temperature outside this range which may occur during the mixing and curing of concrete, the Contractor shall prepare for the Engineer's approval a table or graph showing the probable variation of characteristic strengths with temperature for each grade of concrete to be used in the Works taking the characteristic strengths quoted in this Specification at the temperature at test specified in I.S. 516 or if not specified at 20°C as a datum.

Once agreed these tables or graphs shall be used as a basis for the assessment of strength of concrete where the concrete was wholly or partly mixed and cured with temperatures outside the range specified in I.S. 516. Similar sets of tables or graphs shall be prepared for approval for the strengths at appropriate earlier ages.

#### 4.7.10. Drying Shrinkage

The Total Drying Shrinkage Strain of all the proposed concrete mixes, prepared and tested under approved conditions in the laboratory on the Site or in an approved independent laboratory, in accordance with I.S. 6441 (Part II) (As appropriate) / BS 812-120, shall not exceed the limits given in concrete mix-schedule.

### 4.8. Batching

#### 4.8.1. Approval of Concrete Batching Methods


The Contractor's concrete batching and mixing plant shall conform to I.S. 4925. The Contractor's arrangements for handling, batching, transporting and mixing of materials for concrete, together with all control procedures, shall receive approval in principle from the Engineer before any work commences on site.

Detailed arrangements and Contractor's personnel involved shall be approved by the Engineer before any concrete is mixed for the Permanent Works.

#### 4.8.2. Batching of Materials

All materials for concrete shall be batched separately and by weight.

The grading of coarse and fine aggregate shall be checked as frequently as directed by the Engineer to ensure maintaining it in accordance with the grading used in approved mix design.

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#### 4.8.3. Weigh Batching Plant

Weigh batching plant shall control delivery of cement, aggregates and bulk admixture to an accuracy of not worse than  $\pm 2\%$  on the individual weighment. For added water the accuracy shall be within  $\pm 1\%$  and for any dose-type additive the accuracy shall be within  $\pm 5\%$ .

The weighing mechanism shall be checked and adjusted monthly, and the Contractor shall provide simple and convenient means for this. He shall supply to the Engineer on request records of all check tests and adjustments made to the plant. The Engineer may at any time call for a check test to be made.

The weigh batcher shall be maintained in a clean, serviceable condition. It shall be set up level on a firm base and the hopper shall be loaded evenly. The needle shall be adjusted to zero when the hopper is empty.

#### 4.8.4. Water Content

Due allowance shall be made for the weight of the moisture content of the coarse and fine aggregates and the Contractor shall make readily available to the Engineer assistance and equipment as required to carry out moisture content tests according to I.S. 2386 (Part 3), at intervals deemed necessary by the Engineer to suit local weather conditions. In general, the moisture content of the coarse aggregates and fine aggregates shall be ascertained daily and at any other times when alteration of the moisture content may be expected due to new deliveries of aggregates, inclement weather or any other reason.

The amount of water used shall also take into account the moisture content of the aggregates.

To allow for the variation in mass of aggregate due to variation in their moisture content, suitable adjustments in the masses of aggregates shall also be made.


Water shall not be added to the mixer until just prior to the time when the concrete is to be mixed.

#### 4.8.5. Cement Batching

If the cement is delivered in bags or individual containers, the sizes of batches shall be such that only full bags or containers of cement shall be used.

#### 4.8.6. Rejection of Batched Materials

Notwithstanding his previously given approval of the contents of any storage area, the Engineer may order the removal of any batch of cement and/or aggregates prepared for

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charging into the mixers if he has reason to believe that such a batch is contaminated in any way or the aggregates in the batch are improperly graded.

#### **4.9. Mixing**

##### **4.9.1. Mixing Plant**

Concrete shall be mixed in mechanical mixers complying with I.S. 1791 (batch type mixers). Water shall be fed into the mixers from a tank fitted with water measuring device and means of adjusting the flow of water. The type and manufacture of these mixers, together with all associated plant, shall be subject to the approval of the Engineer.

Where small quantities of high-grade concrete are required the Contractor shall, if the Engineer so requires, provide small, portable, covered pan mixers complying with I.S. 12119 of approved type for this particular work. In such case the mix shall be adjusted to whole bags of cement and no splitting of bags will be allowed.

Such covered pan mixers shall only be used as the Engineer may direct and all the conditions covering the mixing of concrete for large scale concreting shall apply to any mix prepared in pan mixers.

Mixers shall be set up level on a firm base or floating pontoon in case of floating batching plant and maintained within the manufacturer's tolerances, with particular attention to mixing blade clearances and sizes, throughout the period of the Contract and any mixer or plant that is not so maintained or is faulty in any respect shall be removed from the Site.


All mixing plant, truck mixers and concrete delivery vehicles shall be wind proof. The requirements of Clause shall apply in hot weather conditions.

Before beginning concrete mixing operations, all hardened concrete and foreign materials shall be removed from inner surface of mixing and conveying equipment. All conveyances, buggies, barrows shall be thoroughly cleaned at frequent intervals during placing of concrete.

##### **4.9.2. Mixing Requirements**

The maximum size of the batch shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and as stamped on the mixer and the batch size shall not be less than 75% of such maximum.

Mixing shall begin immediately after the cement has been added, either to the water or aggregate, and shall continue until there is a uniform distribution of the materials and the mass is uniform in colour and consistency or as directed by the Engineer. In any event, concrete shall be mixed for at least 2 minutes or for the period and at the drum speed

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specified by the manufacturer of the mixer. Concrete shall be discharged from the mixer on to a level, clean, water-free platform or floor or into water-tight receptacles. The area surrounding the mixer shall be paved and kept clean. When skips or mobile concrete carriers are used, concrete may be directly discharged from the mixer into the skips or rotating drums of mobile carriers.

If there is segregation after unloading from the mixer, the concrete shall be remixed if approved by the Engineer, otherwise the mixed batch shall be rejected.

The entire contents of the mixer shall be removed from the drum before materials for a succeeding batch are placed in it. The solid materials composing a batch shall be deposited in the mixer in accordance with the manufacturer's directions for use.

Within 60 minutes after the introduction of the mixing water to the cement and aggregate, or the cement to the aggregate, the concrete shall be placed in its final position in the forms and fully compacted, except that this period may be extended with the prior permission of the Engineer provided the weather conditions are favourable and the concrete is continuously agitated in an approved purpose-built supply vehicle or an approved retarding admixture is included in the mix. If an initial set should take place, the concrete shall be rejected.


If any mixer is out of operation for more than 20 minutes, it shall be thoroughly cleaned out together with all the handling plant, before any further concrete is mixed and the first batch on recommencing shall have 10% additional cement to allow for sticking in the drum. This shall also be followed at the end of each shift of concrete mixing operation and for the first batch of concrete of the subsequent shift. All mixing and handling plant shall be thoroughly cleaned out before concrete, using a different type of cement or admixture is used.

#### 4.9.3. Hand Mixing

Normally hand mixing of concrete will not be allowed, but where the total quantity is small, the mixing may be done by hand but only with the express permission of the Engineer.

For hand mixing the quantity of cement for any given concrete mix shall be increased by ten per cent and not more than one quarter of a cubic metre shall be mixed at one time. The water/cement ratio shall not exceed that approved for the particular grade of concrete concerned. Hand mixing shall not be permitted for any structural concrete or where there is a particular requirement for the concrete to be durable.

Hand mixing of concrete shall be done on a hard, even and impervious surface of adequate size. The materials shall be turned over not less than three times dry. A measured quantity

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of water shall then be added through a rose while the materials are being turned over not less than three times in a wet state and worked together until a mixture of uniform consistency is obtained.

#### **4.10. Transportation, Placing and Compaction**

##### **4.10.1. Plant and Equipment**

The Contractor shall provide adequate means of transporting and placing mixed concrete in sufficient quantities to meet the programme. All plant and equipment shall be properly designed and constructed with regard to the efficient and rapid placing of the concrete and the safety of the Works and shall be approved by the Engineer before being used. All plant and equipment used for transport and deposition of concrete shall be kept clean and shall be washed out after each interruption in the work and at the end of each shift.

Any proposal for placing concrete by tremie or the use of a concrete pump or placer and associated equipment shall be submitted to the Engineer, together with the fullest possible description of the apparatus and methods to be used. Trials may be required to demonstrate their suitability and that the concrete mix design is appropriate to this method of placing. The Contractor is to ensure that he has adequate back-up facilities to continue placing concrete if a mechanical breakdown occurs.

##### **4.10.2. Transportation of Concrete**


The contents of the mixer shall be discharged in one continuous operation and the concrete transported in such a manner that there shall be no segregation of its constituents. If, in the opinion of the Engineer, any segregation of the concrete materials has taken place during transport, the concrete shall be again turned over and mixed just before it is finally placed in position. No water shall be added to the concrete between the time of mixing and placing.

Whilst being transported from the mixer to the site of placing, all concrete shall be properly protected from loss of any of the ingredients, contamination by dust, sand or other foreign matter and from excessive moisture gain or loss from rainfall or high temperature, and all equipment used shall be purpose-made for the correct transportation of concrete.

During hot weather, concrete shall be transported in deep containers; other suitable methods to reduce the loss of water by evaporation may also be adopted.

##### **4.10.3. Preparation for Placing**

In preparation for the placing of concrete, all construction debris and extraneous matter shall be removed from the interior of forms. Standing water on areas to receive concrete shall be removed before concrete is placed. All exposed reinforcement shall be free from

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loose rust, scale and windblown salts and spray.

Placing of concrete shall not be commenced until the Engineer has inspected and passed the formwork or other areas to receive concrete and any reinforcement, cast in fixings etc., against which the concrete is to be placed. Any approval so given shall not relieve the Contractor of any of his responsibilities under the Contract.

Where concrete is to be cast against an existing concrete face, that face shall have been prepared to expose the aggregate and all loose particles removed. This surface shall be wetted prior to receiving concrete. This preparation shall be subject to inspection by the Engineer.

Preparation for placing under water concrete is specified separately elsewhere in this specification.

#### 4.10.4. Placing of Concrete


Concrete shall be placed and compacted in the shortest possible time after mixing is completed and before it has taken an initial set. It shall be placed as close as possible to its final position to avoid segregation of materials and displacement of reinforcement. Freshly laid concrete shall not be wheeled over or otherwise disturbed. When depositing concrete adjacent to a construction joint, special care should be taken not to disturb the dowels or other reinforcing bars projecting from the existing concrete.

Normally concrete may be deposited with a maximum free fall of 1.5 metres without the use of pipes / chutes / elephant trunks, provided suitable measures are taken to prevent segregation and premature coating of upper reinforcing steel. When pipes are used, they shall, as far as is practicable, be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. In certain circumstances greater heights than 1.5 metres may be allowed but only with the written authority of the Engineer following trials to establish the effect on the concrete.

Chutes may also be used and shall be of steel or steel lined. They shall be constantly kept clean from coatings or hardened concrete or other obstructions. Chutes shall not be set at such an angle that the concrete sticks to them or becomes segregated. Normally, chutes at an angle of more than 45 degrees to the horizontal will not be permitted.

Concreting of any section or unit of the work shall be carried out in one continuous operation between approved construction joints and no interruption of the concreting will be allowed without the approval of the Engineer. Sequence of placing shall be such as to avoid disturbance of partially set concrete.

In cases where the approval of the Engineer is obtained and where delays of more than one

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hour occur between successive concreting when, in the opinion of the Engineer, the previously placed concrete has had time to harden; the resulting joint shall be treated as a Construction Joint. The previously placed concrete shall be cut back to a vertical and/or horizontal face and the joint face treated as specified for construction joints, before placing the new concrete.

Where open ended pipes are cast in, care shall be taken that concrete cannot enter into the pipes.

Except when placing with slip forms each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete, before the start of subsequent placement. Placing shall stop when concrete reaches the top of any opening in walls or the bottom surface of slab in beam and slab construction, and it shall be resumed before concrete takes its initial set but not until it has had time to settle as determined by the Engineer.

In the event of rain storms or other severe weather conditions arising, concreting shall be stopped and appropriate temporary stop ends, vee grooves etc., placed as may be necessary and concrete shall be covered with tarpaulins immediately. To meet such circumstances, the Contractor shall always have in readiness approved framed sheeting, tarpaulins, etc., for the protection of newly placed concrete. Should any concrete be damaged due to rain storms or other weather conditions, the Engineer may order the cutting out and replacement of the damaged concrete, all at the expense of the Contractor.

Except where arrangements, approved by the Engineer are made for placing concrete under water, the areas on which concrete is to be deposited shall be made and kept free from standing water during concreting operations and running water crossing or entering such areas shall be brought under control for at least 12 hours after concreting is completed.


Placing of concrete under water by tremie or pumping or by a placer is specified separately elsewhere in this Specification.

#### 4.10.5. Compaction of Concrete

After concrete has been placed it shall be thoroughly compacted by mechanical vibration applied by immersion vibrators complying with I.S. 2505 or, for surface finishing on thin slabs, approved surface vibrators or vibrating tampers complying with I.S. 2506 / I.S. 2514. Form vibrators if approved for use shall comply with I.S. 4656. Vibrators shall only be used by competent operators properly trained in the correct handling of the particular equipment in use on the Site.

Immersion vibrators shall run at a frequency of not less than 120 Hz when immersed. The



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active part of the vibrator shall be fully immersed while in use and vibration shall be of sufficient duration and intensity to compact the concrete thoroughly but shall not be continued at any one point to the extent that segregation occurs. Vibrators shall not be used to transport concrete in the forms. Vibrators shall be manipulated so as to work thoroughly the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms so that all entrained air is expelled and the concrete surface when exposed is found good and free from air pockets, honeycombing or other defects. Re-tamping of concrete or mortar which has partially hardened shall not be permitted. Concrete once vibrated shall not be vibrated again. Impression vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers. Vibrators shall not be applied directly, or through the reinforcement or formwork, to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. Use of impression vibrators for compacting concrete shall follow the recommendations of I.S. 3558.

Whenever vibration has to be applied externally, the design of the formwork and the disposition of vibrators shall receive special attention to ensure efficient compaction and to avoid surface blemishes.

Every care shall be taken to see that reinforcement, and fittings attached to the shutters are not disturbed and that no damage is caused to the internal face of the shutters when using immersion type vibrators.

Over-vibration shall be avoided.


Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.

The Contractor's attention is drawn to the importance of achieving a high degree of compaction in order to produce as dense a concrete as possible, but not over vibrating concrete against shutters thus causing an increase in the water/cement ratio local to the shutter.

When casting against existing concrete surfaces compaction should be ensured by local use of vibration to remove pockets of air that may be trapped, especially under horizontal surfaces.

The requirements of this Clause do not apply in case of concrete placed under water.



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#### 4.10.6. Setting Concrete

After the initial set of the concrete the forms shall not be jarred, and no strain shall be placed on the ends of reinforcing bars which project. Adjacent works, which may cause vibrations to be transmitted to any setting concrete, may be ordered to be stopped at the discretion of the Engineer.

#### 4.10.7. Records of Concrete Placing

The Contractor shall maintain a Concrete Pour Checklist, the format of which shall be as that shown in Appendix B (At the end of this section) of this document. Unless otherwise directed by the Engineer, this checklist shall be completed in advance of each pour, and submitted to the Engineer within a reasonable time, to permit an inspection before concreting operations commence.

The Contractor shall also keep a record of the date, time, shade air temperature, mix temperature, mix type and samples taken, along with a record of the quantity and place of deposition in a Concrete Pour Card, the format of which shall be as that shown in Appendix 9B of this document.

The Engineer shall be permitted to inspect or request copies of these records at any time.


#### 4.10.8. Hot Weather Concreting

Concreting during hot weather shall be carried out as per I.S. 7861 (Part 1). Specific arrangements shall be agreed with the Engineer for controlling the temperature of fresh concrete. These arrangements shall include night or early morning working, prior cooling and/or shading of reinforcement and forms, shading of aggregate stockpiles, and shading of placed concrete from direct rays of the sun. The Contractor shall further note that the times quoted for mixing and placing and the frequency of cleaning of equipment may have to be modified in hot weather. Covering or other protection of concrete during transport may also be necessary. Trials shall be carried out to determine the adequacy of the control measures and the workability of the fresh concrete under those conditions.

Chillers shall be used to cool the mixing water. Ice shall not be used. The difference between the temperatures of the chilled water and the cement shall not exceed 34°C.

Temperature of concrete at the time of placement shall not exceed 34°C.

Unless otherwise directed by the Engineer, all items of equipment covered by this Clause shall be painted white to minimise solar heat absorption.

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#### 4.10.9. Protection against Rainfall

The Contractor shall provide adequate cover as necessary to protect concrete whilst being placed until it takes its initial set against damage from rainfall.

#### 4.10.10. Contractor's option for concreting in stages

If the contractor intends to carryout concreting of any elements in stages, he shall submit to the engineer all calculations, layout and detailed drawings necessary for construction in stages. All these calculations and drawings shall be approved by the Engineer/ Employer before commencement of concreting work in stages.

### 4.11. Curing

#### 4.11.1. General Requirements

The Contractor shall ensure that curing is carried out such that thermal and plastic cracking of the concrete does not occur.

Until a period of fourteen days has elapsed from the time of placing the concrete, the concrete shall be kept protected against loss of moisture, rapid temperature change, high internal thermal gradients, rain and flowing water, mechanical injury, vibration, impact, contamination by airborne dust and sand, drying winds and surface heating by the sun's rays. This curing period may be varied at the discretion of the Engineer.

Following the completion of the above period, a further period of controlled drying out will be required as directed by the Engineer. This may require that covers, sand layers and the like be kept in place for longer than the 14-day minimum curing period otherwise specified.


The Contractor's attention is particularly drawn to the importance of starting curing as early as possible after placing concrete and maintaining full curing procedures throughout, as specified and directed.

Any concrete which exhibits plastic settlement or plastic or drying shrinkage cracking or which has not been properly cured is liable to rejection by the Engineer.

The requirements of this Clause do not apply to concrete placed under water.

#### 4.11.2. Curing Methods

All methods to be used for curing and protection of freshly placed concrete must receive the prior approval of the Engineer. These methods shall include the use of curing membranes, continuous sprays of water or ponded water, or continuously saturated coverings of sacking,

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hessian, or other absorbent materials, shades and any other precautions that are required for the Contractor to ensure satisfactory curing of the concrete.

#### 4.11.3. Curing Membrane

Where used, curing membranes shall be of non-wax resin based white reflective type which shall not impair the concrete finish in any way and shall be sprayed on the surface of the concrete as soon as all free water has evaporated from the surface, except where provided for below. In the case of formed surfaces, where formwork has been eased or struck before fourteen days have elapsed from the date of placing concrete within them, the curing membranes shall be applied immediately after the formwork has been removed.

The curing compound to be used shall be approved from the Engineer before use. In every case the rate of coverage and method of application, preferably by spraying equipment, shall be according to the manufacturer's instructions to produce a smooth, even textured coat. Where a surface treatment is to be applied to the concrete (e.g., a surface hardener) a curing membrane shall only be used if it is compatible with the surface treatment.

#### 4.11.4. Water Curing


Where water curing is adopted, the concrete shall be covered with sacking, hessian, or other absorbent material, or a 75mm layer of sand, kept constantly wet for 14 days and, where directed by the Engineer, also covered with plastic sheeting to reduce loss by evaporation. Water for curing shall comply with Clause 4.5.1. Care shall be taken to ensure that the temperature of all water used at all stages of the curing process is as close as possible to that of the concrete being cured.

#### 4.11.5. Use of Covers

Curing of concrete surfaces may be carried out by sealing with opaque, reflective plastic sheeting held in close contact with the surface of the concrete and forming an airtight fit around the element being cured. The sheeting shall form a continuous seal and be without tears or holes. If necessary, the Contractor shall provide frames for the plastic sheeting so that the covers can be placed over deck slab pours immediately after the concrete has been floated off and before the brush finish is applied. Such frames can be removed as soon as the concrete is strong enough to support the plastic sheeting without leaving an impression in the concrete surface.

#### 4.11.6. Wetting of Formed Surfaces

Formed surfaces shall, to compensate for any surface drying that has occurred and as soon as the form is removed, be sprayed with water and allowed to reach a uniformly damp

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appearance before continuing with curing.

#### 4.11.7. Curing of Concrete in Hot Weather

When the daytime ambient temperature is greater than 25°C or at such other times as the Engineer may direct, for example, when there is a hot dry wind or low relative humidity, curing shall proceed as detailed below. Any necessary repairs or finishing processes shall be carried out as soon and as quickly as possible, only exposing a small area at any one time.

##### (a) Large Flat Areas, e.g. Slabs (Preferred Method)

- i) Immediately after the required surface finish is applied, cover the concrete surface with polythene sheeting supported by wooden frames to minimise evaporation. Suitable weights must be used at all the edges to keep the polythene sheet in place. All gaps at sides and ends must be filled in to avoid wind-tunnel effects.
- ii) When the surface can carry weight, replace the sheeting and frames by a layer of damp hessian laid directly on the concrete covered by polythene sheet. The hessian must be kept continuously damp for 14 days, (i.e., not wet/dry cycles), and suitable weights must be used to keep the polythene sheet in place.
- iii) After 14 days wet curing, 7 days cover-only curing is required, using suitable weights to keep covers in place.

##### (b) Alternative Method for Large Flat Areas (if potable water is in scarce supply)

- i) As item (a) (i) above.
- ii) When the surface can carry weight, apply white-pigmented non-wax resin- based curing compound as per the manufacturer's instructions. No curing compound shall be sprayed on construction joints.
- iii) Cover with dry hessian for 14 days.

##### (c) Flat Surface with Starter Bars


- i) As soon as concreting is complete, cure the surface with continuous sprays of water round the clock for 14 days.
- ii) Maintain cover-only curing from the 15th to the 21st day,
- iii) As item (a) (iii) above.

##### (d) Vertical Surfaces

- i) Leave formwork in place for at least 24 hours and keep it continuously wet, then, after removing the forms, immediately wet the surface as per Clause 4.11.6 and cover the sides with damp hessian (which is to be kept continuously damp for 14 days) or curing compound (as item (b) (ii) above), both of which are in turn to be covered by polythene sheet.
- ii) Maintain cover-only curing from the 15th to the 21st day.

#### 4.11.8. Thick Sections

The Contractor's attention is drawn to the need to take special precautions, such as careful

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planning of construction joint locations, to limit the build-up of heat in thick sections of concrete, particularly during hot weather. Locations of construction joints shall be subject to the approval by the Engineer.

#### 4.11.9. Curing Notices

Curing notices shall be exhibited for each concrete pour, stating the time and date when the concrete was placed, date for last wet curing and the date for completing of cover curing.

#### 4.11.10. Curing of Repairs

All concrete repairs shall be cured in accordance with this Section of the Specification.

### 4.12. Reinforcement

#### 4.12.1. Reinforcement Steel Specifications


Steel used for concrete reinforcement shall comply with the following Indian Standard Specifications:

I.S. 432 (Part 1)	Specification for mild steel and medium tensile steel bars and hard-drawn steel wires for concrete reinforcement. Bars shall be of Grade I quality complying with the conditions and tests of this Standard.
I.S. 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
I.S. 2062	Specification for steel for general structural purposes. Bars shall conform to Grade A of this Standard.
I.S. 1566 (Part I)	Specification for hard-drawn steel wire fabric for concrete reinforcement.

The reinforcement binding wires shall be of minimum 1.5 mm diameter or of the approved gauge soft annealed and conform to I.S. 280.

All reinforcement shall be clean, free from grease, oil, paint, dirt, loose mill scales, loose rust, dust, bituminous materials or other coatings which may destroy / reduce bond and shall be thoroughly cleaned before being fabricated. Pitted and defective rods or containing cracks or splits shall not be used.

Reinforcement of Corrosion Resistant (CRS) Grade Fe500 may be used in accordance with provisions of IS: 13920 and IS: 1786.

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#### 4.12.2. Testing of Reinforcement Steel

A manufacturer's test certificate shall accompany each consignment, a copy of which shall be handed to the Engineer before such reinforcement is incorporated in the Works. If directed by the Engineer, Samples shall also be tested by the Contractor at his cost in a laboratory approved by the Engineer, before the reinforcement, which the sample represents, is incorporated in the Works.

#### 4.12.3. Storage of Reinforcement Steel

Reinforcement shall be stored on racks clear of the ground/water and shall be protected to prevent accumulation of dust, windblown salt and sand and other harmful substances and from sea spray and saline atmosphere and shall be kept in clean condition until it is required to be used.

The separate types and sizes of bar reinforcement shall be stored in separate racks, the type and diameter being clearly marked in each case. Similarly, different sizes and arrangements of mesh shall also be stored separately and clearly marked in each case. Where large daily variations in ambient temperature and/or humidity occur, storage racks shall be enclosed in a light building.


#### 4.12.4. Cutting and Bending of Reinforcement

The Contractor shall prepare his own bar bending schedules on approved forms from the Drawings and his designs, if any. These shall also indicate the total weight of reinforcement covered in each schedule. They shall be in accordance with I.S. 2502 / I.S. 5525 and shall be submitted to the Engineer in triplicate for approval, at least two weeks before bars are to be cut and bent. The Engineer will check and return one copy with any corrections noted in red ink.

Notwithstanding any comments or approval of these schedules by the Engineer, it is the sole responsibility of the Contractor to ensure their accuracy and compliance with good detailing practice and, where appropriate, the Engineer's Drawings. The Contractor shall allow sufficient time and resources to ensure that any deficiencies in the reinforcement noted once it has been fixed can be rectified without delay to the programme.

Reinforcing bars supplied bent or in coils shall be straightened cold without damage at no extra cost. No bending shall be done when ambient temperature is below 5°C.

Reinforcing bars shall be accurately cut and bent to the shapes and sizes shown on the Contractor's schedules. All bars shall be bent cold unless the written permission of the Engineer is obtained for hot bending. Any reinforcing bar that has already been bent shall not be re-bent at the site of the original bend without the Engineer's permission. High strength

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deformed steel bars shall not be re-bent or re-straightened without the Engineer's permission.

Reinforcement shall be bent by gradual and uniform application of pressure by suitable machines to the forms and dimensions shown on the Contractor's schedules and in accordance with I.S. 2502. The former used for making the bends shall have diameter specified in I.S. 2502. No reinforcement shall be bent when in position in the Works without approval of Engineer whether or not it is partially embedded in hardened concrete. Any bending of reinforcement left projecting from a construction joint or precast element shall be done only at locations and in a manner approved by the Engineer and without damaging the concrete.

Bars which are not required to be bent as per approved schedules shall be truly straight. Stirrups and binders shall be bent to the radius of the bars against which they are to be in contact to fit closely around these bars.

Bars incorrectly bent may be used if approved by the Engineer only if the means used for straightening or re-bending have been approved by the Engineer.

Storage of cut and bent reinforcement shall comply with Clause 4.12.3. If instructed by the Engineer, the surface of the cut and bent reinforcement shall be treated with cement wash.

#### 4.12.5. Fixing of Reinforcement


Reinforcement shall be bent and fixed in accordance with I.S. 2502 and as amplified herein. The Contractor shall be responsible for maintaining the reinforcement in the correct position during concreting and compacting and to this end reinforcing bars shall be accurately fixed together as shown on the Drawings with such laps as are indicated, all to form a rigid cage. Bar crossings shall be secured tightly with at least one turn of binding wire, the ends of the wire being twisted together and bent away from the concrete surface and in no case shall encroach into the concrete cover. Every bar shall be secured in at least 2 places and in addition binding wire tying spacing shall be not greater than every fourth intersection along the bar length. Crossing bars shall not be tack-welded for assembly of reinforcement without the Engineer's permission.

Sufficient mild steel chairs shall be supplied to support rigidly the top reinforcement of all slabs. The legs of these chairs shall be kept off the bottom shutter by suitable cover blocks to provide the specified cover.

Substitution of reinforcement laps / splices not shown on the Drawings shall be subject to Engineer's approval. Splices / laps in adjacent bars shall be staggered.

Subject to the Engineer's approval, spacer units fixed to the reinforcement shall be used in all



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reinforced concrete to give the cover specified herein, on the Drawings or as directed.

Spacers and /or chairs shall be placed at a maximum spacing of 1m or at closer spacing as necessary.

No ferrous metal part of any device used for connecting bars or for maintaining reinforcement in the correct position shall remain within the specified minimum concrete cover to the reinforcement except where expressly instructed or provided for within the Contract. Within the concrete mass, different types of metal in Contact should be avoided to ensure that bi-metal corrosion does not take place.

No permanent spacers to reinforcement shall be allowed to affect the overall uniformity of the surface appearance of Class F2P surface finishes which shall, in any event, comply with the Specification requirements.

Reinforcement temporarily projecting from the concrete at construction or other joints shall be adequately supported and shall not be bent out of position unless expressly permitted or directed. No temporary supports to the reinforcement will be allowed to be incorporated in the finished concrete except for the mild steel chairs referred to above in this clause.

#### 4.12.6. Spacers

Spacers shall be as small as practicable with sides not exceeding 50mm for their purpose and shall be securely fixed in place, by approved means, to ensure that they will not be displaced during the placing, vibration or finishing of the concrete.

Favourable consideration will be given to the use of proprietary plastic or precast concrete spacers provided these are suitable for the particular use required.

Any precast spacer blocks approved for use shall be at least equal in strength to the body of the concrete in which they are being placed, with the largest size of aggregate limited to 10 mm, and the blocks cured for 14 days or more.

They shall be of equal durability and where used on an exposed face shall provide a good colour match as required under the preceding clause. Any blocks cast on site will normally be required to be of a similar mix to the main body of the concrete.

The use of spacer blocks with tying wires cast in will not normally be permitted but where approval for such blocks is given the wire shall be of plastic-coated stainless steel as approved by the Engineer, embedded in the centre of the block.

The vertical distances required between successive layers of bars in beams or similar



members shall be maintained by the provision of spacer bars at such intervals that the main bars do not perceptibly sag between adjacent space bars.

#### 4.12.7. Welding

Generally welding of reinforcement shall not be permitted. However, in specific cases, welding of reinforcement may be permitted provided the Engineer's written approval is obtained in each case. Where this is given welding shall be to I.S. 2751. Where butt welding is carried out the ends of the bars shall be prepared with single 45 deg. V and a backing plate shall be used. The minimum root face shall be one quarter of the bar diameter. Special precautions as specified by I.S. 2751 and the Engineer shall be taken in the welding of high strength deformed reinforcing bars. Prior to giving approval, the Engineer will require performance trials of samples of welded bars to be undertaken in an approved testing laboratory to prove that the joints are of the full strength of bars welded.

#### 4.12.8. Mechanical Joints

The use of mechanical joints and/or mechanical jointing systems for reinforcing bars shall be subject to the prior approval of the Engineer who shall be provided with full details of such joints together with the proposed locations for use and the methods of installation before making a decision. Notwithstanding the provision of such information the Engineer may direct that site tests be carried out on the use and strength of such joints.

#### 4.12.9. Concrete Cover

The minimum concrete cover to reinforcement including stirrups and binders shall be as follows:


Concrete permanently exposed to the elements, or buried	75 mm
Surfaces of pre-cast elements which are covered with in-situ concrete	50 mm for deck / 30mm for buildings

Provided always that the required minimum cover is maintained, the actual position of any bar and the distance between adjacent bars shall be that indicated on the Drawings with a tolerance of plus or minus 5 mm for bars of all diameters.

Tolerance on specified cover shall be (+) 5 mm, (-) 0 mm.

#### 4.12.10. Cleaning and Protection of Reinforcement

The Contractor shall ensure that all reinforcement is free from loose mill scale, excessive rusting or pitting, oil or grease, dust, salts, mud, paint, retarders, deposits or curing membrane, and other harmful matter immediately before concrete is placed. The Contractor

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shall take care to ensure that any matter cleaned off reinforcement does not become incorporated in the concrete or accumulate on other concrete surfaces.

Any reinforcement that the Engineer considers has become excessively rusted in storage or prior to casting in concrete shall be rejected and shall be removed from Site at the Contractor's expense.

Before concreting all reinforcement shall be carefully cleaned of all set or partially set concrete which may have been deposited thereon during previous concreting operations.

All reinforcement projecting from construction joints or likely to be exposed to the weather for long periods before concreting is commenced shall be covered with polythene, binding tape, cement grout or other materials to the satisfaction of the Engineer in order to prevent corrosion of reinforcement or staining of the surrounding concrete. Should, in spite of these precautions, rust staining occurs on any permanently visible surfaces, it shall be removed at once.

#### 4.12.11. Steel Fixer in Attendance

The tied in-place reinforcement shall be checked and approved by the Engineer prior to concrete placement.


During concreting a competent steel fitter shall be in attendance to adjust and correct the positioning of the reinforcement and other embedded fittings, before and during placing and compaction of concrete.

### 4.13. Formwork

#### 4.13.1. Formwork Construction

Formwork shall be rigidly constructed and shall ensure that the finished concrete is true to the required shape, position and level, and to the standard of finish specified. Formwork including the props (number, sizes and locations) shall be of suitable design and substantial construction to carry the loads and pressures due to the wet concrete and any incidental loads such as during concreting and compacting operations without excessive bulging, distortion, settlement, deflection, instability and joints shall be tight enough to prevent leakage of cement slurry and fines from the concrete and which can be stripped and removed without causing any blemish or jar to the concrete. Guidelines of I.S. 14687 shall be followed.

Formwork for recesses, keys, chamfers and radius strips, pockets, apertures, internal voids etc. and all bolts and fittings shall be accurately positioned and securely fixed before commencement of concreting such that they are not dislodged by the concreting operation,

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nor hinder the striking of forms.

The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering of beam and slab. Formwork shall be capable of being easily removed without shock disturbance or damage to the concrete. All forms shall be constructed with removable panels or openings to permit inspection of the inside of the formwork and to allow removal of debris i.e. chippings, shavings, wires, saw dust, dust, etc. and water from the interior of the forms before the concrete is placed. If the shuttering for a column is erected for the full height of the column, one side shall be built up in section, as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.5 m or as directed by the Engineer. The Contractor's attention is also drawn to the requirements of the clauses relating to Concrete Finishes that contain some particular requirements for formwork construction.

Formwork shall be securely braced, wedged and firmly supported. Folding wedges, where used for final adjustments shall be nailed together and to the props, struts or buttons to prevent their loosening during vibration.


All formworks shall be fixed to the proper lines and levels and trued up immediately before depositing the concrete.

The Contractor shall take into account the structural behaviour of the concrete elements being cast and shall ensure that the formwork and staging's are adequately stiff to support the concrete being placed at all stages of placing. Any eccentric loads shall be properly provided for. If so desired by the Engineer, the drawings and calculations for the design of the formwork shall be submitted to the Engineer for approval before erecting the same; however, the responsibility for the same shall be entirely of the Contractor.

Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse all forms shall be thoroughly scraped, cleaned, nails removed holes suitably plugged, joints repaired, and warped lumber replaced to the satisfaction of the Engineer. Contractor shall have enough shuttering to allow for wastage so as to complete the Works in time.

Formwork showing excessive distortion, during any stage of construction shall be removed and corrected / strengthened, prior to placement of concrete.

The requirements of formwork construction for concrete placed under water are specified separately elsewhere in this Specification.

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#### 4.13.2. Internal Ties

Wire ties shall not be allowed; instead bolts passing through plastic sleeves shall be used where permitted by the Engineer. The plastic sleeves shall not be nearer than 75 mm to the finished surface of the concrete. The bolt for this length of 75 mm shall be wrapped in plastic sheet for easy removal. Holes left by the removal of bolts shall be fully grouted under pressure to the full length with 1:2 cement: sand grout and neatly plugged with same mix flush with the surface and finished to the satisfaction of the Engineer.

#### 4.13.3. Permanent Void Formers

Permanent void formers, designed to remain in place after casting of concrete, shall be of a material approved by the Engineer.

#### 4.13.4. Chamfers

Except where specifically detailed on the Drawings or where further elements are to be placed against them, all exposed horizontal and vertical arises shall have a symmetrical chamfer.

This chamfer shall be 25 mm x 25 mm unless detailed otherwise on the Drawings.

#### 4.13.5. Preparation of Forms and Formwork

Before commencement of pouring concrete the faces of forms coming in contact with concrete shall be cleaned and interior of forms shall be thoroughly cleaned out of all materials mentioned in Clause 3.13.1 by approved means to the satisfaction of the Engineer. Where directed, cleaning of interior of forms shall be done by blasting with a jet of compressed air at no extra cost.

A thin uniform coating of approved mould oil or other approved material shall be applied before fixing reinforcement to all surfaces coming into contact with the concrete to allow easy removal of the forms without damage to the concrete. No mould oil or other lubricating medium shall be allowed to come into contact with the reinforcement and embedded steelwork. Any material that will adhere to, discolour or impair the finish to the concrete shall not be used.

Where necessary and approved by the Engineer, to prevent absorption from the concrete, the formwork shall be thoroughly wetted shortly before concreting is commenced.

Shuttering shall be thoroughly scraped, cleaned and, if necessary, repaired before being re-used. Any part of a formwork panel which the Engineer judges incapable of producing a

finish of the specified standard by reason of excessive use or the employment of sub-standard materials shall be replaced by the Contractor at his own expense.

#### 4.13.6. Removal of Formwork

Formwork shall not be disturbed or stripped, unless otherwise approved, until the following times have elapsed after the concrete has been poured:

Vertical formwork to beams, walls, piers, columns	24 hours.
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Soffit formwork to slabs, (with props left under)	3 days.
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Removal of props to slabs

i) Spanning up to 4.5 m	7 days
ii) Spanning over 4.5 m	14 days

Soffit formwork to beams (with props left under)	7 days.
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Removal of props to beams.

i) Spanning up to 6 m	14 days
ii) Spanning over 6 m	21 days

The above time periods are however subject to approval by the Engineer depending on the strength gain characteristics determined from testing of concrete test cubes with the particular cement being used. It is the Contractor's responsibility to ensure that the forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resists surface damage and any stresses arising during the construction period. Any damage resulting from premature removal of forms shall be made good by the Contractor at his own expense.

In case of elements with re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

In addition to the above, no loading (including self-weight) shall be imposed on the concrete which would cause a compressive bending stress greater than one-third of the concrete strength at the time of loading, or one-third of the 28-day strength, whichever is less.

Soffit formwork should be so designed as to facilitate striking, if required, without removal of props being necessary until the times stipulated above have elapsed.

The Contractor's attention is drawn to the need to maintain side shutters as insulation on large concrete pours to prevent surface cracking due to thermal effects. The Contractor's

proposals for stripping shutters on pours of greater than 25m<sup>3</sup> shall be submitted to the Engineer at least 2 weeks before the pour is due to be made.

No superimposed load shall be allowed on any part of the concrete work prior to the removal of the forms and props and/or until such loading is approved. Where concrete is to have filling placed against it the methods and materials of backfilling shall be approved by the Engineer.

Where there is a particular requirement for the early removal of formwork a procedure for establishing whether or not the concrete has reached the required strength shall be agreed with the Engineer beforehand. This shall be based on strength gain characteristics determined from testing of concrete test cubes.

At all times the Contractor shall delay the removal of the formwork if, in the opinion of the Engineer, the concrete contained has not attained sufficient strength.

#### 4.13.7. Tolerances for Concrete Surfaces


Permissible tolerances for concrete surfaces are given in Table 3-1 If permissible tolerances are exceeded, the acceptance or otherwise of the concrete shall be decided by the Engineer. If concrete is rejected, it shall be removed and replaced by the Contractor at his own cost.

The template to be used in determining the deviation in long dimensions shall be:

- a) For straight surfaces, 3m.
- b) For curved surfaces, 1.5m.

**Table 3-1 - Tolerances for Concrete Surfaces**

Type of Structure	Type of Irregularity	Tolerances mm			
		Type of Finish			
		Formed		Unformed	
		Class F1	Class F2	Floated	Tamped
General Exposed Concrete	Departure from alignment and grade as shown on the Drawings	+10 -10	+10 -10	+5 -5	+10 -10
	Variations in cross-sectional dimensions	+10 -5	+10 -10	NA	NA
	Abrupt	0	5	5	5
	Deviations from template in long dimensions	+5 -5	+10 -10	+10 -10	+10 -10
Exposed concrete where	Departure from alignment and grade as shown on Drawings	+5 -5	NA NA	+3 -3	NA
	Variations in cross-sectional	+5	NA	NA	NA

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steelwork is to be fixed; also, tolerance for cast in steelwork	dimensions	-3			
	Abrupt	3	NA	3	NA
	Deviation from template in long dimensions	+5 -5	NA	+3 -3	NA

(Note: NA denotes not applicable)

The tolerance in verticality for all types of finishes for walls, piers, and similar components shall be 0.05 degrees (i.e. approx. 1 in 1145).

#### 4.14. Finishes

##### 4.14.1. Formed Concrete Finishes

Formed concrete surface finishes shall be as follows: -

##### a) Class F1

This finish is formed for surfaces at construction joints. The surface produced shall be free from voids, honeycombing or other large blemishes, steps, sharp protrusions or local hollows. The shutters shall be removed as soon as possible without disturbing the concrete or reinforcement and the surface shall be well wire brushed and hosed down to remove all excess laitance and fine aggregate. Coarse aggregate is to be left exposed but undisturbed.


##### b) Class F2

This finish is for surfaces that are permanently exposed to view. The surface produced by the formwork shall have smooth finish, free from board marks, voids, honeycombing or other large blemishes. Any small blemishes shall be carefully filled immediately after the removal of the formwork and other marked imperfections such as fins or steps or joint marks shall be smoothed off and made good. To achieve this finish, lined wrought timber boards, plywood forms, steel panels or such other material as is approved by the Engineer shall be used. In large pours, the forms shall be of uniform size and be as large as practicable and arranged in an approved uniform pattern with vertical or horizontal joints, unless otherwise directed. Joints between the forms shall be carefully filled or sealed before concreting. The same type and brand of shutter release agent shall be used throughout the Contract on surfaces of forms where a Class F2 finish has been specified.

##### c) Class F2P

This finish is similar to Class F2 except that in addition to the requirements for Class F2 the formwork is to be lined with a proprietary controlled permeability formwork liner as specified in Clause 4.13.4. The same type and brand of controlled permeability formwork liner shall be used throughout the Contract on surfaces of forms where a Class F2P finish has been specified.



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**d) Class F3**

This finish is for surfaces not permanently exposed to view. The surface produced shall be free from voids, honeycombing or other large blemishes, steps, sharp protrusions or local hollows. The formwork may be sawn boards, metal panels or other approved suitable material.

**e) Class F4**

Surfaces of precast elements which are later to be in contact with in-situ concrete, shall be roughened by air-water jetting, between the period of initial and final set, to remove all laitance, cement slurry and fine aggregate. Coarse aggregate is to be left exposed but undisturbed.

#### 4.14.2. Remedial Treatment to Formed Surfaces

Any remedial treatment to formed surfaces shall be agreed with the Engineer following inspection immediately after removing the formwork and shall be carried out without delay unless otherwise specified or directed. Any concrete, the surface of which has been treated, before being inspected by the Engineer or has been treated by unapproved methods, shall be liable to rejection.

Normally, the only form of treatment which will be allowed for Class F2 concrete finish after removal of the formwork will be the filling of minor surface blemishes with a specially prepared approved cement and fine aggregate paste after removal of all loose materials and preparation of the surface by wetting or as directed by the Engineer and/or rubbing down with abrasive blocks and water to produce a smooth surface followed by a thorough washing down with water.


Apart from the filling of minor surface blemishes, as provided for above, plastering of defective concrete shall not be permitted. Any defective concrete finish will be rejected, and the Engineer may order the defects to be cut out and repaired or may reject the entire section incorporating the defective concrete finish.

Bonding between fresh and hardened concrete shall be done by applying an epoxy coat if so directed by the Engineer at no extra cost. The use of epoxy for bonding fresh concrete shall be carried out as directed by the Engineer.

All cement and fine aggregate pastes used for remedying formed concrete surfaces shall be designed to produce, as near as is possible and to the satisfaction of the Engineer, a good colour match with the main body of concrete.

If concrete is rejected, it shall be removed and replaced by the Contractor at his own cost.



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#### 4.14.3. Unformed Concrete Finishes

Unformed concrete finishes shall be as follows:

**a) Screeded Finish - Class U1**

A screeded finish shall be applied where indicated on the Drawings.

The concrete shall be levelled and screeded to produce a uniform surface to the profile shown on the Drawings.

Care shall be exercised not to work in excess fines to the top. Care shall be taken to ensure that the concrete is properly compacted and for this purpose vibrator screed boards or plates will normally be required. Slab concrete shall be tamped when it starts setting, to reduce shrinkage cracks.

**b) Floated Finish - Class U2**

A floated finish shall be applied where indicated on the Drawings. Steel floats shall be used unless otherwise approved or directed. Concrete shall be compacted and tamped as specified for class U1 finish.

Floating shall be done as soon as the concrete has hardened sufficiently and may be done by hand or machine. Care shall be taken that the concrete is worked not more than is necessary to avoid bringing excess fines to the top, to produce a uniform surface free from screed marks which is finished level or to the falls specified on the drawings.

**c) Brushed Finish - Class U3**


A brushed finish shall be applied to all unformed upper surfaces of concrete unless noted otherwise on the Drawings. The requirements of compacting, tamping and working concrete as specified for class U1 finish shall be applicable to this finish also.

The surfaces shall be finished to the levels and falls shown on the Drawings and shall be brushed with a stiff brush, as directed, to give a good running surface. A 100 mm wide strip at the edge of the slab and adjacent to all joints shall be finished smooth with a steel float.

The requirements for the surface finish of rigid concrete pavements shall be a brushed finish as defined above, subject to the approval of the Engineer.

#### 4.14.4. Protection of Surfaces

The Contractor shall ensure that permanently exposed concrete surfaces are protected from rust marks, spillage, stains or damage of any kind. Any marks or damage shall be removed or remedied, all to the satisfaction of the Engineer. In the case of severe damage that may

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affect the serviceability of the concrete section involved or where unsatisfactory appearance of permanently exposed surfaces may result from repairs, the Engineer may order the breaking out and reconstruction of any section.

#### **4.15. Joints**

##### **4.15.1. Construction Joints**

The position and form of construction joints, except where shown on the Drawings, shall be agreed with the Engineer before concreting begins. Normally no construction joints will be allowed within 600 mm below low water level or within 600 mm of the upper and lower levels of wave action. Unless otherwise directed they shall be made across planes of minimum shear. They shall be made only along a horizontal or vertical plane except that, in the case of inclined or curved members, they shall be at right angles to the principal axis of the member. There shall be no cold / construction joints in the casting of any precast elements.


Vertical construction joints shall be made against properly constructed stop-ends, firmly fixed and holed to permit the reinforcement to pass through, or by means of expanded metal. If expanded metal is used, it shall be kept back from the face of the concrete by a distance equal to the specified minimum concrete cover to reinforcement. It shall be securely held in position so as not to distort or move, in accordance with the requirements for normal formwork. It shall be left in position and new concrete placed against it when construction is resumed.

Horizontal construction joints in columns, walls, pedestals and like members shall show a clean straight line. Particular attention shall be paid to wedging of shutters against the previous lift to avoid unsightly lipping or runs.

All necessary steps shall be taken to ensure that good dense concrete is achieved against construction joints.

Prior to concreting, stop-ends may be treated with an approved surface retarder, instead of mould-oil, if required, to facilitate the exposing of the coarse aggregate. Such a retarder may also be applied after concreting to horizontal surfaces which subsequently are to form construction joints. All such uses of retarders for construction joint surfaces shall be subject to the prior approval of the Engineer.

Stop-ends shall be carefully removed, without disturbing the concrete and reinforcement, as soon as possible after concreting depending on the ambient temperature and curing conditions, as approved by the Engineer. Immediately on removal of the stop-ends, such concrete as passes through the stop end shall be hacked off and removed and the joint surface is to be well wire brushed / hacked if the concrete has set hard and hosed down with a high-pressure water jet in order to remove all laitance, cement slurry and fine aggregate. In lieu of

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hacking, hammering with an approved power operated "bush hammer" may also be adopted. When hacking or hammering great care shall be taken to avoid breaking the edges and arises of the joint face. Curing membranes and mould oil/release agents shall also be thoroughly removed from joint surface. Coarse aggregate is to be left exposed but undisturbed. Horizontal construction joints shall also be similarly treated immediately after initial setting of concrete, care being taken to avoid undue erosion of the mortar. After cleaning excess water shall be removed immediately, to limit absorption by concrete.

The positions of temporary stop-ends for vertical joints shall be as approved by the Engineer and the treatment of concrete surface at the stop-end shall be as for construction joints.

Where reinforcement bars up to 12 mm for high strength deformed steel bars and up to 16 mm for mild steel bars are bent aside at construction joints and afterwards bent back into their original positions, care shall be taken to ensure that at no time is the radius of the bend less than 4 bar diameters of plain mild steel or 6 bar diameters for deformed steel bars. Care shall also be taken when bending back bars to ensure that the concrete around the bars is not damaged.

When concreting is resumed against a construction joint prepared as above, the surface of the previously placed concrete shall be hosed down and the surplus water allowed to drain away so that the surface is in a clean saturated surface-dry condition before placing the new concrete.

Fresh concrete shall be thoroughly vibrated near, and against the construction joints to develop proper bond, by working the vibrator right up to the joint and into the angles and corners formed by the joint and the formwork.

#### 4.15.2. Movement Joints

The spacing, location, dimensions and construction of all movement joints shall be as shown on the Drawings, unless otherwise instructed by the Engineer.


#### 4.15.3. Debonding Coat

Where a debonding coat is required, e.g. at a movement joint between two concrete members, this shall be achieved by the use of an approved debonding membrane or bituminous paint.

#### 4.15.4. Pre-formed Joint Filler

Where pre-formed joint filler is detailed on the Drawings, for expansion or other joints, it shall comply with one of the specifications given below.

Joint filler shall be of the thickness shown on the Drawings with a tolerance of  $\pm 1.5$  mm,

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fixed in single thickness sheets, unless otherwise directed, being of suitable lengths, not less than 1.2 metres. Wherever possible joints shall be filled with a single sheet of filler, but where the size of the joint is such that two or more sheets have to be used, these sheets shall be cut and butt-jointed so that the edges are in continuous contact. The sheet joint shall then be wrapped in approved self-adhesive PVC jointing tape to prevent any grout leakage through the joint.

The pre-formed joint filler used for expansion or other joints shall be as detailed or directed and shall normally be non-extruding and resilient type bitumen impregnated fibreboard conforming to I.S. 1838 (Part I). Bitumen coat to concrete surface for fixing the joint filler shall conform to I.S. 702.

Where detailed or directed, bitumen-bonded cork shall be used as pre-formed joint filler, complying with the requirements of ASTM D1751. Where detailed or directed, low density cellular filler shall be used as pre-formed joint filler.

All the above products shall be from a reputable manufacturer and shall be subject to the approval of the Engineer.

#### 4.15.5. Joint Sealing Materials

Where detailed or directed, in particular for vertical or inclined joints, surface sealing of joints shall be by two-part, polysulphide liquid polymer sealant material, complying with the requirements of BS 4254 or equivalent I.S.


Where detailed or directed, hot-poured rubber/bitumen sealing compounds shall be used, for low movement horizontal joints only, complying with the requirements of Grade 'A' as per I.S. 1834.

For similar joints where the potential movement is outside the range of the hot poured rubber/bitumen sealing compounds, a suitable approved cold poured sealing compound shall be used complying relevant I.S. of a type approved by the Engineer.

All the above products shall be from a reputable manufacturer and shall be subject to the approval of the Engineer.

#### 4.15.6. Application of Joint Sealants

Grooves for joint sealants at movement joints shall be formed to the dimension indicated on the Drawings or as otherwise approved or directed by the Engineer. Joint sealants of expansion, movement or other joints, shall be applied to the dimensions indicated on the

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Drawings or as otherwise approved or directed by the Engineer.

All joint sealants shall be mixed and applied strictly in accordance with the manufacturer's instructions and the requirements of this Specification.

Immediately prior to permanent sealing, the groove shall be thoroughly cleaned and any dirt or loose material or any temporary sealing former or other filling material, grease or oil shall be removed. The surfaces of the groove shall be dry at the time of sealing. Any spalling at the edges of the grooves shall be repaired to the satisfaction of the Engineer using an approved material, compatible with the sealant, before the sealant is applied, and care shall be taken not to damage the edges of the groove during sealing. If recommended by the manufacturer or directed by the Engineer the groove shall be primed with an approved priming compound compatible with the sealant, and/or an approved bond breaker strip shall be applied to the back of the joint cavity before sealing.

Unless otherwise detailed or directed, sealants shall be applied so as to be 5 mm below the concrete surface.

#### **4.16. Testing and Control**

##### **4.16.1. Inspection and Tests**

The Contractor shall ensure that the Engineer is offered all facilities and assistance for the inspection of materials, storage, manufacture of concrete and precast concrete, workmanship and testing, and for carrying out all tests as specified or as instructed.

The following documentation shall be maintained at Site: -

- a) Test reports and manufacturer's certificate for materials, concrete mix design details.
- b) Pour cards for clearance of concrete placement.
- c) Records of Site inspection & workmanship, field tests.
- d) Non-conformance reports, change orders.

##### **4.16.2. Control of Mix Proportions**

A check on the moisture content of the aggregate shall be made as required by this Specification for the purpose of assessing the amount of free water to be added at the mixer. The Contractor shall provide himself with a chart, a copy of which shall be given to the Engineer for approval, relating moisture content in the aggregate to water to be added at the mixer for all grades of concrete in use.

Full supervision of the concrete batching and mixing shall be provided by the Contractor to ensure correct proportions of all the various constituent materials. The Contractor shall maintain records of the proportions of various constituents of each batch. If required by the Engineer, equipment shall be installed and maintained for making autographic records of the

constituent materials of each batch. Control shall ensure that the proportions are within the tolerances laid down in this Specification.

The Engineer may direct that checking of mix proportions used shall be made by analysis of hardened concrete in accordance with I.S. 1199.

#### 4.16.3. Determination of Fresh Concrete Temperature

In order to satisfy the requirements of this Specification for measurement of fresh concrete temperature, the following method shall be adopted: -

Within 2 minutes of taking a sample, a type A 100 mm immersion thermometer supplied by the Contractor having a range -5°C to +110°C, graduated at each 1°C and complying with BS 1704, shall be inserted in the sample to a depth of at least 100 mm. When steady conditions have been maintained for 1 minute the temperature shall be recorded to the nearest 1°C.

Unless otherwise directed by the Engineer, the above test shall be carried out on each delivery of concrete that is to be placed in the Works, at the point of delivery.

Temperature records, together with records of humidity and wind speed, shall be submitted daily.

#### 4.16.4. Sampling of Concrete for Strength and Workability Testing


All sampling of concrete and making of test cubes shall be in accordance with the requirements of I.S. 1199, I.S. 516. All such sampling shall be carried out by the Contractor at the site of placing of concrete in the Works.

Sampling for making test cubes shall be carried out in accordance with the following table: -

Quantity of concrete placed of each concrete grade in one continuous Operation, m <sup>3</sup>	Number of Samples
1 - 5	1
6 - 15	2
16 - 30	3
31 - 50	4
51 and above	4 plus 1 additional sample for each additional 50 m <sup>3</sup> or part thereof

Note: - At least one sample shall be taken from each shift. If the concrete is supplied from a ready-mixed concrete plant, the frequency of sampling shall be agreed upon mutually by the Supplier and Engineer

From each sample, taken as provided for above, six 150 mm cubes shall be made for testing for strength.

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Cubes required by the Contractor for his own use in determining the rate of increase of strength or other properties of any mass of concrete shall be considered as additional to the minimum six routine test cubes.

All cubes shall be marked at the time of casting with a serial number, the date, the grade of concrete and other necessary marks to identify the part of the Works from which such cubes were taken. A separate record shall be kept relating each cube to the part of the Works from which it was taken, the type and consignment number of cement from which the cube was made, particulars of aggregate, the water / cement ratio and slump. Workability (slump) of concrete of each sample shall be tested according to I.S. 1199 and recorded.

#### 4.16.5. Curing of Concrete Test Cubes

Concrete test cubes shall be cured in accordance with the requirements of I.S. 1199, I.S. 516 / BS 1881. If required, additional test cubes, made as provided for above, shall be cured in conditions designed to approximate closely to the conditions being experienced by the mass of concrete from which the cubes were taken. However, the results of any tests carried out on such cubes shall only be used for comparison purposes and not as the basis for acceptance or rejection of any concrete in the Works.

#### 4.16.6. Testing and Strength Requirements for Test Cubes

All concrete test cubes shall be crushed to determine compressive strength in accordance with the requirements of I.S. 516. For all cubes tested for strength, the density of the concrete represented by the cube shall first be determined before testing for strength.

For each set of six test cubes, three shall be tested at 28 days and the remaining three shall be tested at an earlier age, as directed by the Engineer. This earlier age shall normally be 7 days. The results of the tests made at 28 days shall be the basis of the standard of acceptance for concrete strength unless the Engineer directs that tests at an earlier age shall form this basis.


Each cube from the three shall be tested and the average of the three results shall be defined as the “test result” for that concrete sample at that age.

Compliance with the characteristic strength requirement for that grade of concrete shall be assumed if the “test results” from 28 days (or such earlier age tests as may be specified by the Engineer) meet all the conditions given in the respective clause.

#### 4.16.7. Records

Cube test results shall be submitted in duplicate to the Engineer on standard certificate forms completed in ink and signed by both the laboratory manager and the Employer’s Engineer.



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They shall be presented to the Engineer as soon as possible after the test results are known to the Contractor.

Works Cube Test Certificates, when presented to the Engineer, shall include the following information: -

- a) The date of casting the cubes
- b) The date of testing the cubes
- c) The age of cubes when tested.
- d) A note of any marks on the cubes
- e) The part of the Works from which the cubes were taken.
- f) The aggregate, type of cement and admixtures used and specified grade of concrete.
- g) The mixer employed (Site plant or ready-mixed concrete supplier)
- h) The curing conditions, including temperature.
- i) The conditions of the cubes when put into the testing machine.
- j) The weights of the cubes
- k) The volume of the cubes, determined by displacement.
- l) Density
- m) The compressive strengths
- n) The appearance of the concrete and the nature of the fracture if these are unusual.

In addition to the above detailed records, the Contractor shall make such records, in a standard form to be agreed with the Engineer, to show the long term performance of the concrete for each grade with regard to strength and such other properties as can be assessed on this basis. These records shall be made available to the Engineer and may be used when assessing the need to change mix proportions, as provided for elsewhere in this Specification.


The results of all other routine tests, as required under this Specification, shall also be recorded in a standard form, to be agreed with the Engineer, and shall be submitted on a regular basis, all as directed by the Engineer.

#### 4.16.8. Non-Destructive Testing

All methods of non-destructive testing of the hardened concrete in the Works shall comply with I.S. 13311 where applicable and shall be subject to the approval of the Engineer and any information submitted prior to approval shall include details of the calibration of the tests and shall show how the tests are able to indicate the desired properties of the concrete.

Where approved or directed by the Engineer such non-destructive testing methods may be used in the event of failure to meet the strength requirements by Works test cubes, as provided for above. Such methods may also be used in the routine control procedures if approved or directed by the Engineer.



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#### 4.16.9. Concrete Core Testing

As and where directed by the Engineer, following the failure by Works test cubes to meet the strength requirements or at such other times when the Engineer has reason to doubt the standard of the concrete placed in the Works, cylindrical core specimens, not fewer than three, shall be cut from the hardened concrete in the Works from locations selected by the Engineer for the purpose of examination and testing.

The cutting equipment and method shall be subject to the approval of the Engineer and shall, unless otherwise directed or approved, produce specimens of diameter 150 mm and height 300 mm.

If required by the Engineer ultrasonic testing of the concrete to I.S. 13311 (Part 1) shall be used to determine abnormalities or density changes within the concrete and to determine the location where cores will be taken.


All examination, preparation and testing of such Core specimens shall be carried out in accordance with the requirements of I.S. 516 and prior to testing the specimens shall be made available for examination by the Engineer.

Cores from suspect areas shall be tested as required by the Engineer, those tests will include:

- Analysis of hardened concrete to I.S. 1199
- Testing concrete core compressive strength to I.S. 516

A full report of examination and testing results, as required by above standards, shall be submitted to the Engineer for each specimen and the Engineer will then decide what further action may be required. In general, the criteria for acceptance of core compressive strength test results shall be as given in I.S. 456.

The Engineer's/ Employer's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the Contractor. For any work did not accept the Engineer may review and decide (i) whether remedial measures are feasible so as to render the work acceptable. The Engineer in that case shall direct the Contractor to undertake and execute the remedial measures, these shall be expeditiously and effectively executed by the Contractor at his own cost, or (ii) reject the work and instruct the rejected portion of the Works to be cut out and replaced at the Contractor's expense, all as per Engineer's directions. In case the Works are accepted in spite of deviation from the Specification, the Engineer may make a reduction in rate of appropriate items with the consent of Employer.

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#### **4.17. Precast**

##### **4.17.1. General**

All precast concrete shall comply with the previous sections of this Specification.

All precast concrete units, hereinafter referred to in this Clause as ‘units’, shall be indelibly marked in an agreed location with a unique reference number that includes its type, the date of casting and identification of the manufacturer.

Precast units should have the strength of M40 grade concrete and reinforcement of grade Fe-415 as per IS: 1786. Cover to the main reinforcement shall be 20 mm.

All precast units shall be cast on, or their shutters supported from a suitably prepared level unyielding paved area.


Units shall be stored in a manner such that additional bending stresses in the units are prevented. The accumulation of trapped water and deleterious matter in the units shall be prevented. Care shall be taken to avoid rust staining, efflorescence and the effects of salt spray.

Units shall not be lifted, transported or used in the Works until they are sufficiently mature as evidenced from the cube test results. Units shall be lifted or supported only at designated lifting and support points. Units shall be stored on hard paved area which is not liable to settlement. Units shall be handled and placed without impact. At all stages of construction, units shall be properly protected to prevent damage to concrete surfaces especially arises and other features.

##### **4.17.2. Contractor's Option to Precast**

In addition to those sections of the Works where the Drawings indicate the use of precast construction, and provided that his proposals meet the Engineer's approval, the Contractor may opt, at Tender stage, to precast any sections which are shown on the Drawings as in situ concrete.

If the Contractor wishes to exercise this option, then, following approval in principle as required above, he shall submit to the Engineer all calculations and layout and detail drawings necessary for the manufacture and installation of the precast units and for the completion of each section of the Works to satisfy the original design requirements. All these calculations and drawings shall be approved by the Engineer before any work is commenced on the manufacture of precast concrete units. The concrete and the steel quantity for the converted units shall not exceed the one provided in the tender drawings and BOQ.

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#### 4.17.3. Drawings and Schedule of Weight

The Contractor will be required, before commencing work on precast concrete to prepare layout drawings of each section of the work showing units to be produced. Detail drawings shall also be prepared for each type of unit showing in detail the grade of concrete, finishes to concrete, joint details, reinforcement, joggles, mortices for dowels, clamps, cramps, lifting hooks and the like. These drawings are to convey faithfully the Engineer's intention and are to be submitted to the Engineer for approval before production of units or moulds etc. begins.

The Contractor shall also supply to the Engineer, as soon as possible after the start of the Contract, a schedule of weights for each type of unit.

#### 4.17.4. Approval of Plant and Working Methods

Full details of the plant and equipment to be used and method and location of precast concrete manufacture, striking of shutters, curing, lifting, handling, storage, transportation and installation in the Works shall be submitted to the Engineer for approval before any work is commenced on the manufacture.

#### 4.17.5. Provision for Handling


Except where these are already detailed on the Drawings, the Contractor shall make provision for all lifting hooks, etc. which are required for handling, lifting and erecting the units in position.

All such lifting and fastening devices shall be subject to the prior approval of the Engineer and shall be shown on the Drawings prepared by the Contractor for the Engineer's approval. In designing and locating such devices the Contractor should note the requirements of this Specification for avoiding damage or distress due to handling, maintaining concrete cover to embedded metal and providing the required standard of finish, particularly on exposed faces. Every attempt should therefore be made to incorporate any such devices on faces which will not be exposed in the finished works.

Where he has exercised his option to use precast concrete, the Contractor shall provide such reinforcement as is necessary to prevent damage and distress due to cracking whilst loading, transporting, off-loading and erecting in position in addition to the reinforcement required for structural stability of completed works. Such additional reinforcement shall be at Contractor's cost and shall also be shown on the drawings prepared for the Engineer's approval.

#### 4.17.6. Moulds

All moulds shall be of adequate strength and stiffness to carry without deformation the loads

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and pressures of wet concrete during the casting and compaction operations. Moulds shall be sufficiently tight to prevent leakage of the concrete and shall be adequately supported, braced and maintained so as to produce units within the tolerances specified with true sharp arises and specified surface finish. Details of materials to be used in the manufacture of the moulds or formwork must be submitted to the Engineer for his approval before commencing work. Shutters shall be so designed that they can be taken apart and reassembled readily.


The assembled moulds shall be checked for accuracy immediately prior to the first casting of each type of unit, and thereafter prior to every third casting or at such closer intervals as the Engineer may require.

The Contractor must allow in his price for a sufficient number of moulds to enable him to maintain the required progress of the Works. No extras will be allowed in the event of additional moulds being required to achieve the stated programme. Each mould shall be allocated a code number and all units cast in that mould shall have the mould code number and date of casting marked on.

#### 4.17.7. Manufacturing Tolerances

Unless otherwise detailed on the Drawings or directed by the Engineer, manufacturing of precast units shall be strictly within the tolerances specified below: -

a)	Length Up to 3m 3 to 4.5m 4.5 to 6m Additional for every subsequent 6m For beam-type sections the length shall be the major dimension of the unit. For slab-type sections the above tolerances for length <u>shall apply to the two major dimensions (ie side, length).</u>	±6mm ±9mm ±12mm ±6mm
b)	Cross Section Up to 500mm 500 to 750mm Additional for every subsequent 250mm With a maximum tolerance of These tolerances shall apply to the two minor dimensions (width, height) of beam-type sections and to the thickness only for slab type sections.00	±6mm ±9mm ±12mm ±6mm
c)	Squareness When considering the squareness of a corner, the longer of the two adjacent sides being checked should be taken as the base line. The shorter side should not deviate from a perpendicular to the longer side by more than following tolerances: - Length of shorter sides Up to and including 1.2m Over 1.2m but less than 1.8m 1.8m and over	3mm 5mm 6mm

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	For the purpose of this requirement any error due to lack of straightness should be ignored; squareness should be measure with respect to the straight lines which are most nearly parallel with the features being checked. When the nominal angle is other than 90° the included angle between check lines should be varied <u>accordingly.</u>	
d)	Straightness or Bow (deviation from Intended Line) Up to 3m 3 to 6m 6 to 12m <u>Additional for every subsequent 6m</u>	
e)	Twist Any corner should not deviate by more than the tolerance stated, from the plane containing the other three corners: - Up to 600mm wide and up to 6m length <u>Over 600mm wide and for any length</u>	6mm 12mm
f)	Flatness The maximum deviation from a 1.5m straight edge placed in any. <u>position on a nominally plane surface should not exceed 5mm.</u>	
g)	Camber The variation in camber between closely associated units should not be greater than 6mm for units up to 4.5m in length, nor 9mm for longer units, and should be visually close matched wherever <u>possible.</u>	
h)	Reinforcement Reinforcement shall be fixed in accordance with Clauses mentioned <u>in this Specification</u>	
i)	Position of Connecting Bolts and Other Devices The position of individual connecting bolts, bolt holes, projecting steel or other devices in any associated group should be within 6mm of its true position in the group in which they are cast. The longitudinal location of any such group or of any individual device should be within 6mm of its true position in the unit in which it is cast, provided that such tolerance does not adversely affect the proper assembly of the whole structure.	

Notwithstanding the above requirements for tolerance, the overall dimensions and shape of any precast unit shall not be such as to prevent the proper erection of that unit in conjunction with any other unit, steelwork or in situ construction.

#### 4.17.8. Curing of Units

Curing of precast concrete units shall be in accordance with the requirements given above, in the relevant clauses.

All proposals for accelerated curing shall be fully detailed including all arrangements for ensuring the effectiveness of curing under all possible climatic conditions.

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#### 4.17.9. Surface Finishes

Surface finishes of precast units shall comply with the requirements given above, in the relevant clauses of this Specification, with the class of finish being as detailed on the Drawings or as directed. In general, no construction joints will be permitted within any precast unit.

#### 4.17.10. Rejection of Units

All finished units, whether erected in position or not, which do not comply with the Drawings and Specifications shall be removed, from the Site and replaced with new items to the Engineer's satisfaction.

Reasons for rejection of units shall include the following: -

- b. No cracked, damaged or repaired units will be acceptable.
- c. No units shall have broken edges whether reinforcement is exposed or not.
- d. No units shall have any reinforcement with concrete cover not complying with this Specification.
- e. No elements shall have a surface finish inferior to that indicated on the Drawings and defined in this Specification.
- f. No units outside the dimensional tolerances shall be acceptable.


#### 4.17.11. Marking and Records

As soon as possible after casting, each unit shall be indelibly marked in a clean and legible manner in an agreed location with its type, date of casting, and a unique reference number, which information shall be clearly visible when units are stacked. Reinforced precast members shall be clearly marked to indicate the upper face.

The Contractor shall maintain records for each unit which shall include the following:

- a. Type & reference number.
- b. Date of manufacture.
- c. Mould number.
- d. Curing method and duration.
- e. Date of removal from mould.
- f. Test Cube reference number and results.
- g. Date of placing in the Works h. Location in the Works.

These records shall be in a format agreed by the Engineer and shall be available for his inspection at all times. Copies of these records shall be supplied to the Engineer on completion.

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#### 4.17.12. Sampling and Testing

Where precast concrete units are manufactured off site, unless specifically provided for herein, all costs involved in sampling and testing required by the Specification shall be borne by the Contractor.

#### 4.17.13. Certificate of Manufacture

For precast concrete units which are manufactured off site, the Contractor shall supply to the Engineer, prior to any unit being delivered to Site, a certificate stating that that unit complies in all respects with the approved Drawings and Specifications.

#### 4.17.14. Erection Programme

Prior to erection of precast concrete units, the Contractor shall submit to the Engineer for his approval a detailed erection programme giving full descriptions of the methods and plant to be employed for lifting, assembling and fixing the units and safeguarding the structure during erection. No erection shall be carried out until the Engineer has approved the methods to be used.

#### 4.17.15. Handling and Erection - General

The Contractor shall be responsible for the safety of the structure and operatives at all stages during the handling and erection of precast concrete units and shall provide all necessary frames, guys, wedges and other temporary supports.

#### 4.17.16. Handling of Precast Concrete Units


All units shall be handled, lifted and transported in a manner which does not cause damage or cracking. When units are lifted by tackle or crane the weight shall be taken up gradually without snatch. When units are being lowered, they shall not be dropped but shall be let down gently into position without impact. Any units dropped and/or damaged during handling, storage, installation, etc. shall be replaced by the Contractor at his expense.

When the positions for sling, lifting holes or lifting eye bolts are shown on the Drawings or otherwise indicated they shall not be departed from without the permission of the Engineer.

The Contractor shall not introduce any holes, cavities, lifting loops, bolts or other features for his own convenience without the written approval of the Engineer.

Where no particular fixings or holes are built in for lifting any unit, the unit shall be supported on blocks firmly bedded and adjusted to align in a true plane in order to avoid



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twisting. The points of support shall be as indicated on the Drawings or as directed. Similar supporting blocks shall be used when storing precast units.

#### 4.17.17. Storage of Precast Concrete Units

All precast units shall be stored off the ground in a manner and in the positions which will prevent damage or cracking of any kind and permit erection with a minimum of preliminary handling and transportation.

If the Engineer permits precast units to be stacked in storage, they shall be arranged so that the supporting timber packs for any unit coincide with the supporting packs for all the units below. Under no circumstances shall any element be supported on a point on any other unit which is not itself supported.

Bolt hole recesses and other cavities shall be plugged in an approved manner to prevent entry of rain or other water unless such water can freely drain away.

#### 4.17.18. Installation of Precast Concrete Units

The Contractor shall accurately set out the work within tolerances described in the following clause. The Contractor shall ensure that all precast concrete units come together without strain in their correct relative positions as shown on the Drawings.

If, due to inaccuracies in position or level or in the dimensions of the units, it is found impossible to assemble the units without straining them into position, no such straining shall be done without the permission of the Engineer and when so directed the Contractor shall dismantle the work and re-erect and make good to the satisfaction of the Engineer.


No cutting of units, enlarging of holes for fixing bolts or other operations for the correction of lack of fit of units shall be carried out except with the permission of the Engineer.

Unless otherwise specified or shown on the drawings, approved bearing or washer pads shall be inserted at all joints and seatings to prevent direct contact of concrete to concrete or concrete to metal.

The use of expanding agents or other additives to the mortar or in-situ concrete for the fixing of precast units shall be subject to the approval of the Engineer.

During the installation of precast units, or the casting of associated in-situ concrete, the Contractor shall not impose any abnormal loads on foundation, pile caps, piers or abutments without the written permission of the Engineer in each and every case.



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#### 4.17.19. Installation Tolerances

Precast units shall be installed so that the completed structure complies with the tolerance requirements for in-situ concrete. The various faces of the completed structure shall comply with the tolerance requirements for the classes of finish specified for those faces.

The following particular tolerances apply to the installation of precast units:

The difference in the exposed vertical face line between adjacent units shall not exceed. 5mm. This requirement shall also apply to the top level of units. In addition, the face line shall be visually matched to show a true straight or curved line (as appropriate).

#### 4.17.20. Bearings


Bearings for all units shall be as shown on the Drawings and as required by the calculations.

### APPENDIX A – CEMENT RECORDS


CEMENT QUESTIONNAIRE (See Section 3.3)		To be completed by Contractor
MANUFACTURER	Company Name	
	Name and Address of producing works	
CEMENT TYPE	Manufacturer's description of cement and brand name	
COMPOSITION AND PROPERTIES	Give average values and corresponding maximum and minimum values for a continuous production period of at least six months, ending not earlier than three months before submission of the data. See Cement Properties Table.	
	Standard with which compliance is guaranteed.	
PRODUCTION CHANGES	State if any material or production process changes have been made since the end of the above period; if any are in prospect, give brief details.	

CEMENT PROPERTIES TABLE (See Section 3.3)			
Period covered: From.....20_ _ To.....20_ _			
a) Composition	Avg. Value	Max. Value	Min. Value
Silica (SiO <sub>2</sub> ) Alumina (Al <sub>2</sub> O <sub>3</sub> ) Total Iron (Fe <sub>2</sub> O <sub>3</sub> ) Calcium (CaO) Tricalcium aluminate (C <sub>3</sub> A) (C <sub>4</sub> AF + 2C <sub>3</sub> A) Magnesium (MgO) Potassium (K <sub>2</sub> O) Sodium (Na <sub>2</sub> O) Sulphur trioxide (SO <sub>3</sub> ) Sulphide sulphur (S) Chloride (Cl-) Certified Average Alkali Content (Na <sub>2</sub> O) Guaranteed Alkali Limit (Na <sub>2</sub> O) Lime Saturation Factor (LSF) Alumina / Iron (A/Fe) ratio Free Lime in Clinker (as CaO) Total Acid soluble alkalis Loss on Ignition Insoluble Residue			

### CEMENT PROPERTIES TABLE (See Section 3.3)

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Period covered: From.....20__ To.....20__			
a) Composition	Avg. Value	Max. Value	Min. Value
b) Properties			
Heat of Hydration @ 7 days @ 28 days Fineness (m2/kg) Setting times - initial - final Soundness (mm) Compressive Strength 3 days 7 days 28 days 3 months			

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### APPENDIX B – CONCRETE RECORDS

<b>EXAMPLE CONCRETE POUR CARD</b>	
Client: Deendayal Port Authority	
Project: Development of ship docking and repair infrastructure in pathfinder creek at Vadinar	
Contractor:	
Date:	Time:
Structure:	Pour no.:
Drg. No.:	Place of deposition:
Shade air temp:	Mix temp:
Concrete Grade: M	Quantity: m3
Max. Aggregate Size: mm	Slump: mm
Start Time:	Completion Time:
Mixing Time:	

<b>EXAMPLE CONCRETE POUR CHECKLIST</b>					
Sl. No.	Item	Contractor's Representative Signature	Engineer's Signature	Remarks	
1.	Centreline Checked				
2.	Formwork and Staging Checked for Accuracy, Strength & Finish				
3.	Reinforcement Checked				
4.	Cover to Reinforcement Checked				
5.	Verified Test Certificate for Cement/Steel	Yes/No	Yes/No		
6.	Adequacy of Material/Equipment for Pour	Yes/No	Yes/No		
7.	Before Concreting Embedded Parts Checked (Location & Plumb)	Civil Items			
		Mechanical Items			
		Electrical Items			
Pour Authorised: Yes / No Site					
Engineer's Signature: Engineer's					
Name:					
8.	Soffit (S) and Pour Top(T) Levels Checked Before(B) and After(A) Form Removal (Only Of Beams Of Over 10m Span & Important Structures)	S(B) S(A)	T(B) T(A)		
9.	Construction Joint Location (if not as per drawing)				
10.	Cement Consumption:	kg	kg/m3		
11.	Number Of Cubes and Identification Mark				
12.	Test Cube Results (7 Days/28 Days)	/			
13.	Concrete Condition Form Removal	V. Good / Good / Fair / Poor			

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	Site Engineer's Name	Site Engineer's Signature:
	<p>Notes:</p> <ol style="list-style-type: none"> <li>1. Items 1 to 7 (both inclusive) to be checked &amp; signed by the Engineer &amp; Contractor's representative.</li> <li>2. Items 8 to 13 (both inclusive) to be filled only by Engineer.</li> <li>3. Each pour to have separate cards, in triplicate one each for Employer, Engineer &amp; site office.</li> <li>4. Under remarks, indicate deviations from drawings &amp; specifications, congestion in reinforcement if any, unusual occurrences, such as failure of equipment, sinking of supports/props. Heavy rains affecting concreting, poor compaction, improper curing, other deficiencies, any other observations, etc.</li> </ol>	

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## **5. MASONRY WORK: BRICK MASONRY**

### **5.1. Relevant IS Standards**

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable in all cases, the latest editions, including all applicable official amendments and revisions shall be referred to:

- IS 1077 - Common burned clay building bricks.
- IS 1200: (Part 3) - Method of measurement of brickworks.
- IS 2212 - Code of practice for brick work. (1st Revision).
- IS 2222 - Specification for burnt clay perforated building bricks.
- IS 3495 - Method of test for burnt clay building bricks.


### **5.2. General**

The Bricks used in the construction of walls in security room and substation walls are common burnt clay bricks of standard size 190 x 90 x 90 mm. The Bricks shall conform to IS:1077 and shall be hand moulded or machine moulded. They shall be free from nodules of free lime, visible cracks, flaws warpage and organic matter. Bricks made by extrusion process and brick tiles may not be provided with frogs. Each brick shall be marked (in the frog where provided) with the manufacturer's identification mark or initials. The bricks shall have smooth rectangular faces with sharp corner and shall be uniform in colour and emit clear ringing sound when struck.

### **5.3. Sampling and Tests**

Samples of bricks shall be subjected to the following tests as per IS 1077

- (a) Dimensional tolerance.
- (b) Water absorption.
- (c) Efflorescence.
- (d) Compressive strength.

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## **6. PLASTERING WORK**

### **6.1. Applicable Codes**

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable in all cases, the latest editions, including all applicable official amendments and revisions shall be referred to: IS: 1542-1977 Specification for sand for plaster.

### **6.2. Definitions**

The term 'plastering' shall cover all type of rough or fair finished plastering, rendering, floating and setting coat or finishing coat, screed, etc., in cement mortar.

"Dubbing out" shall mean filling in hollows in the surface of wall and roughly levelling up irregular or out of plumb surfaces prior to rendering.

"Rendering" or "rendering coat shall mean the plaster coat, which is applied following the "Dubbing out" or the final coat in case of one coat work.

"Floating coat" shall mean the second coat in a three-coat plaster work, to bring the rendering coat to a true and even surface before the setting of finishing coat is applied.

'Setting or Finishing coat' shall mean final coat in a two or three coat plaster work.

"Thickness of plaster" shall mean the minimum thickness at any point on a surface. This does not include thickness of dubbing out.

The term "even and fair" as referred to finishing of the plastered surface shall mean a surface finished with a wooden float.

The term "even and smooth" as referred to finishing of the plastered surface shall mean a surface levelled with wooden float and subsequently smoothed with a steel trowel.

### **6.3. Plastering**

Materials: Ready Mix plaster shall be used for all plastering surface manufactured by Ultratech

(Rapid plast) / ACC / Ambuja shall only be used. The plastering shall be carried out as per the manufacturers specifications and to the thickness specified in the BOQ.

### **6.4. Grooves in Plaster**

For making grooves wooden battens 12 mm thick shall be fixed with nails into loose coat of plaster as per pattern and design in drawings, while grey. Over it the topcoat of plaster mixed with Terrazo or paint will be applied smooth. After curing is complete with coat firm and hard the battens shall be carefully removed without damaging the surface.

## 7. PAINTING & FINISHING

### 7.1. Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable in all cases, the latest editions, including all applicable official amendments and revisions shall be referred to:

IS: No.	Subject
5-1978	Colours for ready mixed paint and enamels (third revision)
75-1973	Linseed oil, raw and refined (second revision)
1020-1962	Ready mixed paint, brushing, red lead, non-setting, priming (revision)
104-1979	Ready mixed paint, brushing, zinc chrome priming (second revision)
109-1968	Ready mixed paint, brushing, acid and alkali resistant, lead free, for general purposes, to IS colour No. 446 red oxide No. 537, Signal red No. 632 Dark admiralty grey and black and other colours as required.
430-1972	Paint remover, solvent type, non-flammable (second revision)
431-1972	Paint remover, solvent type, flammable (second revision)
524-1983	Vanish, finishing exterior synthetic (second revision)
2074-1979	Ready mixed paint, air drying, red oxide-zinc chrome priming (first revision)
2932-1974	Enamel, synthetic, exterior, under coating and finishing (first revision)
5411 (part I) 1974	Plastic emulsion paint, Part I for interior use (first revision)

### 7.2. Finishing

Contractor shall submit proposal for paint colour and finish to Engineer for approval.

### 7.3. Workmanship

Contractor shall obtain the approval of the Engineer regarding the readiness of the surfaces to receive the specified finish, before commencing the work of painting.


Painting of new surfaces shall be deferred as much as possible to allow for thorough drying of the sub - strata.

The surfaces to be treated shall be prepared by thoroughly brushing them free from dirt, mortar droppings and any loose foreign materials. Surfaces shall be free from oil, grease and efflorescence. Efflorescence shall be removed only by dry brushing of the growth. Cracks shall be filled with Gypsum. Workmanship of painting shall generally confirm to IS: 2395.

Surfaces of doors, windows etc. shall be protected suitably to prevent paint finishes from splashing on them.

### 7.4. Oil Bound Distemper



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Oil bound distemper shall be of the following approved make, colour and shade.

#### 7.4.1. Primer Coat

Priming coat for oil bound distemper shall be whitening mixed with petrifying liquid. Newly plastered surfaces to be distempered before a period of six months shall be given a coat of alkali resistant priming paint conforming to IS 109-1968 Specification for ready mixed paint, brushing, priming plaster to IS colour No. 361 light stone and No. 631 light grey, or any other primer as specified by the manufacturer and allowed to dry for at least 48 hours.

#### 7.4.2. Preparation of oil bound distemper

The distemper shall be thinned with water or any other prescribed thinner in the proportion of four parts of paste by weight to one part of cold water or in the proportion as specified by the manufacturers, which shall invariably be followed. To obtain a better finish and longer durability Copolymer based resin glue be added to the prepared distemper solution at the rates recommended by the manufacturers.


#### 7.4.3. Application of Distemper

After the priming coat has dried, the surface shall be lightly sandpapered with zero grade abrasive paper, taking care not to rub out the priming coat and then dusted off. Prepared distemper shall then be applied with brushed in coats comprised of horizontal strokes immediately followed by vertical ones which together constitute one coat. Distempering shall always be started from ceiling down. A uniformly finished surface without patches, brush mark's distemper drops etc. shall be obtained.

Distemper shall be applied in dry weather with double bristled distemper brushes. The first coat shall always be of lighter tint than that required finally, and the subsequent coat shall be applied only after the previous one has thoroughly dried for at least 24 hours.

The distemper shall be thinned and prepared using prescribed thinner as per manufacturer instruction.

Workability of oil bound distemper surface shall be tested with wet cloth. Oil bound distemper shall not come out when surface is rubbed with wet cloth.

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## **7.5. Cement Painting**

Cement Paint shall be of the following approved make, colour and shade.

### **7.5.1. Preparation of Waterproof Cement Paint**

Cement paint shall be made by adding equal volume of paint powder to water and the mix stirred to obtain a thick paste: which shall than be diluted to a brush-able consistency. If the proportion recommended by the manufacturer differs, the recommendation of the manufacturer shall invariably be followed. The water mixed paint shall be kept well stirred during use and shall be applied within one hour of preparation. To prevent algae and moss growth and efflorescence, silicon base water repellent compound may be added to mixture, at the rate as recommended by the approved manufacturer.

The lids of cement paint drums shall be kept tightly closed when not in use, as the cement paint rapidly becomes air set.

### **7.5.2. Preparation of Surface**

The surface shall be thoroughly cleaned of all dirt, dust, mortar drops, efflorescence, chalking, grease and other foreign matter before whitewash is applied.

### **7.5.3. Wetting of Surface**

Before applying cement paint, the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet when the paint is applied. Surface, which readily absorbs moisture, shall be wetted in one operation not more than one hour before painting. Surfaces, which absorb moisture slowly, shall be wetted in at least two operations not less then 30 minutes apart.


### **7.5.4. Application of Paint**

No painting shall be done when the paint is likely to exposed to a temperature below 7°C. Within 48 hours after application.

When weather conditions are such as to cause the paint to dry rapidly, work shall be carried out 'in the shadow' as far as possible, for proper hardening of the paint film.

To maintain a uniform mixture and to prevent segregation, the paint shall be stirred frequently in the bucket.

Unless otherwise indicated, new surfaces shall be treated with minimum of two coats of cement paint of the same colour. Not less than 24 hours shall be allowed between two coats

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and the second or subsequent coat shall not be started until the preceding coat has become sufficiently hard to resist making by the brush being used. In hot dry weather the preceding coat shall be slightly moistened before applying the subsequent coat. For old surfaces the treatment shall be with one coat, unless two coats are indicated.

Cement paint shall be applied with a brush with relatively short stiff hog or fiber bristles. The paint shall be brushed in uniform thickness and shall be free from excessive brush marks. The laps shall be well brushed out.

On external plastered and concrete surfaces, cement paint shall be vigorously scrubbed on in such a manner as to work the paint in to the voids and provide a continuous paint film free from pinholes or other openings. Spray application may be adopted only for dense concrete or interior surfaces where the paint is not required for waterproofing purposes. The finished surface shall be even and uniform in shade, without patches, paints drop etc.

#### 7.5.5. Curing

Painted surfaces shall be sprinkled with water using a fog spray two or three times a day. Curing shall be done between coats and for at least two days following the final coat. The curing shall be started as soon as the paint has hardened so as not to be damaged by the spray, about 12 hours after the application.

### 7.6. Synthetic Enamel paint on MS works


Enamel Paint shall be of the following approved make, colour and shade.

#### 7.6.1. Preparing new surfaces (Primer Coat)

The surfaces shall be thoroughly cleaned of dirt, fluxing material, other foreign matter and scrapped thoroughly with hand scraper followed by wire brushing first with coarse and then with fine wire brushes and finally sand papering the surface to remove all mill scale and rust. The surface shall then be wiped finally with mineral turpentine to remove oil, grease and perspiration left by hand marks.

Temporary rust protective material if any, applied to the steel work to protect during transport and storage shall be removed with suitable solvent as a preliminary to other preparatory treatment. Surfaces already pre-treated or primed in a factory shall be carefully inspected and damaged areas shall be thoroughly degreased and cleaned of all rust and touched up.

Painting shall be in accordance with manufacturers' recommendation.

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## **7.7. Mural Painting**

Mural Paint shall be of the following approved make, colour and shade.

### **7.7.1. Preparation of Surface**

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-Charge after inspection before painting is commenced.

### **7.7.2. Wetting of Surface**

Before applying cement paint, the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet when the paint is applied. Surface, which readily absorbs moisture, shall be wetted in one operation not more than one hour before painting. Surfaces, which absorb moisture slowly, shall be wetted in at least two operations not less than 30 minutes apart.

### **7.7.3. Priming of Surface**

The wall is completely allowed to dry. After the wall has thoroughly dried, apply a coat of acrylic primer over the entire wall.


### **7.7.4. Application of Paint**

No painting shall be done when the paint is likely to be exposed to a temperature below 7°C. Within 48 hours after application. Acrylic paint can be used for Mural art painting.

When weather conditions are such as to cause the paint to dry rapidly, work shall be carried out 'in the shadow' as far as possible, for proper hardening of the paint film.

To maintain a uniform mixture and to prevent segregation, the paint shall be stirred frequently in the bucket.

Unless otherwise indicated, new surfaces shall be treated with minimum of two coats of acrylic mural paint of the same colour. Not less than 24 hours shall be allowed between two coats and the second or subsequent coat shall not be started until the preceding coat has become sufficiently hard to resist marking by the brush being used. In hot dry weather the preceding coat shall be slightly moistened before applying the subsequent coat. For old surfaces the treatment shall be with one coat, unless two coats are indicated.


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Acrylic mural paint shall be applied with a brush with relatively short stiff hog or fibre bristles.

The paint shall be brushed in uniform thickness and shall be free from excessive brush marks. The laps shall be well brushed out.

The finished surface shall be even and uniform in shade, without patches, paints drop etc. A minimum of two to three coats of paint for each layer. Make sure you give your paint enough time to dry in between each coat. Each coat doesn't need to completely cure, but the surface should not be wet. Have some soap and water nearby to clean your brushes if you're using the same brushes for different colours. Employ paint trays or other items that you can use to hold and mix your paint.

The Measurement and payment of mural painting shall be in square meter.

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## **8. FLOORING**

### **8.1. Application Codes**

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable in all cases, the latest editions including all applicable official amendments and revisions shall be referred to:

- IS:777 Specification for glazed earthenware tiles
- IS:1237 Specification for cement concrete flooring tiles
- IS:2114 Code of practice for laying in - situ terrazzo floor finish
- IS:2571 Code of practice for laying in - situ cement concrete flooring
- IS:2690 Specification of burnt clay flat terracing tiles: Part 1 Machine made
- IS:3536 Specification for ready mixed paint, brushing, wood primer, pink
- IS: 4457 Safety code of scaffolds and ladders (Parts 1 and 2)
- IS: 4631 Code of practice for laying of flexible PVC sheet and tile flooring
- IS: 4832 Specification for epoxy resin, hardeners and epoxy resin composites for floor topping
- IS: 5318 Code of practice for laying of in-situ granolithic concrete floor topping

### **8.2. Workmanship**

Before the flooring work is taken up, the following operation shall have been completed:

The completion of all preliminary operations, such as laying of services affecting the laying of floors Plastering of all inside walls, ceilings and outside walls and fixing of door and window frames in place all heavy work in the room may be completed.


The thickness of each course or layer constituting the floor shall be as specified or indicated. The floors shall be laid to levels or falls as indicated or as directed by the Engineer/Architect.

The surface shall be finished to a reasonably true plain surface. The desired slope for proper drainage shall be provided in the sub floor and bedding. Floors shall not sound hollow when tapped.

All points of level from the finished floor surface and outlets shall be clearly marked and outlet opening made beforehand.

In the case of suspended floor slabs any slope in the floor finish shall be given in the structural concrete itself. The surface of the floor slabs shall be kept rough to provide an adequate bond for the topping.

Unless otherwise directed, the joints shall be of uniform thickness, perfectly straight

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throughout the length of a row, with rows parallel to each other. Transverse joints shall be at right angles to longitudinal joints to avoid sympathetic cracks likely to be induced in the adjoining panel, the joints shall not be staggered. The pattern of laying the floor units viz. straight, diagonally or to herring bone or any other pattern shall be as directed by the Engineer.

Where full size tiles cannot be fixed these shall be cut/sawn to the required size and then edges rubbed smooth to ensure straight and true joints.

Tiles fixed in the floor adjacent to the wall shall enter plaster, skirting or dado to a minimum, depth of 10 mm.

### **8.3. Mortars**

Cement and composite mortars (1:6) shall be made as detailed in section of this Specification relating to Masonry Works. The quantity of water added shall be the minimum to give sufficient plasticity and workability for laying. A high-water cement ratio will produce a screeded bed with a high trying shrinkage and shall be avoided.

Unless otherwise specified, bedding layer of mortar for laying floor units, where specified shall be not less than 20 mm.


Mortar in joints shall be restricted to the width of the joints and any smearing of mortar on the surface of floor on either side of joint shall be removed immediately. The finished surface of mortar in joints shall be flushed with the floor surface.

### **8.4. Ceramic / Vitrified tile flooring**

Providing and laying Ceramic or vitrified tiles of approved colour/shade of size of 300 mm x 300 mm or 600mm x 600mm as per tender drawings or approved manufacturer's specifications. A tolerance of +/- 1mm in facial dimensions and +/- 0.5mm shall be allowed in thickness of tiles.

#### **8.4.1. Water**

Water used for both mixing and curing shall be fresh, clean, free from oil, salt, acid, alkali or other chemicals and deleterious matter conforming to IS: 456 :1978

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#### 8.4.2. Mortar bedding 1:3 (1 cement: 3 coarse sand)

The amount of water added while preparing mortar shall be the minimum necessary to give sufficient plasticity for laying. Care shall be taken in the preparation of the mortar to ensure that there are no hard lumps that would interfere with even bedding of the tiles. Before spreading the mortar bed, the base shall be cleaned of all dirt, scum or laitance and loose materials and then well wetted without forming any pools by the use of screed battens to proper level or slope. The thickness of the mortar bedding shall not be less than 20 mm thick. The tiles shall be laid on the bedding mortar when it is still plastic but has become sufficiently stiff to offer a fair cushion for the tiles. Levelling the floor to desired level by the mortar.

#### 8.4.3. Fixing of Tiles

Base shall be cleaned and wetted. Before laying the tiles, cement slurry of honey like consistency at 3kg. /sq.m shall be applied over the bedding. At a time, area to accommodate about twenty tiles shall be applied with cement slurry. Tiles shall then be washed clean and fixed in the grout one after the other, each tile being gently tapped in its position till it is properly bedded and in level and line with adjoining tiles. The joints shall be as thin as possible but not exceeding 1.0 mm wide. In the case of skirting and dado, the wall surface shall be covered with about 15mm thick plaster of cement and sand mortar 1:3 and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal lines. The back of tiles shall be buttered with cement paste and set on bedding mortar. The tiles shall be gently tapped in position one after the other. Top of skirting or dado shall be truly horizontal and the joints vertical or as per required pattern.

The joints shall be grouted with slurry of white cement mixed with pigment of required shade to match colour of the tile as per the direction and approval of Engineer.


#### 8.4.4. Cleaning

After the tile has been laid in a room or the day's fixing work is completed, the surplus cement grout that may have come out of the joints shall be cleaned off before it sets. Once the floor has set, the floor shall be carefully washed clean and dried. When dry, the floor shall be covered with oil free dry sawdust which shall be removed only after completion of the construction work and just before the floor is occupied.

### 8.5. Ceramic / Vitrified Tiles in Dados/skirting

Providing and fixing Ceramic / Vitrified tiles of approved colour/shade with size of 300 mm x 150 mm or 200 mm X 150 mm or approved manufacturer's specifications and minimum 6 mm thick for dado and skirting in required positions, on 15mm thick plaster of



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cement mortar 1:3 including filling joints with white cement slurry mixed with pigments of approved quality to match the colour of the tile colour as per the direction and approval of the Engineer, curing and cleaning the tile after fixing as per directions of the Engineer.

#### 8.5.1. Materials

Ceramic/vitrified tile including specials shall be of the approved make and quality and shall confirm to IS: 13755 in all aspects. The Engineer shall approve the sample of the tiles, which will keep them in his office for verification as to whether the materials brought for use confirm to the approved samples.

#### 8.5.2. Plastering


Cement plaster of about 12 mm for block walls shall be applied to the part of the wall where dado or skirting is to fix as per specification. The proportion of mortar shall be as mentioned in the item. The plaster shall be roughened with wire brush or by scratching diagonal lines.

#### 8.5.3. Fixing of tiles

Dado & skirting work shall be done only after fixing tiles on the floor. The ceramic/vitrified tiles shall be soaked in water for at least 2 hours before being used for dado work. Tiles shall be fixed when the cushioning mortar is still plastic but before it gets very stiff. The back of tiles shall be covered with a thin layer of neat cement paste @ 3kg/Sqm covered with a layer of approved adhesive and the tile shall then be pressed on the plastered surface and gently tapped against the wall with a wooden mallet. The fixing shall be done from the bottom of wall upwards without any hollows in the bed or joints. Each tile shall be fixed as close as possible to the adjoining. The tiles shall be joined with white cement slurry mixed with coloured pigments to match the tile colour as per the proportion of the manufacturer and directions and approval of the Engineer. Any difference in the thickness of tiles shall be evened out in cushioning mortar so that all tile faces are in one vertical plane. The joints between the tiles shall not exceed 1.0 mm in width and they shall be uniform. While fixing tiles in dado work, care shall be taken to break joints vertically. After fixing the dado, skirting etc. they shall be kept continuously wet for 7 days. Top of the skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated.

If doors, windows or other opening are located within the dado area, the sills, jambs, angles etc., shall be provided with ceramic/vitrified tiles and appropriate specials according to the foregoing specification and such tiled area shall be measured along with the dado.

#### 8.5.4. Cleaning

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After the tiles have been fixed the surplus cement grout that may have come out of the joints shall be cleaned off before it sets. After the complete curing, the dado work shall be washed thoroughly clean.

## **8.6. Kota Stone Flooring**

The slabs shall be selected quality, hard, sound, dense and homogenous in texture, free from cracks, decay, weathering and flaws. They shall be machine cut to the 20-40 mm thickness of manufacturer's specifications and they shall be of uniform colours and size 600mm x 600mm.

The slabs shall be the top (exposed) face polished before being brought to site. Before starting the work, contractor shall get the samples of slabs approved by the Engineer.


### **8.6.1. Preparation of Surface and Laying**

Sub-grade concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 Cement: 4 Coarse sand) with minimum thickness of 20 mm. The slabs shall be laid in the following manner: Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness of 20 mm. the slab shall be washed and cleaned before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4 kg of cement per square meter. The slab to be paved shall be lowered gently back in position bedded in level. Subsequent slabs shall be laid in the same manner and joints between adjacent slabs shall be thin as possible and run in straight line. After each slab has been laid, surplus cement grout coming out of the joints of the slabs shall be cleaned off. The surface of these flooring as laid shall be true to levels, lines and shape as instructed by the Engineer. The slabs shall be matched as shown in drawings or as instructed by the Engineer.

Slabs that are fixed in the floor adjoining the wall enter not less than 12 mm under the plaster skirting or dado. The junction between wall plaster and the floor shall be finished neatly and without waviness.

### **8.6.2. Curing, Polishing and Finishing**

The floor shall be kept wet for a minimum period of 7 days. The surface shall thereafter be ground evenly with machine fitted with fine grade blocks. The final grinding with machine fitted with the finest grade grit blocks shall be carried out the day after the first grinding described above or before handing over the floor, as ordered by the Engineer.

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For small areas of where circumstances so require, hand polishing may be permitted in lieu of machine polishing after lying. For hand polishing the following Carborundum stones shall be used, it is grinding - Medium Grade stone Final grinding - Fine Grade

In all other respects, the process shall be similar as for machine polishing. After the final polish, oxalic acid shall be dusted over the surface at the rates of 33 gm unless otherwise stated in CPWD specifications. Per square meter sprinkled with water and rubbed hard with pad of wooden rags. The following day the floor shall be wiped with a moist rag and dried with a soft cloth a finished clean.

If any slab is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with wooden mallet.


#### **8.7. Kota Stone in Skirting**

They shall be laid against a bedding of cement mortar 1:4 to a true plane, level and plumb. The workmanship shall be similar to flooring with alignment matched with flooring and height as mentioned in tender drawings.

The skirting shall be laid projecting beyond the finished plastered surface as directed. The skirting surface shall be re-polished with hand to the satisfaction of the Site Engineer. The skirting shall be cured for 7 days.

#### **8.8. Granite Stone Flooring**

Granite shall be of selected quality, hard, sound, dense and homogeneous in texture, free from cracks, decay, weathering and flaws. Thickness of granite slab to be laid shall be minimum 20 mm in risers, strings and treads, and 30 mm in platforms unless otherwise specified by manufacturer. Platform indicated in one piece and projected to form nosing shall be of same thickness as tread. Nosing shall be plain or moulded as per details. The granite slab shall be the top (exposed) face polished before being brought to the site. Every granite piece shall be of uniform colour and cut to required size and shape, chisel dressed on all beds so as to give truly vertical, horizontal, radial or circular joints as required. Before starting the work, contractor shall get the samples of slabs approved by the Engineer.

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#### 8.8.1. Joints

Joints shall only be permitted at the curvatures or when the width/length is more than 0.6 and 2 m respectively. Number of joints shall be limited to one for every 2 mts. Depth of joint shall be uniform 6 mm from face of stone and as fine as possible but not more than 1.5 mm thick on exposed face. Beyond 6 mm from face of stone thickness of joint shall increase in an inverted ‘V’ shape to give good mortar bond between two stones. Inverted ‘V’ shape portion shall be filled with the bedding mortar and face 6 mm portion shall be filled with pointing mortar/cement slurry.

#### 8.8.2. Preparation of Surface and Laying

Sub-grade concrete or the RCC slab on which Granite is to be laid shall be cleaned, wetted and mopped. All stone shall be wetted before placing in position and shall be floated on 20 mm thick 1:3 Cement Mortar (1 Cement: 3 Coarse Sand) and bedded properly with wooden mallets without use of chips or pinning of any sort. Two stones shall be jointed with pointing mortar/ cement slurry admixed with pigment to match the shade of Granite.


Riser’s stone shall extend from top of one tread to the underside of the tread and butt the string and securely anchored. No damaged piece shall be used in the work.

Matching of the grains of Granite slab to be carried as per directed by Engineer. The slabs shall be laid in the following manner:

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness as indicated. The slab shall be washed and cleaned before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4 kg of cement per square meter. The slab to be paved shall be lowered gently back in position bedded in level. Subsequent slabs shall be laid in the same manner and joints between adjacent slabs shall be thin as possible and run in straight line. After each slab has been laid, surplus cement grout coming out of the joints of the slabs shall be cleaned off. The surface of these flooring as laid shall be true to levels, lines and shape as instructed by the Engineer. The slabs shall be matched as shown in drawings or as instructed by the Engineer.

Slabs, which are fixed in the floor adjoining the wall, enter not less than 12 mm under the plaster skirting or dado. The junction between wall plaster and the floor shall be finished neatly and without waviness.

#### 8.8.3. Curing, Polishing and Finishing

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The floor shall be kept wet for a minimum period of 7 days. The surface shall thereafter be ground evenly with machine fitted with fine grade blocks. The final grinding with machine fitted with the finest grade grit blocks shall be carried out the day after the first grinding described above or before handing over the floor, as ordered by the Engineer.

For Small areas of where circumstances so require, hand polishing may be permitted in lieu of machine polishing after lying. For hand polishing the following Carborundum stones shall be used, it is grinding - Medium Grade stone Final grinding - Fine Grade.

In all other respects, the process shall be similar as for machine polishing. After the final polish, oxalic acid shall be dusted over the surface at the rates of 33 gm unless otherwise stated in CPWD specifications. Per square meter sprinkled with water and rubbed hard with pad of wooden rags. The following day the floor shall be wiped with a moist rag and dried with a soft cloth a finished clean.

If any slab is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with wooden mallet.

## **8.9. Cement Concrete flooring**

### **8.9.1. Cement concrete sub flooring, base or subbase.**

Preparation of subbase:


Before laying cement concrete sub floor, the surface of the subbase such as hard core of hard broken bricks shall be thoroughly compacted and cleared of all dust, loose particles and any other deleterious materials.

Unless otherwise indicated, materials for hard core shall be broken to gauge not exceeding 63 mm. Hard core of gauge up to 100 mm may be specified and used when laid in hard standing and pavements where power roller is used for consolidation.

Brick aggregate shall be from well brunt or slightly over burnt bricks and shall not contain any appreciable solution of sulphate content when used on a wet side.

Hard core filling shall be spread and levelled in layer not exceeding 15 cm thick watered and well rammed or rolled where indicated.

Cement concrete of the specified mix in sub-floor shall be mixed as specified in Section Concrete, and shall be laid, Compacted and finished as specified under Cement Concrete Flooring. The top surface shall be broomed to have adequate bond with the topping.

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Flooring shall be commenced within 48 hours of laying the concrete sub floor, etc. failing which the surface of the sub floor, etc, shall be roughened with steel wire brushes, wetted by sprinkling water and smeared with a coat of cement flurry at 3 kg. Per sq.m.

#### 8.9.2. Cement concrete Hardened Flooring Size of panels

The floor topping shall be divided into suitable panels. Size of the panel is governed by the thickness of floor finish, the type of construction (monolithic) local conditions of temperature, humidity and the season in which flooring is laid. Generally, no dimension of a panel shall exceed 4 m in case of floor topping laid monolithically with the base concrete and 2 m in case of floor topping lay separately on a hardened base. In case of ground floors, stopping panel may synchronize with that of the base concrete. Length of a panel shall not exceed one and half times its breadth. The exact dimensions of the panels shall be as directed by Engineer.

Floor finish is to be laid monolithically with the base concrete.


#### 8.9.3. Laying the sub-floor or Base

The area to be paved shall be divided into suitable panels. Before placing the base concrete, the sub-base shall be properly wetted. The concrete of the specified mix shall then be deposited between the screed strips, thoroughly tamped and the surface screeded uniformly. The surface shall be finished rough to provide adequate bond for the topping.

#### 8.9.4. Laying the Floor Finish or Topping

On the clean, green surface of the base concrete, the topping of the specified mix shall be placed in positions as soon as possible but generally not later than two to three hours of laying the base concrete. The topping shall then be thoroughly tamped or vibrated struck off level and the surface floated with a wooden float to a fair and even surface. The surface shall be tested with a straight edge and mason's spirit level to detect any inequalities in the surface, which, if any, shall be made good immediately. Where indicated, dividing strips shall be provided for effective separation of panels. The mix for the topping shall be stiff enough to prevent accumulation of any excess water or laitance on the surface.

The base concrete and the topping shall be laid in alternate panels, the intermediate panels being filled in after one to two days as directed. The screed strips shall be removed the next day after the concrete has been deposited in the panels; the edges of panels shall be examined for any honeycombing or undulation which, if found, shall be repaired straight and smooth by the cement mortar. If the intermediate panels are not filled the next day, the screed strips shall then be cleaned and put back against the edges of panels till the concrete in the alternative panels is to be deposited. When the concrete is being compacted in new

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panels, care shall be taken to avoid damage to the panels already laid.

#### 8.9.5. Dividing strips

When dividing strips are provided, the base concrete and the topping may be laid in all the panels simultaneously.

#### 8.9.6. Wear Proof Topping

For light or heavy-duty floors, metallic floor hardener such as Ironite/Hardonate and cement shall be thoroughly mixed to an even colour in dry state in the proportion recommended by the manufacturer. This mixture shall be mixed with crushed granite basalt/trap as indicated (6 mm and down) in the proportion 1:2 by volume. Requisite amount of water shall then be added to form a workable mixture.


The topping of the thickness as indicated, shall be laid while the underlying surface is green. When the initial set has taken place, the surface shall be trowelled even the smooth with a steel trowel. Dry cement or mixture of dry cement and sand shall not be sprinkled directly on to the surface with the object of absorbing moisture or for stiffening the mix. The final trowelling shall not be commenced until such time as the surface has so hardened that pressure with a finger cease to make any indentation. The topping shall be kept damp with wet sacks or sand, for 7 days before putting to use.

#### 8.9.7. Finishing the surface for smooth

Where an even smooth surface is indicated, the surface, after being floated with a wooden or steel float, shall be finished with a steel trowel. Finishing operations shall start shortly after the compaction of concrete and shall be spread over the period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled three times at intervals so as to produce a uniform, hard and closed in it surface. Immediately after laying, only just sufficient towelling shall be done to give a level surface. Excessive trowelling in the earlier stages shall be avoided, as this tends to work a layer rich in cement to the surface. Sometime after the first trowelling and after a duration depending upon the temperature and atmospheric conditions, the surface shall be retro welled to close any pores in the surface, and to bring to surface and scrap off any excess water in concrete laitance (it shall not be trowelled back into the topping). The final trowelling shall be done well before the concrete has become too hard but at such a time that considerable pressure is required to make any impression on the surface. Spreading and trowelling of a rich mix of dry cement and aggregate on to the surface shall not be permitted.

#### 8.9.8. Spike rolling.



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Spike rolling to concrete surface where indicted shall executed with a suitable roller to produce indentations while the concrete is green. Expanded metal impressions, where indicated, shall be made on the floor surface while green by pressing expanded metal of the mesh as directed to a depth of 3 mm and removing the same carefully.

#### 8.9.9. Curing

Immediately after the flooring surface is finished, it shall be protected from rapid drying and strong sunlight. As soon as the surface has hardened sufficiently to prevent damage to it, it shall be kept continuously moist for at least fifteen days by means of wet gunny bags or 50 mm thick layers of damp sand spread over the surface or pooling water on the surface. During this period the flooring shall not be exposed to any traffic. Regular traffic on the floor shall be allowed only after 28 days.

#### 8.9.10. Finishing

The junction of floors with wall plaster dado or skirting shall be rounded off neatly where so required up to 25mm radius. Persons engaged on the finishing operation shall be provided with raised wooden platform to sit on, so as to prevent damage to the new work.



## 9. ALUMINIUM WORK

This section covers the requirement for furnishing of all materials, labour accessories, tools and equipment for installation of anodized matt finish or powder-coated aluminium glazing doors, windows & railings including fabrication, fixing and fittings etc.

### 9.1. Applicable Codes and Standards

The codes and standards generally applicable to the work of this section are listed herein under:

IS: 733	Wrought aluminium and aluminium alloy bars, rods and sections (for general engineering purpose).
IS: 1285	Wrought aluminium and aluminium alloy, extruded round tube and hollow sections (for general engineering purpose).
IS: 1362	Dimension for screw thread for general purpose.
IS: 1761	Transparent sheet glass for glazing and framing purposes.
IS: 1948	Aluminium doors, window and ventilators.
IS: 1949	Aluminium windows for industrial buildings.
IS: 7088	Recommended practices for anodizing aluminium and its alloys.
IS: 5523	Method of testing anodic coating on aluminium & its alloys
IS: 2835	Transparent sheet glass for glazing & framing purposes

The following clauses are intended to amplify the requirements of the references/documents listed above and the contractor shall comply with these clauses. The contractor shall submit shop drawings for fabrication & erection and samples for approval.


### 9.2. Materials

#### 9.2.1. Aluminium alloy

Aluminium alloy used in the manufacture of extruded door and window sections shall correspond to IS designation HE9-WP of IS: 733. Aluminium alloy hollow section and coupling sections used shall conform to IS designation HV9-WP of IS: 1285. They shall conform to dimensions shown in Fig. 5 to IS: 1948 unless otherwise specified in the drawings.

Screw threads of machine screws used in the manufacture of aluminium doors, window and ventilators shall conform to IS: 1362. Other threads may be used if permitted by the Engineer.

#### 9.2.2. Samples and shop drawings

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All aluminium doors, windows and ventilators shall be furnished by an approved manufacturer and shall be conforming to IS: 1948. Before placing their order, the contractor shall submit shop drawings and samples for the approval of the Engineer. If required, the contractor shall also submit the necessary engineering calculations. Shop drawings shall clearly show all work including mechanical systems, the arrangement of components, the sequence and details of fabrications, assembly and erection. These drawings shall also give full size details, all dimensions and thickness anchoring devices and accessories.

### **9.3. Fabrication**


#### **9.3.1. Frames**

Frames of aluminium doors and windows shall be of profile and dimensions as shown in the drawings, Frames shall be square and flat, the corners of the frames being fabricated to a true right angle. Both the fixed and opening frames shall be fabricated out of sections, which have been cut of length, metered and welded at the corners. Where hollow sections are used with welded joints (Aluminium sections should be machine screw jointed) argon-arc welding or flash-butt welding shall be employed (gas welding or blazing shall not be done). Sub - dividing bars of units shall be tented and riveted into the frame.

Fabricate aluminium frames to allow for clearances and shim spacing around perimeter of assemblies to enable installation into prepared openings provide for thermal movement. Provide anchorage devices to securely and solidly attach the frame assembly in place. Accurately and rigidly fit together joints and corners, match components ensuring continuity of line and design. Ensure joints and connections are flush, hairline and weather-proof. Provide drain routes and outlets to exterior for moisture entering joints and connections occurring within the frame construction.

#### **9.3.2. Shutters**

Shutter thickness and dimensions of vertical stiles, head and sill shall be as shown in the drawings. Unless otherwise specified, the hinges shall be of anodized aluminium alloy and shall normally be of projecting type. Slot shall be cut in the fixed frame and the hinges inserted inside and may be riveted to the frame. The fins for hinges shall be of stainless steel of non-magnetic type of aluminium alloy HR-30 anodized and shall be sealed with oil, wax of lanolin.

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### 9.3.3. Fittings

Handles, peg stays, tower bolts, locking device, hinges and pivots, floor springs, automatic door operators shall be of the design and make approved by the Engineer. Door leaf shall be equipped with adjustable mechanism located in top rail near lock style that will provide for minor clear adjustments after installation. Snap of (Clip on) anodized/powder coated aluminium beadings and glazing clips shall be provided as per design and size approved by the Engineer.

### 9.3.4. Finish

After fabrication, any fabrication oil, scratches and tool marks shall be removed leaving the surface free from discoloration, blemishes and defects. Aluminium surfaces shall first be given a medium matte finish by caustic soda etching or by mechanical methods. All aluminium glazing shall be anodized conforming to IS: 7088 to the light fast shade approved by the Engineer. A thick layer of clean transparent lacquer based on methacrylate or cellulose butyrate shall be applied to all aluminium glazing to protect the surface during installation. The lacquer coating shall be removed after the installation is completed.


The unit assemblies shall be anodized/powder coated finish. Anodizing shall be minimum 15 microns thick of mat texture, non-directional and non-specular. Anodized surfaces shall be suitably protected during transportation, storage and erection. Powder coating if specified shall be not less than 50 Micron.

## 9.4. Receiving and stacking

Fabricated aluminium frames and members shall be individually wrapped and delivered at site in crates. The contractors shall receive and unload the same at site with utmost care. The crates shall be opened, and the materials carefully examined by the Engineer to detect any damage. Damaged materials shall be immediately removed from the site. Materials found to be acceptable on inspections shall be repacked in crates and stored safely in a vertical position above ground in a dry area. During the unpacking and repacking operations, the contractor shall take all precautions to ensure that the protective coating of the fabricated materials is not damaged at all.

## 9.5. Installation

Just prior to installation, the frames and members shall be unscratched and stacked on edge on level bearers and supported evenly. The contractor shall assemble the various components to form units as called for in the drawings. The assembled units shall be placed in correct final position in the openings and marks made at jambs, sills and heads against holes provided in the frames for anchoring. The frames shall side of appropriate size shall

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be drilled at the marking with an electric drill to house the expansion bolts.

Expansions bolts shall be inserted in the holes, struck with a light hammer till the nut is forced into the anchor shell. The frames shall be set in the openings by using wooden wedged at supports and shall be plumbed in position. The wedged shall invariably be placed at the meeting points of glazing bars and frames. The frames shall be installed straight, level, without distortion and anchored to the supports through cadmium-plated machine screws of required size threaded to expansion bolts.

Where aluminium comes into contact with concrete, brickwork, stone masonry, plaster or dissimilar metals, it shall be coated with an approved insulation lacquer, paint or plastic tape to ensure that electro-chemical corrosion is avoided. Insulation material shall be trimmed off to a clean flush line on completion. Adjustments shall be lubricated. Operating parts shall be protected against accumulation of dirt and foreign matters.

#### **9.6. Weather proofing**

Frame at door perimeter shall be fitted with non-porous polymeric weather stripping and door bottom shall have an adjustable elastomeric weather-strip. Weather strips shall not bind or prevent door from closing easily and tightly with weather tight contact between metal.


Alternatively gaps between frames and supports as well as any gap in the various sections shall be raked out as directed and filled with mastic cement of approved make and colour to ensure complete water tightness. The mastic cement shall be of such colour and composition so that it would not stain the supports and shall receive paint without bleeding. Moreover, it shall not sag or run and shall not set hard or dry out under any weather conditions.

#### **9.7. Final cleaning**

Protective coating and warning markings shall remain undisturbed until final acceptance. Immediately prior to final inspection, temporary protective covering or coating shall be removed, and surfaces shall be washed with a suitable thinner and left in a finished condition having approved uniform appearance and free from all marks and blemishes. Wash and polish glass on both faces.

#### **9.8. Measurements**

For fixed portion: Weight of Aluminium sections used in the fixed portion including Aluminium snap beadings shall be measured for payment.

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For open able portion: Weight of Aluminium sections used in the open able shutters including fixing of fittings shall be measured for payment.

For panelling: Area of panelling shall be measured.

For glazing: Area of glass including neoprene gaskets shall be measured.

## **9.9. Guarantee Bond**

All aluminium work shall carry two years guarantee after completion of the work against water leakage, unsound material and workmanship and defective anodising as per approved Performa. Two years guarantee must be given by the specialised firm, which shall be counter signed by the contractor, in token of his overall responsibility in addition 10% (Ten Percent) of the cost of these items would be retained as guarantee to which the performance of the work done. The cost guarantee against this item of work shall be in addition to the security deposit mentioned elsewhere in the contract form. If any defect is noticed during the guarantee period, the contractor should rectify it within seven days, and if not attended to, the same will be got done from another agency at the risk and cost of the contractor. However, this security deposit can be released in full, if bank guarantee of equivalent amount for two years is produced and deposited with the department.

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## **10. FITTING & FIXTURES**

The work covered under these specifications consists of supplying different types of fittings and fixtures required for doors, windows, ventilators etc. The supply shall be in accordance with the specification, drawings/approved samples. The contractor for approval of the Engineer shall submit samples of various fittings and fixtures proposed to be incorporated in the work before order for bulk supply is placed.

### **10.1. General**

All fittings and fixtures shall conform to relevant IS code and made of brass, anodized aluminium iron oxidized (M.S.) or as specified. These shall be well made reasonably smooth and free from sharp edges, corners, flaws and other defects. Screw holes shall be counter sunk to suit the heads of the specified screws. All hinges' pins shall be of steel for brass hinges and aluminium ally NR-6 or steel pins for aluminium hinges with nylon washers as specified. All riveted heads pertaining to hinge pins shall be well formed. Screws supplied for fittings shall be of the same metal and finish as the fittings. The contractor for approval of the Engineer shall furnish samples of each fixture/fitting.

The fittings and fixtures to be incorporated in the work shall be strictly according to the approved sample. Fittings shall be fixed in proper position as shown in the drawing and as directed by the Engineer. These shall be truly vertical or horizontal as the case may be. Screws shall be driven home with a screwdriver and not hammered in. Recess shall be cut to the exact size and depth for the counter sinking of hinges. The fittings and fixtures shall be fixed in a workman like manner and any damages done either to fittings and fixtures or to the shutter frames etc. should be rectified by the contractor at his own cost.


Mild steel fittings shall be bright satin finish black stone enamelled or copper oxidized (black finish), nickel chromium plated or as specified.

Brass fittings shall be finished bright satin finish or nickel chromium plated or copper oxidized or as specified.

Aluminium fittings shall be anodized to natural matt finish or dyed anodic coating less than grade AC 10 of IS: 1868.

Stainless steel fittings shall be non-magnetic, rust & moisture proof, strong & sturdy. Pin of hinges shall also be of stainless steel.

### **10.2. Butt hinges**

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Brass and aluminium hinges shall be manufactured from the extruded sections and shall be free from cracks and other defects. M.S. butt hinges shall be cranked and manufactured from M.S. sheets. All butt hinges shall conform to latest I.S. specifications butt hinges shall generally conform to relevant I.S. viz IS 1341 (M.S.) IS:205 (Cast brass & aluminium, IS:362 (Parliament hinges); IS:453 sprig hinges, IS:3818 (Piano hinges) etc. The size of butt hinges shall be taken as the length of the hinge. Width of the hinge shall be measured from the centre line of hinge pin to end of flange.

### **10.3. Tower bolts**

These shall generally conform to IS 204 (Part II & I). They shall be well made and shall be free from defects.

The tower bolts shall be of the following types:

- MS semi barrel tower bolt with MS sheet pressed barrel and G.I. bolt or with MS barrel and MS sheet bolt.
- Oxidised brass barrel tower bolt with brass sheet barrel and rolled or drawn brass bolt.
- Anodized aluminium tower bolt with barrel and bolt or extruded sections of aluminium properly.

In case of M.S. tower bolt plates and straps after assembly shall be firmly riveted or spot-welded properly.


The knobs of brass tower bolts shall be cast and the bolt fixed into the knob firmly as per I.S. specifications. The tower bolt shall be finished to correct shape and pattern so as to have a smooth action. Wherever specified, aluminium barrel tower bolts shall be manufactured from extruded sections of barrel & bolts.

Knobs shall be properly screwed to the bolt and riveted at the back. The size of the tower bolt shall be taken as the length of barrel without top socket.

### **10.4. Door latch**

This shall be of MS, cast brass or as specified shall have smooth sliding action. MS Latch shall be copper oxidized (Black finish) or as specified. Brass Latch shall be finish bright, CP or oxidized or as specified.



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### **10.5. Aldrops/Sliding Door Bolts**

These shall be oxidized brass or anodized aluminium, iron oxidized or as specified and shall be capable of smooth sliding action and shall be as per relevant I.S. Brass sliding door bolt (Aldrop) shall be made from rolled brass generally conforming to IS:2681. M.S. sliding door bolt shall generally conform to I.S. 281. The hasp shall be of cast brass and screwed to the bolt in a workman like manner. Alternatively, the hasp and the bolt may be in one piece. Bolts shall be finished to shape and threaded with worth standard and provided with round brass washers and nuts or square or hexagonal shape. All components shall be smooth and polished. The leading dimensions of aldrop shall be as the length of the bolt and specified diameter.

### **10.6. Door handles – bow/plate handles**

These should generally conform to IS:208. Unless otherwise specified door handles shall be of 100 mm size & windows handles of 75mm size. These shall be of cast brass of specified size, shape and pattern as approved by the Engineer. All edges and corners shall be finished bright, chromium plated or oxidized as specified. Anodized aluminium or iron oxidized (M.S.) handles shall be of specified size, shape and pattern. The size of the handle is taken as the inside grip of the handles, the same shall be manufactured from M.S. sheet pressed into oval section as per I.S.

### **10.7. Mortise lock & latch.**


This should generally conform to I.S. 2209. Handles shall conform to IS 4992. Mortise lock with latches and a pair of level handles shall be 6 levers, with zinc alloy pressure die cast/brass or as specified body of approved quality and shall be right or left-handed as specified. The pair of handles shall be either brass chromium plated or anodized aluminium of approved shape and pattern or as specified. It shall be of the best Indian make of approved quality. The size of the lock shall be determined by its length. The lock for single leaf door shall have plain face and that for double leaf door a rebated face. Level handles with springs shall be mounted on plates and shall be of approved quality, anodized aluminium or as specified.

### **10.8. Hydraulic Door Closer**

This shall be generally conforming to IS: 3564, hydraulic door closer shall be of approved quality and make. The operation of the Hydraulic door closer shall be very smooth.

This should be of H.D.-66 for external/main doors and elegant –63 for all internal doors. The overall height should not be more than 170mm, for H.D.-66 and 160mm-63, base shall be 110 x 60 mm for H.D.-66 100 x 55 mm for elegant-63 weighing not less than 4.5 kg. For



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H.D.-66 and 4 kg. for elegant –63. Speed of the Hydraulic door closer shall be adjustable and latch closing also shall be adjustable type. Suspension and lubrication of door closer shall be in perfect line and level.

The contractor shall provide for all the incidentals required for fixing these fixtures and fittings such as cadmium plated screws etc. Fittings and Fixtures shall be fixed securely in a workman like manner all as directed by the Engineer. Any of the fixtures damaged during the fixing shall be removed and new one fixed in their place and the surface of joinery made good where affected, at his own expense. Mortise plates shall be used over holes where the bolts enter in the aluminium work. Metal sockets shall be provided to all bolts where the shoot enter brick, stone, concrete etc. The incidental Fixtures like mortise plates, metal sockets screws etc. shall not be paid for separately.

### **10.9. Floor door stopper**

The floor doorstopper shall conform to IS: 1823. This shall be made of cast brass of overall size as specified and shall have rubber cushion. The Engineer shall approve the shape and pattern of stopper. It shall be of brass finished bright, chromium plated or oxidized or as specified. The length of its plate shall determine the size of doorstopper. The body of the doorstopper shall be cast in one piece. All parts of the doorstopper shall be of good workmanship and finish and free from surface and casting defects. Aluminium stopper shall have anodic coating of not less than grade AC-10 of IS 1868.

### **10.10. Workmanship**

#### **10.10.1. General**

All builders' hardware shall be fixed to joinery in a secure and efficient manner. Special attention shall be given to the size and fixing of screws to ensure that the screws are driven (and not hammered) tight and the heads of the screw do not protrude.


#### **10.10.2. Hinges**

All hinges except T or strap hinges shall be countersunk into the edge of timber joinery and frames to depth equal to the thickness of the leaf of the hinge.


#### **10.10.3. Metal Sockets**

These shall be provided to all tower bolts and sliding bolts where the bolts enter brick, stone, or concrete. These shall be securely fixed flush with the surface into mortices and cemented. Mortice plates over holes shall be provided where the shoots enter.

#### **10.10.4. Oiling**

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All locks, bolts, springs and other items of builder's hardware with moving parts shall be properly oiled and handed over in working condition on completion.

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## **11. GLAZING**

The work covered by this specification includes furnishing and fixing the glass panes to aluminium doors and windows, strictly in accordance with specifications and drawings.

### **11.1. Materials**

The float/toughened glass shall be special selected/selected ordinary quantity, as specified and it shall be free from bubbles, flaws specks, waves, air holes, distortion, scratches or other defects. The glasses in bulk quantities shall be brought to site in makers original packings and Maker's guarantee shall be produced if called for by the Engineer. The glass shall be of required thickness as mentioned in the items of schedule of quantities or drawing or as directed by the Engineer. The contractor shall submit the sample of the glass which he proposes to use on the work and only such approved quality of glass shall be used in the works. The glass brought tot site shall be protected against damages. Whenever frosted (obscure) glass is mentioned in the item of schedule of quantities and/or shown in drawings, the glass shall be of sand blown pattern and shall also be got approved by the Engineer.

### **11.2. Beading**

The beading shall be of aluminium of superior quality in case of aluminium doors and windows and/or required sizes mentioned in the items of schedule of quantities and /or shown in drawing. The junction of the beadings shall be mitre jointed.

### **11.3. Workmanship**

The glass shall be cut to the required sizes of panels where it is to be fitted, and it shall be so cut that it fits properly in the frames without ratting. Pre-measurement of each panel prior to the cutting of glass is essential.

The beading shall then be fixed to glass panes and screwed at close intervals not more than 10cm. from each corner and the intermediates not more than 20cm. apart. When glass panes are fixed with aluminium beadings having mitred joints or aluminium beading thin layer of glazier putty shall be applied covering the area in contact between the glass and sash bars and beadings. In case of louvers, all the exposed edges of the glass shall be ground properly.

### **11.4. General**

After the inspection is over and permitted by the Engineer, glass panes shall be cleaned off any labels, paints smears and spots and shall be washed from both the sides and all glazing

left clear, perfect and free from ratting. The contractor shall provide all the scaffolding, tools and plants for fixing the glass panes at his own cost. In case of aluminium windows, any hardware if fixed in position, shall be removed temporarily before fixing the glass and which shall be refixed back in position, all at the contractor's cost.

#### Sun Control Polyester Film - Reflective Type

Type of film	Sun control - Reflective
Base	Polyester
Thickness	50 micron (200 gauge)
Colour	Bronze, Silver, Gold
Radiant Transmittance (DIN 67507 & CIE 20) (300mm to 2500mm global)	Tc 18%
Radiant Reflectance (DIN 67507 & CIE 20) (300mm to 2500mm global)	Pe 45%
Radiant absorbance (DIN 67507 & CIE 20) (300mm to 2500mm global)	ae 37%
UV Transmittance (280 mm to 380 mm)	Tuv 3 %
* Total Rejected Solar heat	72%
* Total Admitted Solar heat	28%
Shading Co-efficient (Solar Factor:	Sc 0.28
'U' Factor	U 0.96 Btu/(hr) (sq. Ft.) (F)

#### PHYSICAL PROPERTIES

Residual Shrinkage	0.3% TD, 0.7%; MD
Service Temperature	-70 to 130°C
Combustion Rate on Glass	Negligible
Melting Point	250°C
Co-efficient of Expansion	1.7X10~5in/in*C

## 12. WATER PROOFING

### 12.1. General

Elastomeric membrane-based water proofing treatment shall be done for exposed terrace.

### 12.2. Preparation of Surfaces

Any cracks in the roof structure shall be cut to 'V' section cleaned wetted and filled up flush with cement and sand mortar (1:3) slurry. It shall be ensured that the top of roof is at a uniform gradient of not less than 1:100.


The surface of roof and that part of parapet and gutters, drain mouths, etc. over which waterproofing treatment is to be applied shall be cleaned of all foreign matter such as, fungus, moss, dust, etc. by wire brushing and dusting. For cast iron drain outlets, a groove shall be cut all-round to tuck in the treatment. Concrete angle fillets shall be provided at junctions between roofs and vertical faces of walls (parapet and RCC walls), around obstacles such as pipes, chimney stacks, etc. and other similar situation to ease up abrupt corners in the waterproofing treatment and the waterproofing treatment taken over the fillets. At drain mouths the fillet shall be suitably cut back and rounded off for proper application of waterproofing treatment and easy flow of water.

### 12.3. Polymer Modified Bituminous Roof Water Proofing Material

Bituminous membrane for waterproofing shall be 4mm thick prefabricated polymer (Atactic polypropylene) modified and shall be reinforced with nonwoven Polyester and shall have following properties. Test methods of all these properties shall be as per relevant ASTM.

codes.

Thickness	: 4mm
Penetration at 25deg. C, 100g, 5 seconds	: 25+_Smm
Softening point	: 110 to 150 deg. C
Low Temp. Flexibility	: 2 deg. C to -5 deg. C
Tensile strength	
Longitudinal	:> 500N/ 5cm
Transverse	:> 500N/ 5cm
Elongation	
Longitudinal	: > 40%
Transverse	:> 40%
Nail tearing resistance.	
Longitudinal	: >= 130N
Transverse	:>= 130N

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Water absorption :0.2% max

#### **12.4. Workmanship**

##### **12.4.1. Preparation of surface**

Preparation of surface shall be as described in Clause 1.2.1.

##### **12.4.2. Primer coat**

One coat of bituminous solvent based primer of approved quality and conforming to IS: 3384

shall be cold applied @ 0.2-0.4 litre/Sq M over the entire area to be waterproofed including.

vertical surfaces. The primer shall be allowed to be dry for minimum 24 hours.

#### **12.5. Fixing of APP Membrane**

APP polymer modified bituminous membrane shall be laid over the primer coat by torch welding. The membrane shall be properly pressed during laying to remove any entrapped air.

The joints should be sealed properly with necessary side laps of 100mm and end laps of 150mm.


The membrane shall be continued along the vertical surfaces up to a minimum height of 300mm. Suitable fillet of 75mm radius shall be formed in cement concrete (1 cement :2 coarse sand :4 stone aggregate of 6mm & down size by volume) at the junction of horizontal/ vertical surfaces. The continued membrane shall be terminated in minimum 20mm x 10mm chase to be provided in the vertical surface and shall be sealed with approved polyurethane sealant.

#### **12.6. Protective layer**

Protective layer shall be provided as described in Clause 1.3. The plain cement concrete layer shall be provided directly over membrane without sprinkling of clean sand.

#### **12.7. Guarantee**

All the above treatment for both sunken portion and exposed terrace the contractor shall furnish five-year guarantee for satisfactory performance of water proofing treatment on account of any kind of defect or leakage and shall be required to rectify the same without any extra charges within the guarantee period.

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### **13. MISCELLANEOUS ITEMS**

#### **13.1. Demolition works.**

##### **13.1.1. General**

The existing approach trestle connecting the existing berthing jetty and the land shall be demolished before the piling activities of new approach trestle. Demolition work shall not be initiated without the written approval of Engineer in charge.

Demolition shall be carried out from the land end and progressed towards the berthing jetty and the demolished concrete and reinforcement shall be disposed of at the location identified by the Engineer in charge.

The demolition of existing approach trestle shall be carried out such that the same does not pose any danger to the port activities or to the existing structures and all safety precautions shall be taken during this operation.


Demolition of existing fender wall at the existing jetty shall be carried out in a sequence to avoid disturbance to the existing berthing jetty operation part by part.

##### **13.1.2. Precaution**

All materials obtained from dismantling or demolition shall be the property of the Government unless otherwise specified and shall be kept in safe custody until they are handed over to the engineer-in-Charge/ authorized representative. The operations shall be got approved from the Engineer-in-Charge before starting the work. Due care shall be taken to maintain the safety measures prescribed in IS 4130 and construction and demolition waste management rules 2016 shall be followed. Necessary steps shall be taken to keep noise and dust nuisance to the minimum. All work needs to be done under the direction of Engineer-in-Charge. Helmets, goggle, safety belts etc., should be used whenever required and as directed by the Engineer-in-Charge. The demolition work shall be proceeded with in such a way that it causes the least damage and nuisance to the adjoining building and the public. Barricading shall be provided as per NGT guidelines.

##### **13.1.3. Measurement and payment**

The Measurement of demolition is calculated in cubic meter and the payment also should be made per cubic meter of demolished concrete.

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### **13.2. Hand Railing**

Tubes for hand railing shall conform to material specifications. All tubes shall be straight and without any dents / deformations. Tubes shall be profile cut and ends shall be prepared to a neat and workman like finish. All elements shall be directly welded. Tubes shall be cold bent to shape and curvature in case of discontinuous ends of handrails. Lower ends of vertical posts shall be cut and splayed (for grouting in pockets provided in the concrete members). For removable type of hand railing, suitable base plates (with provision for bolting) shall be welded to the lower end of vertical posts as shown on the drawings.

The maximum spacing on handrail posts shall be 1500 mm.

Handrail height on stairs shall be 1070 mm taken from the centre of the stair tread.

Hand railing shall be continuous and extend around the edges of all platforms, landings, walkways, and stairways except at stair and ladder accesses. Bolted removable sections shall be provided where necessary to permit removal of or access to equipment.

Handrails at the bottom of stairways shall terminate at the bottom post or completely turn and attach to the post.

Finished handrail shall be free of burrs and sharp edges, which would cause injury to personnel.

Hand railing shall be fixed to the bearing members by bolting or as approved by the Engineer.

### **13.3. Crash Barrier**

Crash barriers shall be provided on the approach trestle roads on both sides as per IRC 67:2001.

The maximum spacing of vertical post shall not exceed 2.0m. The vertical post shall be ISMC 150 section (galvanised) as per IS 2062 E250 Quality A.


The double W section beam shall be 150 mm x 4.5 mm bolted to the vertical post as shown in drawings and specification mentioned as per IRC 5:1998.

The vertical post shall be anchored to the concrete using base plate (16mm thick) and anchor bolts (22 mm dia) as per drawings.

All steel items including base plate, W section, anchor bolts etc. shall be hot dip galvanised to a minimum thickness of 300 microns.

### **13.4. Safety Ladders**



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Ladders shall be located and constructed as shown on the Drawing. Ladders are to be 400mm wide with rungs at 250mm maximum spacing and are to be fabricated from mild steel flat bars or rolled steel angles to suit fixing details. Rungs are to be solid mild steel rods. Fabrication shall be to the approval of the Engineer, all ladders to be galvanised in accordance with Section 5 of this Specification after fabrication.

### **13.5. Expansion Joints**

All the expansion joints shall be of prefabricated type of SENTINEL ALGAFLEX T 50 or equivalent. These prefabricated joints shall comprise metal reinforcing plates completely encapsulated inside a hardwearing elastomer. The complete system shall be bolted to the deck slab shall provide excellent ride quality. Expansion joints shall provide a movement of up to 50mm, shall be suitable for all skew angles.

### **13.6. Fixing Metalwork to Concrete**


#### **13.6.1. General**

Bolts, cast-in sockets, frames, metal inserts etc. to be fixed in-situ concrete shall be set accurately in the shuttering or hung from special supports in their correct positions. They shall be firmly fixed so that they cannot be displaced during the placing of surrounding concrete.

Where approved by the Engineer, holes for bolts may be drilled in concrete after it is hardened. Care shall be taken to ensure that damage to steel reinforcement does not occur. The holes shall be drilled using a rotary percussive drill employing air or water flushing of the hole. All dirt shall be removed prior to grouting in the bolt.

The use of diamond-drilled holes will not be permitted, unless the Contractor can demonstrate to the Engineer that reinforcement has been accurately displaced and will not therefore be cut by the drilling. In the event that approval for diamond drilling is given and reinforcement is subsequently cut, the Contractor shall carry out any additional remedial works, which the Engineer may instruct at the Contractor's expense. Any diamond-drilled holes to accommodate grouted anchor bolts shall be thoroughly roughened as recommended by the bolt manufacturer and to the satisfaction of the Engineer.

Pre-formed holes for foundation and holding down bolts shall be formed by boxes of approved type which can be struck cleanly, or which are suitable to be left in or by expanded metal sleeves. Polystyrene shall not be removed by burning. After the concrete surrounding the boxes or sleeves has hardened and the form stripped, if necessary, the holes shall be cleaned out and temporarily plugged until the bolts are to be fixed. Any damage to holes shall be made good by the Contractor.

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All ragbolts or indented bolts shall be of approved type and shall be accurately set in position with the shank extending so that two threads will protrude past the nuts. They shall be set before the concrete is placed and care shall be taken to protect the bolt threads. Galvanized ragbolts or indented bolts shall be used with galvanized steel sections. Before bolts are grouted in, the holes shall be thoroughly cleaned. Grout of the type indicated or otherwise approved shall be placed in the hole and around the bolt and the surface shall be finished to present a uniform appearance with its surroundings.

Angles forming frames or edges to pits and trenches shall be given an approved protective system. They shall be fixed to the concrete with fish-tailed lugs.

Patent fixing arrangements shall be fitted in accordance with manufacturer's recommendations. Cartridge driven pins shall only be used when approved by the Employer's Engineer and shall not be used for any fixing subject to tensile stress.

#### 13.6.2. Hand railing and Standards

The Contractor shall be responsible for the detail design of all hand railing in accordance with the requirements of this Specification.

The hand railing shall be fixed true to line and the standards set plumb and securely fixed on a mortar bed to the structural concrete or grouted into the structural concrete.


### 13.7. Grout

Unless specified otherwise, grouting shall be carried out with Portland slag cement in the proportion (1:2) with non-shrinkage grouts of approved manufacturers dosage as recommended by the manufacturer and approved by the Engineer.

The dosage, proportions and mixing procedures as per manufacturers details subject to Engineer's approval. The compressive strength after 28 days shall be at least 300 Kg./Sq.cm.

Grouting shall be done after erection and making proper alignment of the structural steel, unless otherwise approved by the Engineer. The surface, which is to be receiving the grout, shall be thoroughly cleaned using compressed air immediately prior to the grouting operations. Grouting pumps from one side of the base plate shall pour the grout mixture continuously. The grout shall be carefully worked under the base plates and shall completely fill the space between the underside of the plates and concrete pedestal including voids around anchor bolts. The procedure for laying grout shall be strictly as per manufacturer's procedure under expert's supervision taking care to avoid air locks edges shall be finished properly. After the grout has its initial set, the grout shall be removed.

### 13.8. MS Grills (Windows & Skylights)

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All structural Steel as per tender drawings shall confirm to IS 226 sections for grills and shall be free from loose mill scales, rust, pitting or any other defects affecting the strength and durability.

#### 13.8.1. Fabrication

The grill shall be fabricated to design and pattern shown in the drawings. All joints shall be made in best workmanship with slotting and welding as required to the specified size and shape. The edge of MS Flats with size 25mm x 10 mm unless otherwise approved manufacturer's specifications, shall be suitably mitred before welding to get the specified size and shape. The joints shall be filled to remove excess stay after welding. Screws, nuts, washers, bolts, rivets, and may other miscellaneous fastenings, devices shall be of steel and shall be provided by the Contractor.

Manufactured MS Grills then be fixed between the framework to correct alignment. Any undulations, bends etc found shall be rectified by contractor at his own cost. The complete assembly of grill so fixed shall be firm and there shall not be any lateral movements.

The samples of the grills shall be submitted for approval before taking mass fabrication.

#### 13.8.2. Installation

The approved grill shall be fixed in position where specified and shown in drawings on masonry walls and any damages to walls, frames etc. caused during the fixing of grills shall be made good by grouting with cement mortar/packing/repairing properly at the Contractor's cost.

#### 13.8.3. Painting


Painting shall be done as per the specifications specified under section Steelwork Protection.

### 13.9. Laminate (Doors)

#### 13.9.1. Plywood Boards

Plywood boards minimum 12mm thick can be pre-laminated boards or formed by gluing and pressing three or more layers of veneers with the grains of adjacent veneers running at right angles to each other. The veneers shall be either rotary cut or sliced and shall be sufficiently smooth to permit an even spread of glue. Face veneers may be either commercial or decorative on both sides or one side commercial and the other decorative. Plywood shall be of BWP grade or BWR grade as per IS: 303.

#### 13.9.2. Adhesive

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Adhesive used for bonding BWP grade of plywood boards shall be BWP type synthetic resins conforming IS:848 respectively.

#### 13.9.3. Thickness

Plywood boards shall be of thickness 12 mm as per tender drawings. Tolerance in thickness shall be  $\pm 10\%$  for boards up to and including 5 mm;  $\pm 7\%$  for boards 6 to 9 mm and  $\pm 5\%$  for boards shall be sanded to a smooth finish.

Moisture content of the plywood boards when tested in accordance with IS:1734 (Part –1) shall not be less than 5 per cent and not more than 15 per cent.

#### 13.10. M. S. Fan Clamps

M. S. fan clamps type 1 or 2 of 16 mm dia. M. S. bar bent to shape with hooked ends in RCC slabs, beams during laying including painting two coats synthetic enamel paint over a coat of primer over the exposed portion of loop.

#### 13.11. SS Handrails

For platforms, staircases, landings, and corridors made of Stainless steel, shall be provided with handrails consisting of a top rail of stainless-steel pipe diameter 60mm and wall thickness 5mm.


#### 13.12. Service Pit Covers

Service pits shall be fitted with a heavy-duty galvanised steel or concrete cover sat on a rebate. The covers shall be made watertight by the addition of a polysulphide sealant all round. All materials and workmanship shall comply with this Specification.

#### 13.13. Fixings to concrete

Bolts, cast-in sockets, frames etc to be fixed in situ to concrete shall be set accurately in the shuttering or hung from special supports in their correct positions. They shall be firmly fixed so that they cannot be displaced during the placing of surrounding concrete. Unless otherwise specified, all such steelwork which is to be cast into concrete shall be provided with Protective System A.

Where approved, holes for bolts may be drilled in concrete after it is hardened. Care shall be taken to ensure that damage to steel reinforcement does not occur. The holes shall be drilled using a rotary percussive drill employing air or water flushing of the hole. Holes shall be carefully cleaned and blown out before the fixings are placed and grouted.

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The use of diamond drilled holes will not be permitted, unless the Contractor can demonstrate to the Engineer that reinforcement has been accurately displaced and will not therefore be cut by the drilling. In the event that approval for diamond drilling is given and reinforcement is subsequently cut, the Contractor shall carry out any additional remedial works that the Engineer may instruct at the Contractor's expense. Any diamond drilled holes to accommodate grouted anchor bolts shall be thoroughly roughened as recommended by the bolt manufacturer and to the satisfaction of the Engineer.


Preformed holes for foundation and holding down bolts shall be formed by boxes of approved type which can be struck cleanly, or which are suitable to be left in or by expanded metal sleeves. Polystyrene shall not be removed by burning. After the concrete surrounding the boxes or sleeves has hardened and the form stripped, if necessary, the holes shall be cleaned out and temporarily plugged until the bolts are to be fixed. Any damage to holes shall be made good by the Contractor.

All rag bolts or indented bolts shall be of approved type and shall be accurately set in position with the shank extending so that two threads will protrude past the nuts. They shall be set before the concrete is placed and care shall be taken to protect the bolt threads. Galvanised rag bolts or indented bolts shall be used with galvanised steel sections. Before bolts are grouted in, the holes shall be thoroughly cleaned. Grout of the type indicated or otherwise approved shall be placed in the hole and around the bolt and the surface shall be finished to present a uniform appearance with its surroundings.

Angles forming frames or edges to pits and trenches shall be given an approved protective system. They shall be fixed to the concrete with fish-tailed lugs as shown on the drawings.

Patent fixing arrangements shall be fitted in accordance with manufacturer's recommendations. Cartridge driven pins shall only be used when approved and shall not be used for any fixing subject to tensile stress.

All fixings into concrete shall be electrically isolated from the reinforcing steel to avoid bimetallic corrosion. Where fixings are of dissimilar metal to the items being fixed, they shall include suitable isolating washers to ensure that there is no electrical contact between the fixing and item.

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### **13.14. Resin Anchors**

Anchor bolts, nuts and washers shall be stainless steel to IS 1367 or equivalent approved. The bolts shall be installed in polyester resin. Where anchorage holes are drilled horizontally the resin shall be installed in capsules and the anchor bolt installation shall be carried out strictly in accordance with the manufacturer's written instructions. The drilled holes shall be irregular and dust free and shall be drilled using a rotary percussive drill on air or water flush. Diamond drills shall not be used.

The Contractor shall provide to the Engineer for review and approval details of the anchorage system proposed, which shall include the following:

- name of resin anchorage manufacturer
- type of resin
- bolt diameter.
- bolt anchorage length.
- hole diameter.
- method of installation

When requested by the Company, the Contractor shall undertake in situ tension tests on selected anchorages to demonstrate the adequacy of the anchorage, at the Contractor's own expense.

### **13.15. Jetty Drainage**

The roadway/ walkway/ deck shall be laid to falls and drained using 75mm dia. PVC pipes directly to the sea. The pipes shall be cast into the concrete at locations as shown on the Drawings and project a minimum 50mm below the deck soffit.

### **13.16. PVC Pipes**

All pipes for drain water from roof of the auction hall to the collection tank shall be of size 110 mm dia. All pipes shall comply with IS4985-2000 and IS12818- 1992 with a pressure rating of 6 kg/cm<sup>2</sup>. All should be maintained as per relevant IS/IEC codes to avoid interference. However, minor distribution piping within the building including pumphouse cum substation, toilets and other area shall be fitted as per drawings with suitable diameter ranging from 20mm to 100mm depending on the location and all fixing including anchor bolts, U clamps etc shall be included in the scope of the contractor without any additional cost.

All PVC/UPVC ducts and drainpipes shall comply with IS4985-2000 and IS12818- 1992 with a pressure rating of 6 kg/cm<sup>2</sup>. The Contractor shall take precautions during the installation of the ducts/pipes in order to avoid damage. Tentative quantity of PVC pipes used in the drain and water pipeline is given in Table 12.0.

**Table 12.0 Tentative Quantity of PVC pipe**

S. No	Description of Pipes	Quantity (m)
1	Drainpipe - 110 mm dia.	1000.0
2	Waste pipeline - < 100 mm dia.	300.0

### 13.17. Water Supply

#### 13.17.1. HDPE Pipes & Fittings

All pipes for water supply from land to proposed ship docking facility shall be HDPE pipe of material grade PE80 PN6 class as per IS 4984-1995. Tentative quantity of water pipeline is given in Table 12.1. However, the contractor shall carry out actual field survey and adjust the quantities for all items specified in the clause. No extra payment shall be made in this regard.

These pipelines are the main supply lines from existing water line inside the port facility. These pipes are buried underground from underground water tank up to the end of existing approach trestle. After that the pipes will be placed on the drain duct provided on both sides of the Approach trestle.

**Table 12.1 Tentative Quantity of Pipeline**

S. No	Description	Dia of Pipe (mm)	Thickness (mm)	Length of Pipe (m)
1	HDPE	160.00	8.7	425.00
2	HDPE	110.00	12.5	300.00
3	HDPE	90.00	10.2	50.00
4	HDPE	50.00	5.7	50.00
5	HDPE	25.00	2.9	80.00
6	HDPE	20.00	2.3	25.00

However, contractor shall survey and establish the actual requirement at site. No extra payment for increase in quantity will be permitted.

#### 13.17.2. Laying of pipeline

Excavation of trench of suitable width and 1.5m depth as shown in drawings through all type of soft or hard soil layer for laying the HDPE pipe on land as directed by the EIC. After excavation to 1.5 m depth, the base of the trench is strengthened by dry stone rubble packing before laying the HDPE pipes. The HDPE pipe is laid in the trench above stone rubble packing and after laying the pipe, the excavated area shall be backfilled with the excavated soil and / or borrowed sand of required capacity and levelled as per existing ground conditions adjacent to the road or other areas. The HDPE water supply pipeline shall also be laid on the approach trestle, jetty and buildings with U clams complete with bolts anchored on to the concrete at not more than every 3m center to center or supported on U clamps of vertical surfaces and / or supported on galvanised angles as required including any other supports as shown in drawings.

#### 13.17.3. Jointing and fittings of pipeline



The pipe shall be joined with butt, heat fusion joints as outlined in ASTM D2657. All joints shall be made in strict compliance with the manufacturer's recommendations. A factory qualified joining technician as designated by pipe manufacturer or experienced, trained technician shall perform all heat fusion joints in the presence of the inspector. Lengths of pipe shall be assembled into suitable installation lengths by the butt fusion process. All pipes so joined shall be made from the same class and type of raw material made by the same raw material supplier.

All fittings of water supply HDPE pipes shall be as per IS: 4984-1995 (or as revised). All fittings shall have manufacturer's trademark stamped on it. All fittings shall be tested at manufacturer's works. Contractors may be required to produce certificate to this effect from the manufacturers.

#### 13.17.4. Testing of HDPE pipe

Pressure testing shall be conducted per Manufacturer's recommendations and as approved by the Engineer in charge. All HDPE mains shall be field-tested. Contractor shall supply all labour, equipment, material, gages, pumps, meters, and incidentals required for testing. Each main shall be pressure tested upon completion of the pipe laying and backfilling operations, including placement of any required temporary roadway surfacing.

#### 13.17.5. Cleaning & Disinfection of Pipelines

At the conclusion of the daily work, thoroughly clean all the new pipe stored nearby at site to remove all dirt, stones, pieces of wood or other material which may have entered during the construction period by forcing a cleaning swab through all mains 2" or greater. Debris cleaned from the lines shall be removed from the job site.

#### 13.17.6. Miscellaneous works

The water pipeline consists of following miscellaneous works.

##### i) Water meters

Providing and fixing domestic water meter of approved make with CI external strainer and non-return valve and MCGM tested etc. complete as directed by the Engineer in charge.

Tentative quantity of water meters used in the water pipeline is given in Table 12.2

**Table 12.2 Tentative Quantity of Water meters**

S. No	Description of water meters	Nos
1	For 15.00 mm dia. pipe	5.0
2	For 25.00 mm dia. pipe	2.0
3	For 50.00 mm dia. pipe	4.0
4	For 110.00 mm dia. pipe	1.0
5	For 160.00 mm dia. pipe	1.0

##### ii) Valves



Providing and fixing gun metal wheel valve gate type (Peet valve) tested by MCGM or bearing ISI.

mark complete as directed by the Engineer in charge. Tentative quantity of valve used in the water pipeline is given in Table 12.3

**Table 12.3 Tentative Quantity of Valves**

S. No	Description of valves	Nos
1	For 15.00 mm dia. pipe	10.0
2	For 20.00 mm dia. pipe	5.0
3	For 25.00 mm dia. pipe	5.0
4	For 50.00 mm dia. pipe	5.0
5	For 80.00 mm dia. pipe	5.0

iii) Bends

Providing & fixing mechanical bends to 160mm dia. pipes by mechanical bends as per manufacturer's instructions etc. complete as directed by the Engineer in charge. Tentative quantity of bends used in the water pipeline is given in Table 12.4

**Table 12.4 Tentative Quantity of bends**

S. No	Description of bends	Nos
1	90-degree bends	12.0
2	45-degree bends	6.0

### 13.18. Sanitary Fixtures and Fittings

#### 13.18.1. Workmanship

All sanitary wares shall be fixed in a neat workmanlike manner, true to level and plumb. Manufacturer's instructions shall be followed closely regarding installation and commissioning.


#### 13.18.2. Protection of Fixtures

Fixtures shall be protected throughout the progress of the work from damage. Special care shall be taken to prevent damage and scratching of chromium plated fittings. Tool marks on chromium fixtures, etc. shall not be accepted.

All fixtures shall be fixed with chromium plated brass screws with washers whenever necessary. Protective paper on fixtures shall be removed with hot water only at the final completion of work.

#### 13.18.3. Sanitary ware

All porcelain sanitary ware shall be of first quality, free from warps, cracks and glazing defects. All sanitary ware, fittings and fixtures shall be as shown in drawings and indicated in Bill of Quantities.

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#### 13.18.4. Testing

When the installation has been completed to the satisfaction of the Engineer it shall be tested in the following manner:

- b) The entire system shall be slowly filled with water, allowing any trapped air to escape.
- c) When all outlets are closed the system shall be checked for water tightness.
- d) Each outlet shall then be checked for rate of flow and correct operation.

#### 13.18.5. List of approved makes for plumbing and sanitation materials.

Contractor to obtain written approval of Brand and model prior to procurement of material.

### **13.19. Specification for Sewage Treatment Package**

#### 13.19.1. Scope

The scope of includes design, procure, supply, commission the complete skid Mounted Sewage Treatment Package of capacity for 50 pax. at proposed ship docking facilities.

The skid is to be placed in the jetty with suitable concrete foundation. Sewage from the toilets shall be the input to the skid. The toilets are located on the first floor of the building, suitable size of pipeline to be laid and necessary pumping arrangement shall be provided. The scope of work includes the following.

- (i) Detailed designing & Engineering, which includes,
  - To prepare Process & Instrument Diagram with pipe sizing after visiting the site.
  - To prepare Layout
  - Preparation of detailed Specifications for Equipment
  - Preparation of Specifications for Electrical Distribution Board
  - Providing necessary GA drawing for approval of factory.
- (ii) Procurement & Supply of equipment as mentioned in Equipment list.
- (iii) Erection of equipment & instruments at site.
- (iv) Preparation of Piping, Electrical, Instrumentation documents:
  - Instrument List
  - Electrical Load List
  - Earthing
  - Provide technical support and clarifications during execution to ensure construction is carried out as per design.
- (v) Provide as-built drawings of Layout, Hydraulic Profile and P&ID.
- (vi) Transportation of equipment / material to site.
- (vii) Commissioning of all Equipment, Instruments as per respective lists.

(viii) As the building are fully occupied Sewage shall be available during commissioning

### 13.19.2. Design Criteria

The sewage effluent characteristics are estimated as follows.

- a) Sewage - 15 m<sup>3</sup>/Day
- b) Operating Hours - 8 Hours
- c) Design parameters.

The process parameters to be used for the design of STP are given in Table below.

Sr. No	Parameter	Inlet Parameter	Process	Outlet Parameter	Units
1.	Actual Flow	15		15	(m <sup>3</sup> /day)
2.	pH	5.5 to 8		6.5 to 7.5	---
3.	COD	450 to 600		<200	(ppm)
4.	BOD	250 to 350		<40	(ppm)
5.	TSS	150		<50	(ppm)
6.	Oil & Grease	10 - 15		<5	(ppm)

### d) Process Scheme


Sewage shall be flowing by gravity from the toilets located at the first floor of the auction hall to STP. The skid will consist of following units:

- Bar Screen
- Oil and grease trap.
- Aeration Tank with Diffused Aeration System
- Secondary Settling Tank with Sludge Recycle Pumps
- Intermediate Holding Tank with Filter Feed Pumps
- Pressure Sand Filter
- Activated Carbon Filter
- Treated Water Holding Tank
- Chemical Dosing Systems
- Bag type sludge filter.

In addition to these Contractor may include other items which may be required to make the treatment system complete.

### e) Process Description

Sewage from last chamber of septic tank first enters the Bar Screen. Here, all macro solid particles are screened and separated from the sewage. The sewage then enters into the oil and grease trap (Both units are built in Aeration tank). In this trap, oil and grease content is removed. From oil and grease trap, sewage overflows in the Aeration Tank with media,

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where it receives Activated Sludge Treatment. It is also provided with diffuser system at the bottom of the Tank for aeration. Aeration helps in maintaining the Dissolved oxygen levels in the reactor. The MLSS (Mixed Liquor Suspended Solids) carry out the biological degradation of the sewage. The sludge generated during this process needs to be separated. This separation is carried out in Secondary settling tank. The overflow from the Secondary Settling Tank is collected in the Intermediate Holding Tank. Here, it has to receive ozonisation for disinfecting the water. Then, with the help of filter feed pumps sewage is transferred through Pressure Sand filters (PSF) for further treatment. PSF uses sand as filtration media. From PSF, water is fed to Activated Carbon Filter (ACF). This treated water is then collected in Treated Holding Tank. A part of the sludge from the secondary settling tank is recycled back to the aeration tank and excess part of it is discharged to the bag type sludge filter. Sufficient number of sludge bags may be supplied for smooth running for one year.

#### 13.19.3. Commissioning:

Contractor has to depute their engineer as required for erection and commissioning. Factory shall attach its manpower during the activities & operation of the plant. Commissioning shall immediately follow the physical completion.


- Necessary Approval from Pollution Control Board of state of Maharashtra regarding acceptability of the system & the quality of output water shall be obtained by the Contractor.
- All consumables such as bio-sludge/cow dung, dosing chemicals, oils/grease, etc. required for plant commissioning/operations shall be arranged by the Contractor.
- Contractor has to supply the consumables, dosing chemicals etc. for smooth running of the plant for one year.

#### 13.19.4. Operation

The skid shall be so designed that it runs on full autcycle and that a single operator can keep watch on the system. Visual indications should be available on the control panel to prompt the operation for action and to resort to manual operation in case of requirement.

#### 13.19.5. Technical Documents


- i) The supplier shall supply in quadruplicate, the manuals for operation, mechanical maintenance, electrical maintenance with wiring diagram, and electronic maintenance with circuit diagram with complete description, spare parts drawing and list. The documentation shall include the System description and technical specifications of the whole system. The documents shall be in English language. These manuals are required to be supplied in softcopy also. The manuals shall contain complete list of electrical/electronic parts/instruments/equipment used in the machine giving the following details:

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- a) Nomenclature
- b) Part Number
- c) Order Code
- d) Type/make.
- e) Complete address of parent manufacturer with tel.no. /fax/e-mail
- f) Complete address of authorized Indian Service Centre
- g) Quantity used.
- ii) The supplier shall furnish detailed specification of various consumables to be used in this equipment with its Indian equivalent. The document shall contain the periodicity of replacement of consumables. The supplier shall provide technical literature of all bought out units/sub-assemblies fitted in the equipment.
- iii) The supplier shall provide evidence of his capability to deliver the Skid mounted STP by a reference to at least 05 similar systems already supplied and commissioned.
- iv) The whole equipment should be securely packed to avoid any loss or damage during transit, so that it reaches the consignee in a perfectly serviceable condition.
- v) The supplier shall forward the foundation drawing and service requirements that shall be necessary for the operation and maintenance of the equipment, 3 months prior to pre-despatch of equipment.
- vi) The supplier shall provide the maintenance service support.
- vii) The supplier shall impart training for Operation and Maintenance aspects free of cost at the installation site.

#### 13.19.6. Warranty

The equipment along with all sub-components and accessories should be guaranteed for smooth working for a period of ONE year from the date of successful commissioning for any damage, defect or malfunctioning that is attributed to deficiencies during use of the system. The supplier shall be liable to provide free replacement of equipment/sub-system in any such eventuality to ensure proper functioning of the system.

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## **14. BOLLARDS**

### **14.1. General**

Bollards shall be cast iron and shall comply with the requirements of I.S. 210 for the grade or grades of iron most suitable for the casting of required capacity of bollards, and shall be designed, manufactured, and supplied by an approved manufacturer.

The requirements of Clause 10.2.6 of BS6349: Part 4, Code of Practice for Design of Fendering and Mooring Systems are to be complied with such that if overload, the mooring equipment or its anchorage to the structure shall fail before the overall structure is damaged.

### **14.2. Capacity and Quantity**

The capacity of the bollard is the Safe Working Load (SWL) on the bollard. The bollard and its anchorages shall be designed to safely withstand the specified working load after fixing. The minimum SWL required for the bollard is 90 Tonne for the outfitting jetty and also 100 Tonne at the end of the jetty. The numbers of bollards shall be in accordance with contract drawings, BOQ and specifications as a minimum.


### **14.3. Design Features**

The bollard and its anchorages shall be designed to safely withstand the specified working load after fixing.

- Bollards will be Twin-Horn, T-Head or Sloping Lobe type.
- Each bollard will be capable of supporting, at least, two mooring lines, of approximately 50 mm diameter. Tension of each bollard generated by mooring lines will be less than bollard capacity in order to avoid bollard overloading.
- Maintenance will be reduced to a minimum therefore simplicity on design will be priority consideration.
- Bollards working ranges will be consistent with project drawings.

The factor of safety on the design of the bollard shall be 3 on tensile strength. The factor of safety of 3 is applicable for shear, bending, and axial stresses. The combined bending, axial and shear calculated by Von-Mises equation shall have a factor of safety of at least 2. The tensile strength of the cast iron depends on the thickness of material used for the casting. Guidance given in IS 210 shall be used to select the suitable tensile strength for material and thickness used in the casting. The design verification of bollard for structural strength requirements shall be carried out in accordance with IS 800.

The structural design of anchorages bolt group shall be designed to I.S. 800 and anchorage length shall be determined in accordance with IS 456. Bollards shall be designed for a

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horizontal operating range of 180 degrees and a vertical operating range of 15 degrees down and 30 degrees up. All parts of the bollard in contact with the mooring lines shall be smooth and not induce wear on the mooring lines. All bolt recesses shall be filled with a mixture of pitch tar and sand to form a smooth surface up to the top of the bollard base. Anchor bolt embedment length into concrete shall be calculated for the worst-case loading from the direction and angle specified in this specification.

The design life of the fender system shall be minimum 10 years.

#### **14.4. Source**

Bollards shall be obtained only from such manufacturers who have supplied in the last five (5) years similar capacity and type of bollards to similar users and who possess adequate testing facilities and equipment and employ competent staff for detailed testing and examination as specified herein.

Bollards of similar type and capacity already supplied by the manufacturer from whom bollards are proposed to be obtained, shall have been in trouble free service for at least three (3) years and certificates from the actual users to that effect shall be submitted to the Engineer for his review before the bollards are ordered out. The Contractor shall also furnish to the Engineer (i) manufacturer's name and address (ii) three copies of the manufacturer's design and drawings for the bollards and their fixings (iii) three copies of the specifications to which bollards and their accessories conform, before the bollards are ordered out, for Engineer's approval.

#### **14.5. Test and Inspection**


Mechanical tests shall be carried out on in accordance with I.S. 1030 or equivalent ASTM or British Standard and the results reported to the Engineer. Mechanical test pieces shall be cast from the same batch of material and at the same time as the bollards. Following tests shall be performed:

- (i) Tensile Strength and elongation - as per I.S. 1608.
- (ii) Impact Strength - as per I.S. 1757.
- (iii) Bend Test - as per I.S. 1599
- (iv) Transverse strength - as per relevant, I.S. Specification.

The results of all the tests shall conform to recommendations of the Standard followed. For every two bollards cast, one test on each of the above categories shall be performed.

In addition to the above tests, C.I. bollards shall be X-ray tested at Site by the Contractor in the presence of the Engineer's Representative before installation in position, at the cost of the Contractor. The Contractor shall provide all testing equipment.



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The bollards and their accessories shall be installed in the Works only after the Engineer has inspected them at Site for any flaws or defects, inimical to their usage and has approved the quality.

#### **14.6. Painting of Bollards**

All bollards, whether or not mentioned on the drawings shall be painted after installation with one coat of primer of red oxide, zinc chrome paint conforming to IS 2074 “Ready mixed paint red oxide zinc chrome priming” and two coats of finishing paint of yellow colour to IS 2933 “Enamel, exterior (a) Undercoating (b) finishing”. The rates quoted by the contractor shall be deemed to be inclusive of cost of painting etc., complete. Surfaces of metal against which concrete will be placed, shall be free from oil, grease or other objectionable matter.

#### **14.7. Anchorage Hardware**

Anchorage bolts shall be of minimum grade 8.8 as per IS 5634 and IS 1367 and hot dip galvanized. Contractor shall carry out calculations for anchor bolts assuming available anchorage depth in to in-situ concrete of 500mm. Drawings shall be used as reference for location of bollard units, installation details and conditions.

Anchorage shall be embedded in concrete, to allow the union between them and bollard basis, passing through corresponding holes and holding them with nuts. Steel for the anchorages shall be in accordance with IS 800.

Once the installation of bollards is finished, the Authority Engineer shall carry out all the tests as necessary to prove its correct operation.


#### **14.8. Installation**

Bollards shall be fixed in the Works as shown on the drawings and in the manner approved by the Engineer. Templates shall be used to ensure that bolts are in the correct position. The holding down bolts shall not project above the top of the bollard base. Samples of the bolts, nuts, washers, etc., shall be submitted to the Engineer for approval before being used in the Works.

Bollards supplied by the manufacturers with apertures for the introduction of cement grout and shall be grouted after fixing. The bollards shall be installed on a minimum bed of 20 mm approved cementitious non-shrink grout having minimum compressive strength of 70 MPa on 7 days. The bollard shall be filled with approved cementitious grout or M30 grade concrete and the bolts re-tightened after the grout under the base has set.

The templates shall be carefully marked to show the centreline of the bollard and the leading



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edge that is to face the quay edge.

Any bolt protruding above the top of the baseplates of the bollards shall be trimmed down to the correct level. Any damage caused to the threads of the bolts during trimming shall be made good. The cost of carrying out all corrective work upon the bolts shall be at the cost of the contractor.

#### **14.9. Documentation**

CONTRACTOR shall submit, at least, following information for approval prior to manufacturing bollards and hardware:

- Shop drawings for bollards.
- Detailed design calculations demonstrating proposed anchorages meet loading requirements with the required safety factor.
- Grout
- Bolts, nuts and washers
- Chemical analysis test reports
- Coating system data sheets

Contractor shall submit following information after manufacture of bollards and hardware:

- Mill test certificates for each heat number.
- Certificate of conformance for line pull rating.
- Record showing heat numbers and serial numbers.

## 15. FENDERS

### 15.1. General

The Contractor shall design, supply and install rubber fender units in accordance with the drawings and this Specification. The Contractor should be aware that the Employer requires a long service life together with low maintenance costs for the fender systems. Design and fabrication of all steel work shall be in accordance with clauses of this Specification. The fender types shall be installed at the positions shown on the Drawings.

### 15.2. Design and Performance Requirements

#### 15.2.1. Fender System

The fender system selected for the project comprised of following fender units and position as indicated on the drawings.

Location	Description	Quantity
Outfitting jetty 1,2 and 3	Arch Fender (DAV 1000H) or equivalent having Energy absorption capacity including fender panel support frame and removable type frontal pads and all necessary fixtures. <u>DD fenders including fender panel and support frame.</u>	As per drawings and bill of quantity
Approach trestle	Arch Fender (DAV 400H) or equivalent having Energy absorption capacity including fender panel support frame and removable type frontal pads and all necessary fixtures.	

The berthing energy and the fender reaction should be restricted to the values applicable for the above listed fenders. The fender units, fender panels, low friction facings, fixings, chains and fittings for fendering shall be obtained from approved specialist suppliers and manufacturers and shall be fabricated, assembled, installed and tested in accordance with manufacturer's instructions and recommendations.


#### 15.2.2. Design Vessels

Particulars of the design vessel are as follows:

Description	70,000 DWT vessels
Length (L)	235m
Breadth (B)	38.0m
Depth	19.9m

The design life of the fender system shall be minimum 10 years with a warranty for 2 years.

#### 15.2.3. Fender selection

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Following points shall be considered while selecting a suitable fender.

- a) Berthing velocity shall be taken as 0.2 m/sec for largest vessel and 0.45 m/sec for the smallest vessel.
- b) Berthing angle shall be considered as 10 degrees while considering derating of the fender for angular berthing.
- c) Temperature and Velocity derating shall be considered in accordance with PIANC guidelines.
- d) Allowances shall be made for manufacturer's tolerances on energy absorption and reaction from the fender.
- e) Fender shall have sufficient shear capacity against sagging / drooping due to its own self weight and weight of fender frame without the effect of weight chains. Calculations shall be submitted in this regard for approval.
- f) The energy absorption of DAV 1000 H is 21.7 Ton/m, and the reaction force is 278.1 Ton.

### **15.3. Fender Units**

The locations of fenders to be provided and installed under this Contract are shown on the Drawings. Prior to procurement or installation of the fenders the Contractor shall provide to the Engineer for review manufacturer's data to demonstrate general product compliance with this Specification. Details of similar fender units, including fender type, location and date of installation, which have been successfully installed for similar conditions, shall also be provided.

The Contractor shall supply to the Engineer the following information:

- Identification marks
- Name of manufacturer
- Place and date of manufacture.
- Size and rubber grade of fender unit
- Certificates of origin of each fender bearing the corporate stamp and signature of an authorised person and giving a unique reference to each fender so that it is traceable to its place and date of manufacture.
- Test results.

### 15.3.1. Load Deflection Characteristics

All the fenders supplied shall exhibit load deflection and energy-deflection characteristics as per requirement. Unless otherwise specified all fenders shall exhibit linear load-deflection relationship for deflection of at least 52.5%. Other characteristics shall be as per table below.


1.	Berthing condition	Moderate wind and swells site condition with Moderate berthing condition
2.	<b>Design parameters.</b>	
	a. Berthing angle	10°
	b. Factor of Safety for abnormal berthing energy	2.0
	c. Berthing energy of fender	@52.5% deflection the minimum energy absorption.
	d. Reaction force	@52.5% deflection the reaction force.
	e. Overall thickness of fender system at right angles to the face of wharf.	5000mm from the face
3	Number of fenders	As per BOQ
4.	Type of fender	Arch Fender and DD fender
5.	Accessories	Anchor bolts (Super Bolt) nuts, washer etc., as required for fixing the fender in position.

### 15.3.2. Documentation

All fender units shall be permanently marked with a unique reference so that they can be individually identified both during manufacture and once incorporated into the Permanent Works. For the latter case, the marks are to be clearly legible to someone standing on the quay/dolphins. For all fenders, full records of manufacture and installation are to be kept on forms to the approval of the Engineer, including:

- a) Manufacturer, location of manufacture
- b) Method of manufacture
- c) Mould reference where appropriate, supervisor in-charge
- d) Date(s) of manufacture.
- e) Location of fender unit in Works, and date of installation
- f) Confirmation that the fender has been subjected to a "break in" cycle, including details.
- g) Any other relevant information
- h) Authorised signatures confirming details are correct.

Preliminary forms shall be submitted to the Engineer prior to delivery of the fender units to Site. Final forms shall be submitted within two weeks of installation of the fenders.

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### 15.3.3. Fixings for Fenders

All bolts and fender anchors used for securing components of the fender system shall be designed by the Contractor to suit the specified fender rubber and Contractor's facing panel and chain design.

All fixings shall be stainless steel Grade 1.4401 to BS EN 10088 (or AISI grade 316). The bolts shall be well lubricated with a PTFE tape or spray or with a suitable underwater lubricant (Aqua Lube or similar) to prevent galling between the bolt and socket. The positions of the fender anchors shall be determined by the Contractor to suit the fender unit design, whilst still satisfying the geometrical requirements and restrictions shown on the drawings.

All fixings shall be such that they are stronger than the items they are fixing, in order to avoid damage to the fixings in the concrete.

### 15.4. Assembly and Installation

Rubber fenders shall be handled and stored in accordance with the manufacturer's instructions. Great care shall be taken to prevent cutting or tearing of the rubber, particularly in the area of any embedded plates and around bolt holes and bolt recesses in the fender base, flanges or fins.

Fenders shall normally be stored in the protection packings in which they have been transported. Fenders shall be handled in such a way as to prevent them from being distorted, overstressed or damaged in any way. All slings, ropes or chains for handling fenders shall be of rubber or nylon sheathed.

Final fender alignment shall be such as to provide, within recommended tolerances, a straight line to the berthing face. Fenders shall be installed in accordance with the manufacturer's recommendations/instructions, from the installation of cast-in sockets to the final tensioning of fixing chains. The concrete surface onto which the fender rubber is fixed shall be vertical, flat and continuous and shall provide full bearing for the area of the fender rubber.

Tolerances on fender panel installations shall be compatible with tolerances on concrete structures to which they are affixed but shall in no circumstances be installed to dimensions that exceed the tolerances stated herein.

Individual fender panel installations shall meet the required tolerances for position (relative to the specified level for the top of the unit), and for verticality (measured at four corners of fender panel in planes both parallel to and normal to the berthing face).

Fender installation tolerances shall be:

- Position (top level of unit)  $\pm 25$  mm.
- Alignment (at centreline of rubber cell)  $\pm 30$  mm
- Verticality (elevation and "sectional")  $\pm 25$  mm

### 15.5. Permitted Tolerances

Tolerances on fender performance and physical dimensions shall not exceed the following.

i) Performance:

- Energy absorption (E) =  $\pm 10\%$
- Reaction force (R) =  $\pm 10\%$

ii) Physical Dimensions:

- Height of fender (H) =  $\pm 2\%$

The rated reaction and energy absorption specified in this specification excludes the tolerances and shall be selected while selecting the suitable fender.

### 15.6. Fender Inspection Requirements

The testing, except for fatigue testing, shall be carried out in accordance with the latest revision of Supplement to Bulletin No 45 "Report of the International Commission for Improving the Design of Fenders" by PIANC.


All fenders shall be inspected at the manufacturer's Works and shall be duly certified by a third-party inspection agency as fully meeting this specification. The third-party inspection agency shall be Lloyd's or IRS, or other agency approved by the Employer. The cost of Third-Party Inspection shall be borne by the contractor.

The Contractor shall supply to the Engineer in-house laboratory material testing reports giving results of all tests performed on each batch of material actually used for the fender manufacture, duly certified by the third-party inspection agency, at the time of supply of fender units.

### 15.7. Fender Testing Requirements

Verification testing to determine compliance with the specified energy and reaction requirements shall be carried out in accordance with Section 6 of Appendix A of the "Guidelines for the Design of Fendering Systems: 2002", published by the International Navigation Association.

A minimum of 10% of fenders or a minimum of 2 Nos shall be tested at the local ambient

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temperatures. These tests shall be witnessed by Employer's Engineer or his representative. All rubber fenders shall be subject to at least a single "break in" compression cycle to rated deflection at the factory prior to shipment. Original copies of test certificates shall be sent to the Engineer. The Contractor may elect to test the fenders at a different berthing velocity or different temperature to suit his testing apparatus, provided he establishes the effect of the differences in accordance with the PIANC Guidelines.

Samples for verification testing shall be actual fender elements selected at random. One fender unit shall be selected from each batch of ten units produced of a particular size, grade and specification. Where different moulds are used or the manufacturing process is altered, this shall be treated as a new batch of fenders for the purpose of this Clause. Where there are less than ten fenders in a batch, then one fender shall be tested from that batch.

The Engineer shall be given at least four weeks' notice of when and where the fenders are to be tested. The Contractor shall furnish in-house laboratory testing report for the deflection-load and deflection-energy absorption tests carried out on the selected fender duly witnessed and certified by the third-party inspection agency specified herein at the time of supply of the fender units. The Contractor shall provide facilities to permit the Engineer to witness the tests if he so desires.

Where the test is not carried out at the conditions specified for the Rated Performance Data, then tests to establish the Temperature Factor and Velocity Factor shall be carried out in accordance with Appendix A of the "Guidelines for the Design of Fendering Systems: 2002". These tests shall be considered as part of the verification testing, and the requirements of the previous paragraph shall apply.

Full details of the tests shall be provided, including certification of the test equipment used.


## **15.8. Documentation**

### **15.8.1. Calculation Notes**

Following notes shall be included, as a minimum:

- Fender rubber strength against drooping in vertical direction due to self-weight of fender and frontal frame.
- Fender System Justification (front panels and fender) according to performance requirement including manufacturer tolerances.
- Panel structural justification
- Fixing and accessories structural justification
- Anchor bolt calculations for fenders and chains.

### **15.8.2. Drawings**

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Including, at least, following drawings:

- Fendering system plans (plan view, front and side elevations)
- Anchor bolt layout.
- Insert details.
- Bolts, nuts and washers' details
- Bill of material

#### 15.8.3. Fabrication related Procedures

- Fitting justification
- PE-UHMW pads technical data sheets.
- Fender's performances curves
- FAT procedure and PIANC procedure
- Handling, transportation, and storage procedure
- Installation and maintenance procedure
- Painting procedure
- Inspection and tests plan


#### 15.8.4. Certificates and Test Reports

- PIANC Material certificates for rubber, including material traceability sheet.
- Material certificates type 3.1 for accessories or, at least, Certificate of compliance with the purchase order type 2.1, including material traceability sheet.
- FAT report
- PIANC test report
- Painting report

#### 15.8.5. Special Points of Consideration

- i) All metal parts including bolts, washers head, plate, etc., are to be of stainless steel only.
- ii) The system should preferably be designed to facilitate easy removal of old bolts and reinserting of new bolts in case of bolts connecting the fender to the wharf fail.
- iii) Suitable arrangements to prevent the bolt working loose while in operation due to berthing force and frequent tightening of the bolts is to be avoided.
- iv) The connection between the front bearing plate and the fender rubber should be carefully designed to avoid the bolts shearing often.
- v) Full specifications with illustrations and necessary drawings, spare parts lists, complete set of all necessary tools and spanners shall be supplied along with the



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fenders together with detailed instructions and all other information needed for guidance and any further clarification that may be sought later to enable proper installation of the fenders.

- vi) All materials and workmanship and duty shall be corresponding to Indian Standard Specifications and ratings. In case the materials and ratings are as per standard specifications and ratings other than I.S.S. or I.S. ratings the supplier shall enclose two copies of such standard specification or ratings along with his tender.
- vii) Compression test shall be performed on fender extracted from a lot of shipment at random to confirm that the fender meets with the specifications, viz., energy, absorption, reaction load and deflection including tolerance, it any. (To compress the sample fender vertically, with the compression tester to measure the reaction load, one rubber fender will be tested at a time).
- viii) The recovery in height of the rubber fender at one minute after the fender is released from the load should be more than 95% of its original height.
- ix) All materials used shall be new and no material shall be used on the work without the prior approval of the Employer's Engineer or his representative.
- x) The decision of the Employer's Engineer or his representative regarding the quality of any materials used on the work will be final and binding on the contractor. He shall remove from the site of work any material rejected as unfit for use on the work at his own cost as soon as he is ordered to do so, failing which the Employer's Engineer or his representatives shall remove such materials from the site of work and shall deduct the cost incurred by such removal by the Board from the site of work from any moneys due to the contractor.
- xi) All the work shall be carried out as per relevant specifications and to the satisfaction of the Employer's Engineer.
- xii) The specification of all other materials shall be as per the relevant Indian Standard specifications as applicable. All BIS specifications referred to in this schedule shall be the latest version.

#### 15.8.6. Defect Liability Period for Fenders

The Contractor shall warranty the complete fender system for a period of 24 months from the date of completion of work, for any kind of manufacturing defects or deviations from specified performance. An amount of 5% of the value of the marine fender work will be held towards the satisfactory performance of the fenders until expiry of defect liability period. However, the Contractor may also submit a Bank guarantee for an equivalent amount (as stated above) issued from any Nationalized Bank having its branch in Kandla or enforceable and encash able at Kandla.

## 16. SPECIFICATION FOR STEEL FABRICATION AND ERECTION


### 16.1. Scope

This specification covers the requirements for furnishing of all materials, labour, equipment and services for supply and delivery of all structural and miscellaneous steel for the jetty works. General requirements and procedures for the Contractor's supply and control of materials are covered in this specification.

### 16.2. Codes and Standards

The design and construction of steel structures shall be in accordance with the following Codes and Standards referenced herein. Fabrication of steel structure, except as modified herein, shall be in accordance with latest edition of the following codes and standards:

IS 800	General Construction in steel – Code of practice Hot
IS 814	Specification for Covered electrodes for manual metal arc welding of carbon and carbon manganese steel
IS1363 Part 1	Hexagon head bolts, screws and nuts of product grade `c' - part 1: hexagon head bolts
IS1363 Part 2	Hexagon head bolts, screws and nuts of product grade `c' - part 2: hexagon head screws
IS1363 Part 3	Hexagon head bolts, screws and nuts of product grade c - part 3: hexagon nuts
IS1477	Code of practice for painting of ferrous metals in buildings - part 1: pretreatment
IS 2062	Hot rolled low, medium and high tensile structural steel
AISC	Structural Steel for Buildings of the American Institute of Steel Construction.
AWS D1.1	Structural Welding Code of the American Welding Society.
IS 816: 1969	Code of Practice for use of metal arc welding for general construction in mild steel.
IS 822: 1970	Code of Practice for inspection of welds.
IS 1024: 1999	Code of Practice for use of welding in bridges and structures subject to dynamic loading.
IS 1182: 1983	Recommended practice for radiographic examination of fusion welded joints in steel plates.
IS 1363: Pt1 2002, Pt 2	Specification for hexagon head bolts, screws and nuts of product grade C. 2002, Pt 3 1992
IS 1367: 2002	Technical supply of threaded steel fasteners.
IS 2062: 1999	Steel for general structural purposes - specification.
IS 3757: 1985	Specification for high strength structural bolts.
IS 4260: 2004	Ultrasonic testing of butt welds in ferritic steel.
IS 5334: 2003	Code of practice for magnetic particle flaw detection of welds. IS 6623: 2004 High strength structural nuts.

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IS 7215: 1975	Tolerances for fabrication of steel structures.
IS 7307 (Part 1): 1974	Approval testing of welding procedures.
IS 7310 (Part 1): 1974	Approval tests for welders working to approved welding procedures.
IS 8500: 1991	Structural steel - micro alloyed (medium and high strength qualities).
IS 9595: 1996	Recommendations for metal arc welding of carbon and carbon manganese steels.
ASTM A36:2005	Specification for Structural Steel
ASTM A435: 1990	Specification for straight-beam ultrasonic examination of steel plates for pressure vessels
ASTM E709: 2001	Guide for magnetic particle examination
ISO 10474: 1991	Steel and steel products - Inspection documents
ISO 10474: 1991	Steel and steel products - Inspection documents

In the event of conflict, inconsistency or ambiguity between material requisition, data sheets, drawings, this Specification, Standards and Codes referenced herein, or other documents, the Contractor shall refer to the Engineer's Representative, whose decision shall prevail. In principle the requirements of the most stringent document shall apply.

### 16.3. Working Drawings


The design of the subject structures with descriptions, sizes, sections and relative locations of various structural members is shown on the Construction Drawings.

The shop drawings to be prepared by the Contractor to facilitate the fabrication and assembly of the structures shall provide full and complete information and instructions including typical shop details and procedures needed for that purpose. Review of shop drawings by the Engineer's Representative or its representative does not relieve the Contractor of his responsibility to complete the work in accordance with the contract and specifications.

The Contractor shall provide drawings and calculations of temporary works, inclusive of support points, jacking points, sling points, etc.

The Contractor shall provide the Engineer's Representative with "as built" drawings upon the completion of fabrication. These drawings shall be the latest revision of the Contract Drawings modified to show the structural members as fabricated, including such items as additional weld splices, windows, material substitutions, etc. Electronic copies shall also be provided to the Engineer's Representative.

Substitution and modifications shall not be allowed without prior approval by the Engineer's Representative. The Contractor shall detail the extent of substitutions and

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modifications, provide the effect on schedule, and cost and submit proof of equivalency of material.

The modifications/alterations required due to small dimensional mismatch from engineering drawings is to be carried out by the Contractor under his Scope of Work.

Contractor shall notify the Engineer's Representative in writing, at time of submission, the deviations from requirements of Contract Documents stating the reason for these deviations.

#### **16.4. Submittals**

Submit mill certificates, welding procedures, fabrication procedures and Inspection and Test Plans to the Engineer's Representative in accordance with the Contract requirements.

All materials shall be properly marked and traceable in accordance with this Specification.

Shop drawings conforming to the format used for the Contract Drawings shall be submitted.

Ensure the accuracy and quality of shop drawings are verified by the Contractor's Engineer's Representative before the drawings are submitted to the Engineer's Representative for his review.

Submit, in accordance with the Contract Schedule and in accordance with the Contract requirements, shop drawings to the Engineer's Representative for their review. One print shall be returned by the Engineer's Representative, stamped to indicate that the drawings have been reviewed and comments added where applicable. If the shop drawings are illegible, obscure or incomplete, they may be returned by the Engineer's Representative marked "not reviewed", and such shop drawings are to be properly redrawn and resubmitted.

The Contractor shall make changes in shop drawings, which the Engineer's Representative may require consistent with the Contract Documents and resubmit. When the Engineer's Representative's review is complete and requested changes made, the Contractor shall provide copies of shop drawings incorporating requested changes in accordance with the Contract requirements for the use of and distribution by the Engineer's Representative. Ensure work and units supplied conform to the final shop drawings.

The Engineer's Representative's review of shop drawings is for general concept only, and in no way relieves or mitigates the Contractor's obligation for drawing accuracy, suitability or materials and to produce works that are complete, accurate and fit for their intended purpose. Any errors in dimensions, sizes, welds, connections, fasteners and details shown on the shop drawings are the responsibility of the Contractor.

The Contractor shall allow a three-week period for the Engineer's Representative's review. Any work that proceeds before the shop drawings have been accepted for fabrication by the Engineer's Representative is at risk of the Contractor.

The Contractor shall submit to the Engineer's Representative as-built documents in quantity and format as required by the Contract. As-built documents shall be submitted to the Engineer's Representative within 14 days after completion of fabrication.

The Contractor shall submit a proposed fabrication, delivery and erection schedule for all steelwork items. The Contractor shall submit a progress report at the end of every week identifying the progress of shop drawings, material ordered and expected delivery date, material received, material fabricated, material painted, material shipped, and material erected.

## 16.5. Materials

### 15.5.1. Structural Steel

All steelwork comprising of rolled shapes, plates and pipes shall comply with IS 800, IS 808, IS 2062 and relevant international standards such as British codes, ASTM, API and Euro Norms, unless specified otherwise. The material for the steel structures shall be selected from the table below together with the material requirement specified in the GFC drawings. Any substitution shall not be allowed unless it is approved by the Engineer.

No	APPLICATION	Specification	Minimum Yield Strength (MPa)
1	Plates and Shapes for guide pin piles connection secondary structures – handrails support, coming, pile liners and miscellaneous applications.	IS 2062 E250 Quality C	250
2	Plates and Shapes for Guide pin piles connection with the proposed jetty.	ASTM-A131-DH36 Or Equivalent Indian Grade Steel (IS 2062 E350 Quality C)	350
3	Plates for rolled tubulars guide pin piles. Ø 1424X50mm (Rolled as per API Spec. 2B)	ASTM-A131-DH36 Or Equivalent Indian Grade Steel (IS 2062 E350 Quality C) (Rolled as per API Spec. 2B)	350
4	Anchors bolts for all base plates.	IS5624 & IS 1367 Part 3 – Class 8.8	640

5	Structural bolts for steel connections.	IS3757 & IS 1367 Part 3 – Class 8.8	640
6	Steel Grating	ASTM A36	250
7	Handrail pipes	IS 1161 Yst 250	250
8	Sacrificial Anodes	GALVALUM III or equivalent	-


#### Notes

- a) All material shall be new stock and shall be free from deformations.
- b) All steel shall be manufactured by processes which ensure a product which is substantially free of segregation.
- c) All fabricated structural pipe shall conform to API Specification 2B, "Specification for Fabricated Structural Steel Pipe", except as modified by this General Specification.
- d) Spirally welded pipe shall not be used. ERW pipe may be allowed provided that it is supplied from an API certified manufacturer.
- e) All fabricated structural pipes less than 762mm O.D. shall conform to API Specification 5L, "Specification for Line Pipe", except as modified by this General Specification.
- f) Contractor shall furnish three (3) certified original mill certificates for all pipe, structural shapes, and plate for integration into the Trace of Material Notebook. Mill certificates shall include chemical analysis, and mechanical and non-destructive examinations and shall be identified by heat number, plate number, mill certificate number, page number, purchase order number, and mill identification.
- g) All testing of material shall be witnessed by an Engineer/Engineer's Representative who shall also countersign the mill certificate and shall be approved by the classification society surveyor.
- h) Grating and stair treads shall be steel, 32mm X 5mm serrated bar grating with bearing bars at 30mm on centers and cross bars at 50mm on center except as modified on Fabrication Drawings. All gratings shall be serrated and galvanized.

#### 15.5.2. Special Requirements

Fabrication, welding, cutting bending of plates to be as per BS5400 Part 6 and relevant classification society (IRS/ABS/BV/DNV etc.) rules. Contractor has to bear the cost of classification society surveyor visits including transportation and day charges based on the number of visits during inspection and approval. Where provisions of BS: 5400-6 differ from Classification Society rules, the Classification Society rules shall be adopted.

Structural steel shall comply with the applicable national steel standards listed in section 2.0. and the supplementary requirements given in this section. All steel shall be new and unused. All steel shall be manufactured by basic oxygen or electric arc furnace processes. All steel shall be fully killed and made to fine grain practice.

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Unless further restricted by the applicable national material standard, the maximum permitted carbon equivalent (C.E.) shall be 0.43.

$$CE = C + (Mn/6) + (Cr+Mo+V)/5 + (Ni+Cu)/15$$

Steel greater than 10mm thick shall be Charpy-V impact tested at a maximum temp of 0°C, at a minimum frequency of one test set per cast and heat treatment batch.

Plate material shall be examined by ultrasonic examination in accordance with ASTM A435 as follows: -

For plate thickness of 12.5mm and above, 5% of plates from each heat produced shall be examined. Should any plates not comply with the acceptance criteria of ASTM A435 then a further 5% of plates from the same heat shall be examined. Should any of these plates then be found defective then all other plates from that heat shall be examined.

For plates used to fabricate lifting points (padeyes, padears), 100% of plates from each heat shall be examined by ultrasonic examination.

Where structural members are identified during structural analysis as being subject to high through thickness stress the use of material with guaranteed through thickness properties (Z-Quality) (Z35) is required.


Z-Quality Plate shall comply with the following:

All plate to be subject to 100% ultrasonic examination in accordance with ASTM A435 or BS 5996.

1. Maximum permitted sulphur content to be 0.005% (Ladle).
2. The through-thickness tensile strength shall be not less than 80% of the minimum specified tensile strength.
3. The minimum short transverse reduction of area shall be 35% average, and 25% individual reading when measured in accordance with the testing and sampling requirements of BS EN 10164.

CONTRACTOR shall fully define materials requirements in his steel MR including any items listed in the applicable national steel standard that are subject to purchaser / supplier agreement.



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CONTRACTOR shall also specify material certification level and inspection requirements to the steel supplier. The minimum Certification level for primary structural members shall be ISO 10474 3.1B.

All structural steel shall be fully identified against the relevant material certificate. Material identification marking shall be transferred during cutting such that full traceability is achieved.

All bolting materials shall be hot dip galvanized in accordance with IS 1367 (Part 13) or equivalent.

#### 15.5.3. Fasteners

All bolts, screws, nuts and other fasteners shall be of adequate cross-sectional area to safely withstand the envisaged or specified working forces. Unless otherwise specified all fasteners shall be at least of carbon steel according to IS 1363 and shall be hot dip galvanized. All anchor bolts shall be furnished with at least two nuts to facilitate installation.

#### 15.5.4. Welding Electrodes


Steel welding electrodes shall comply with the requirements of IS 814, except that they shall be uniformly and heavily coated (not washed) and shall be of such a nature that the coating will not chip or peel during its use with the maximum amperage as specified by the manufacturer.

#### 15.5.5. Plant Inspection

The Contractor shall provide the Engineer's Representative with full access to inspect materials and fabrication. The Engineer's Representative may undertake the inspection of materials at the source. Manufacturing plants may be inspected periodically for compliance with specified manufacturing methods, and materials samples shall be obtained for laboratory testing for compliance with materials quality requirements. This may be the basis for acceptance of manufactured lots as to quality. In the event plant inspection is undertaken, the following conditions shall be met:

- The Engineer's Representative shall have the cooperation and assistance of the Contractor and the producer with whom he has contracted for materials.
- The Engineer's Representative shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished.
- The inspection agency shall be advised of the production and/or fabrication schedule a minimum of 48 hours prior to beginning work on any item requiring inspection. All materials for which the Engineer's Representative has requested plant inspection and which are fabricated without such inspection shall be considered unacceptable. Any



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testing required proving the acceptability of such materials shall be performed at the Contractor's expense.


- The type and extent of inspection shall be at the discretion of the Engineer's Representative's representatives: every item, procedure and connection associated with the work shall be subject to non-destructive inspection by the Engineer's Representative's representatives.
- Methods of non-destructive control shall include but not be limited to visual, dimensional, radiographic, ultrasonic and magnetic particle inspections.
- The Engineer's Representative may call for a coupon to be cut out for destructive testing.
- During the progress of the work, the Engineer's Representative may order in writing to the Contractor:
  - The removal from the Contractor's or Subcontractor's yard of any improper materials and equipment which are not appropriate for the work and their replacement.
  - The repair or proper re-execution, notwithstanding any previous test, of any works which in respect of materials or workmanship, is not in accordance with the contract.
- Acceptability of materials and fabrication shall be as stated in each corresponding specification and in the contract drawings. All material and work found not in conformity with these documents shall be rejected or repaired at the Contractor's sole expense to the satisfaction of the Engineer's Representative.
- The Engineer's Representative shall be the sole judge for the acceptability and their decisions shall be final.

The Engineer's Representative reserves the right to retest all materials which have been tested at the source of supply, prior to incorporation into the Work, and to reject all materials which, when retested, do not meet the requirements of the specifications.

#### 15.5.6. Manufacturer's Certification

The Engineer's Representative may permit the use, prior to sampling and testing, of certain materials or assemblies when accompanied by manufacturer's certificates of compliance stating that such materials or assemblies fully comply with the requirements of the contract. The certificate shall be signed by the manufacturer. Each lot of such materials or assemblies delivered to the Work shall be accompanied by a certificate of compliance in which the lot is clearly identified.

Materials or assemblies used on the basis of certificates of compliance shall be sampled and tested at any time and if found not to be in conformity with contract requirements shall be subject to rejection whether in place or not.

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All steel for the steel work and fasteners shall be supplied with test certificates. The contractor shall submit these certificates to the Engineer's Representative prior to the supply of the materials. Materials obtained from stocks may be checked by the Engineer's Representative for exterior defects either in the workshop or at the site.

Test requirements for the materials to be ordered are specified in IS 2062 and shall include V notch impact tests at 0° C from each quantity of 20 tons or part thereof. The results of these tests shall be included in the test certificates.

#### 15.5.7. Storage of Materials

Materials shall be so stored as to assure the preservation of their quality and fitness for the Work. Stored materials, even though approved before storage, shall again be inspected prior to their use in the Work. Stored materials shall be located so as to facilitate their prompt inspection.

Storage locations shall be approved by the Engineer's Representative.

Private property shall not be used for storage purposes without written permission of the owner or lessee. Evidence of permission should be furnished to the Engineer's Representative upon his request.

All material shall be properly stored on wood timbers or pallets and shall be protected from standing water, corrosive products, blast cleaning, painting and dropped object.

Damaged materials or materials with defects shall not be used in the fabrication. Replacement or reparation of this material shall be decided by the Inspector.


#### 15.5.8. Handling Materials

All materials shall be handled in such a manner as to preserve their quality and fitness for the Work. Material shall be transported to the work area in vehicles so constructed as to prevent damage or loss of material.

All materials shall be handled with suitable and approved handling devices and methods, which do not induce excessive deformation or stress.

#### 15.5.9. Unacceptable Materials

All materials not conforming to the Plans and Specifications at the time they are used shall be considered unacceptable and all such materials shall be rejected and shall be removed immediately from the site of the Work unless otherwise instructed by the Engineer's Representative. No rejected material, with defects corrected, shall be used until approval has been given by the Engineer's Representative.

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#### 15.5.10. Materials Traceability and Tracking System

The Contractor shall be responsible for maintaining the tracking system for all materials, including primary and secondary steelwork, from receipt of materials to final assembly within the structure. The material's tracking system shall include material utilization forms. The Contractor shall submit the procedure to the Engineer's Representative for approval.

#### 15.5.11. Marking of Steel

All structural steel shall be fully identified against the relevant mill test certificate. The cutting of plates, pipes and beams, and transferring of unique identification numbers and other marks shall be carried out such that a particular grade of steel, including scrap, can be identified against its materials certificate. The specified identification shall be maintained at all times. The Contractor shall transfer markings when cutting steel, using round nosed dies only. The Contractor shall submit the procedure to the Engineer's Representative for approval.

If any material is found without the appropriate reference or material certification, it shall not be used in any part of the fabrication until it can be identified to the satisfaction of the Engineer's Representative. For unidentified material found in the fabrication, the Contractor shall be responsible for proving the identity of the material to the satisfaction of the Engineer's Representative at no extra cost to the Engineer's Representative.

The Contractor shall establish and maintain a quarantine area and an appropriate marking system, for material found defective, damaged or certification. This material shall not be used without the prior authorization of the Engineer's Representative.


The Contractor shall take care to preserve the plate rolling direction in marking plates.

Different grades of steel, including cut segments or shapes, plate and remnants shall be marked. The steel types shall be stored in well-defined locations to avoid inadvertent mixing.

#### 15.5.12. Member Identification

Before starting the works, the Contractor shall establish a numbering system to identify each member or element of the structure. This identification numbering system shall be used as an aid for indexing radiographs, repairs, etc. An identification system shall be furnished to the Engineer's Representative and the Inspector before the start of the job. This numbering shall be used on all shop drawings.

#### 15.5.13. Marking

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It is the Contractor's responsibility that all materials supplied are adequately marked for identification against delivered test certificates. When materials are stored, the identification marking shall be easily accessible. Material that cannot be identified by proper marking shall be rejected.

Each rolled plate and shape shall be mechanically marked with the following information:

- Material heat or batch number.
- Steel type and supply condition (see below)
- Producer's trademark.
- Section number (if relevant).

Supply condition shall be indicated by marking after the Steel Type designation.

All such markings shall be carried out by die stamping in a frame of white paint. The letters used for the stamping shall be at least 8 mm in height and performed with a round nose tool.

Die stamping shall include the certifying Engineer's Representative stamp for all primary and special categories of steel.


Paint marking shall be as follows:

- A 300mm-by-300mm rectangle with the following data stenciled in 50mm high white letters shall be printed on each item of the material:
  - Project Reference
  - Purchase Order number and designation.
  - Item size (thickness, width, length, section identification diameter and wall thickness, etc...)
  - Type of steel and grade
  - Heat number from which it was produced.
  - Destination
  - Gross and Net Weights
  - Package Number
  - Mark principal rolling direction for plates (arrow)

#### 15.5.14. Inspection by the Engineer's Representative

The Engineer's Representative shall inspect the material, fabrication, assembly, coating, loading and transport of all items and shall have free access at all times to any part of the Contractor's or Subcontractor's mill or yard that concerns his work.

The Engineer's Representative shall have the right to inspect at all times any tools, materials, procedures and equipment used or to be used in the fabrication, assembly, coating and loading of the structures.

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The Contractor shall furnish, install and maintain in a safe operating condition the necessary scaffolding, ladders, walkways, adequate lighting, etc., for a safe and thorough inspection by the Engineer's Representative's representative.

The Contractor shall assist the Engineer's Representative in the execution of inspections and tests by providing personnel, inspection and test equipment as required.

#### 15.5.15. Inspection by the Contractor

The Contractor shall give or provide all necessary superintendence and constant inspection during the completion and maintenance of the works.

The Contractor shall provide and have continuously available equipment required for inspection of the works or parts of the works. This equipment (including X-Ray or radiographic equipment) shall be suitable for examining, measuring and testing any work and quality of specification. All inspection equipment shall be calibrated whenever necessary, be in good condition and properly maintained. The equipment shall be used and maintained exclusively by personnel qualified to an approved standard. All inspection personnel shall be subject to the approval of the Engineer's Representative.

### 16.6. Execution


This section defines the Engineer's Representative's minimum requirements regarding preparation of structural members and materials, and final tolerance in the fabrication of steel structures.

The Contractor shall design and prepare proper procedures and submit them for the approval of the Engineer's Representative and provide all equipment necessary for the fabrication of the structures.

Items specified to be offshore installed shall be fabricated so that offshore work will be minimal.

Prior to start the work in the Contractor's or Subcontractor's mills or yards, the Contractor shall submit for Engineer's Representative's approval sufficiently detailed documents pertaining to the proposed procedures and sequences they plan to use in the fabrication, assembling and joining of the various parts of the structures. Parts to be prefabricated shall be clearly indicated.

The Contractor shall do the fabrication and erection of structural steel in accordance with IS 800 and IS 2062.

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## **16.7. Fabrication and Erection**

### **16.7.1. General**

The Contractor shall fix the steelwork complete and shall provide and erect all temporary stages necessary for the carrying out of the work in such manner as not to interfere with traffic or roads etc. and provide all cranes, plant and labour required for the same. Before any work is begun by the Contractor on the site, he shall submit to the Engineer for his approval the procedures he proposes for the erection of the steelwork together with drawings of all temporary works required. Such approval by the Engineer shall not relieve the Contractor of his obligations under the Contract.

The Contractor shall fix the steelwork and erect and maintain all temporary works in such a manner as to ensure complete safety at all times for all members of the workforce and any other persons in the vicinity of the works.


Steelwork shall be fabricated and erected in accordance with IS 800 or equivalent approved by the Engineer and with this Specification. The method of construction welding sequences, etc. shall be arranged to give minimum distortion. No holes or notches shall be made in the steelwork other than those shown on the drawings without approval of the Engineer. Similar approval must be obtained prior to the enlargement of any hole.

The butting end of members shall be faced in a milling or ending machine after the members have been completely fabricated so as to butt in close contact over the entire surface.

### **16.7.2. Shop Drawings**

The GFC drawings provided to contractor by employer are design drawings. It is to be noted that these drawings shall not be directly used for fabrication. The Contractor shall prepare shop drawings and provide two (2) copies of all shop drawings prior to commencing fabrication. The engineer shall review the shop drawings, mark in red any necessary corrections, sign the shop drawings as having been reviewed and return one (1) copy to the Contractor. This review by the Engineer shall not relieve the Contractor of his responsibilities and obligations to fabricate all items in accordance with the Contract Documents. It is intended to determine if Contractor has correctly interpreted the Work and to identify possible errors or omissions in a timely, efficient, and economic manner.

Shop drawings shall include, but not be limited to welding joint details showing joint preparation and welding symbols, all fabrication dimensions, and qualified welding procedures. In addition to these requirements, the shop drawings shall indicate a numbering system to identify each weld. This weld numbering system shall be used for all non-destructive testing and identification purposes.

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The contractor shall provide three (3) sets of as-built drawings after the completion of fabrication and installation at site indicating any changes to design drawings received from Employer marked in RED colour and obtain approval for the same.

#### 16.7.3. Welded Connections

All structural welding and welding procedures shall be in accordance with approved drawings and specifications. The following points shall be noted.

- a) All structural welding between beams web to web, flange to flange or flange to web, plated connections shall be full penetration butt weld unless otherwise noted.
- b) The welds between plates can be single bevel or double bevel depending on the thickness. Usually, for plates less than 20mm, single bevel butt weld can be permitted. For plates thicker than 20mm, double bevel butt weld is required.
- c) All tubular connections forming a junction between pipes of two different or equal diameters shall be welded from outside using single bevel full penetration weld using approved weld procedure depending on the thickness.
- d) Bevels shall be prepared in accordance with the details shown in GFC drawings and codes and standards for the type of welding adopted. The deviations shall be strictly in accordance with IS 816, IS 822 / AWS D1.1 whichever is applicable.
- e) Tubular connections for the walkway structure, tower monitor structure and other connections shall be carefully fitted with a root gap not exceeding 3mm. The edge preparation shall be carried out by automatic or manual profiling machines, but manual cutting is not permitted.



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#### 16.7.4. Bolted Connections

Bolted connections wherever employed shall be used with appropriate considerations, tolerances and fabrication sequence.

- a) All holes shall be drilled or punched in the structure prior to sandblasting and painting. Bolt holes shall be punched or drilled at right angles to the metal surface and shall be finish-reamed to a diameter of 1.5mm larger than the specified bolt diameter. Any drilling or punching that is required but not clearly specified or shown on the Fabrication Drawings shall be completed only after approval of Engineer.
- b) Use of a drift pin in bolt holes during assembly shall not distort the metal or enlarge the hole. Holes that must be enlarged to admit the bolts in connections using high strength bolts shall be reamed. For all bolted connections, poor matching of holes shall be cause for rejection.
- c) Bolts shall be driven accurately into the holes without damaging the threads. Bolt heads shall be protected from damage during driving. Bolt heads and nuts shall rest squarely against the metal. Unfinished bolts transmitting shear shall be threaded to such a length that no more than one (1) thread shall be within the grip of the structural members. The bolts shall be of a length that shall extend entirely through, but no more than 7mm beyond the nuts.
- d) Bolt heads and nuts shall be drawn tight against the work with a suitable wrench. Bolt heads shall be tapped with a hammer while the nut is being tightened. After having been finally tightened the nuts shall be locked by a locking procedure approved by Engineer. High strength bolts shall be tightened to a bolt tension not less than the "Minimum Bolt (Pre-Tension)" value specified in Bolt specification or IS standards and shall not be less than 70% of its axial strength.
- e) When bolt heads or nuts bear upon bevelled surfaces they shall be provided with square tapered washers to afford a seating for the nut square with the axis of the bolt.
- f) All dissimilar metals which induce electrolytic action are to be isolated with suitable nylon washers/plates. These metals include stainless steel and zinc coated mild steel (e.g. galvanized, sherardised and zinc sprayed items) which need to be isolated from un-treated mild steel.
- g) All nuts and bolts specified on the Drawings shall be to the required size with correct threaded length and be supplied with matching nuts and washers also of the same material, except where electrolytic action is to be avoided.
- h) Where small parts such as bolts and nuts etc. are to be sherardised, they shall be treated to receive a coating of finished thickness not less than 30 microns.
- i) Where bolts, nuts and washers etc. are to be hot dip galvanised, they shall be treated to receive a finished thickness of zinc coating of not less than 80 microns thickness.

#### 16.7.5. Structural Pipe Splices



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#### 15.7.5.1. General


- a) Segments of pipe of the same diameter may be spliced. The minimum distance between splices shall be 1.20 meters or one (1) pipe diameter, whichever is greater. There shall be no more than two (2) splices in any 3.05 meters interval of pipe. Splices shall be in accordance with API Specification 2B.
- b) Splices shall be made to produce members whose straightness equals that of the uncut pipe. The alignment of abutting pipe ends shall minimize offset between pipe surfaces.
- c) When two (2) sections of pipe to be joined are of different wall thicknesses, there shall be a smooth transition. The slope of this transition shall not exceed one in three (1:3) along the length of the pipe. This may be accomplished by sloping the weld surface, by chamfering the thicker cylinder, or by a combination thereof.
- d) Where wall thickness changes within a bracing member, the outer diameter (O.D.) shall remain constant unless explicitly shown otherwise in the Fabrication Drawings.

#### 15.7.5.2. Welds

- a) Splices in 762 mm diameter and larger pipe members shall be full penetration double-V-groove butt joints. The ends of members shall be beveled to give a minimum included angle of sixty (60) degrees on each side. Root openings for manual welding shall be not less than 1.5mm inch nor greater than 5mm.
- b) Splices in sections of pipe less than 762 mm in diameter shall be full penetration, single-V-groove butt joints, welded from one (1) side only. The ends of members shall be beveled to give a minimum included angle of sixty (60) degrees. Root openings for manual welding shall not be less than 1.5mm nor greater than 3mm.
- c) Maximum weld reinforcement at splices shall be 2.5mm for members having a thickness of 13mm or less; 3mm for thicknesses of over 13mm, but not greater than 26mm; and 5mm for thicknesses greater than 26mm.

#### 15.7.5.3. Location of Splice or Weld Seam

- a) Longitudinal weld seams of adjoining sections shall be staggered a minimum of ninety (90) degrees apart.
- b) The orientation of jacket leg or skirt pile sleeve node cans shall be such that the longitudinal seam does not intersect with jacket bracing at the joint. Permitted locations for circumferential welding seams on jacket leg or skirt pile sleeve node cans shall be approved by Engineer. In the case of joints other than at jacket leg or skirt pile sleeve node cans, effort shall be spent to ensure that an intersecting brace weld line does not intersect a circumferential seam of the through brace member.

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Where this requirement cannot be met, the circumferential seam shall be within a zone as agreed upon by the Engineer.

- c) No circumferential brace pipe splice shall be located closer than two times (2X) the outside diameter of the brace pipe from a jacket leg or skirt pile sleeve joint can.
- d) Where one brace pipe intersects another, no circumferential splice on the intersecting brace shall be located closer than two times (2X) the outside diameter of the intersecting brace from the joint.
- e) With the exception of brace pipe X-joints, effort shall be made to ensure that the orientation of the longitudinal seam on the through brace member shall be such that it does not intersect with the intersecting brace pipe. Where this requirement cannot be met, the longitudinal seam on the through brace shall be located as agreed upon by Engineer.
- f) With the exception of brace pipe X-joints, the orientation of the longitudinal seam on the intersecting brace member shall not fall in line with the toe or heel of the connection or within fifteen (15) degrees from these positions in each direction.
- g) In the case of brace pipe X-joints, the orientation of the longitudinal seam on the through brace member shall be at the center line of either of the incoming braces.

#### 16.7.6. Beam Splices

Segments of beams with the same cross sections may be spliced. The use of the beam shall determine the locations and frequency of splicing. In cantilever beams, there shall be no splice located closer to the point of support than one-half of the cantilevered length. For beams employed in any span between supports, there shall be no splice in the middle one-fourth of any span nor in the one-eighth of the span nearest any support nor over any support. Splices shall not be located closer together than twice the depth of the beam or 1.0 m whichever is smaller.


### 16.8. Welding

#### 16.8.1. General

Welding electrodes shall be in accordance with IS 814/ IS 815/ IS 816. Only electrodes of the grade compatible with the characteristics of the parent metal shall be used.

At all stages of fabrication and treatment the steelwork shall be subject to inspection by the Engineer or his appointed representative. Any work not to the satisfaction of the Engineer shall be immediately rectified at the Contractor's expense.

Approval given to steelwork at an earlier stage of fabrication or supply shall not preclude rejection of any steelwork either before, during, or after erection.

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#### 16.8.2. Weld Sizes and Specifications

All welds shall be of size, length, and type as shown on the GFC Drawings or specified herein. Where no designation is given, all structural welds shall be continuous, full penetration groove welds. Joint details showing other than full penetration groove welds can be submitted to Engineer for review and approval. All welds shall be sized to develop the full strength of the smaller of the two (2) members being joined.

#### 16.8.3. Welding Equipment

All welding equipment shall be in good condition and subject to inspection by the Engineer. All voltage, amperage, and/or wire feed speed gauges on SAW machines shall be fully operable and properly calibrated. Any equipment found in need of repairs shall not be used for production welding until repairs have been made and the machine has been approved for use by the Engineer.

#### 16.8.4. Electrodes

Electrodes for SAW shall conform to IS 816 and subjected to following conditions.


- a) All electrodes shall be subject to inspection by the Engineer and electrodes which show signs of deterioration or damage shall be rejected.
- b) The maximum size of electrodes shall be 4mm for stringer or starting beads and 5mm for passes following starting beads in multi-pass welds.
- c) Jet rods shall not be used for any field welding and shall only be permitted in yard welding upon prior approval by the Engineer.
- d) Heating and storage temperatures shall be as per the electrode manufacturer's recommendations. Only one (1) package of electrodes of each size shall be removed from the store at a time by each welder. No open package of electrodes shall be left exposed to the atmosphere. Electrodes left as mentioned shall not be used and shall be rejected by Engineer. Fabrication Contractor's electrode handling procedure must be submitted to Engineer for approval.

#### 16.8.5. Workmanship

It shall be of the highest quality in relation to the class of work. Care shall be taken in all preparation of the work, the selection of the finest materials and in the employment of fully qualified and tested operators.

All welds shall be designed to seal the joints between sections completely unless specified otherwise by the Engineer.

Welding operations shall be completed before any final machining or other fitting work is

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carried out.

All main butt welds shall have complete penetration, shall be made between prepared fusion faces and when possible, shall be welded from both sides.

The ends of the welds shall have full throat thickness obtained by the use of extension pieces secured on each side of the main plates. Additional metal remaining after removal of the extension pieces shall be removed by machining or other approved means and ends and surfaces of the welds smoothly finished.

In the fabrication of built-up assemblies all butt welds in each component part shall be completed before final assembly. Where butt welds are to be ground flush there shall be no loss of parent metal.

All fillet welds shall be continuous and where sealing runs are adopted; they shall have the appropriate corrosion allowance. All welds shall be smooth in preparation for painting.

Peening of welds resulting in deformation of the weld surface shall only be carried out with express permission of the Engineer, but all spatters shall be cleaned off and all slag removed on completion of the weld and before examination by the Engineer.

Before welding commences the Contractor must ensure there is no paint within 75mm of the surface to be welded except in so far as wash primers for blast cleaned steel declared by their manufacturers to be suitable for welding may be permitted.

After fabrication, all fins caused by welding shall be removed and the weld shall be smoothly finished all round.

#### 16.8.6. Submerged Arc Welding (SAW) Process


All welding (including tack welding) shall be accomplished using low hydrogen process. Automatic submerged arc (SAW) or manual shielded metal arc (SMAW) welding processes shall be used wherever practical.

Arc welding shall be carried out in conformity with IS 816 / 4353 / AWS D1.1 and all other relevant IS Standards. The welding procedure shall conform to the recommendations of the electrode manufacturer.

All electrodes shall be stored in a warm dry place and shall not be kept loose in the welding bay unless required for immediate use. Electrodes which have areas of flux covering broken or damaged shall be discarded.

#### 16.8.7. Welder and Welding Operator Qualification

##### Initial Qualification

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It is the intent that only qualified welders and welding operators shall be used in the fabrication of structural steel work. Engineer intends to test each welder and welding operator who has not been:

- engaged in a given process of welding for which he is qualified for a period exceeding six (6) months, and
- qualified as an Engineer within the past one (1) year.

The contractor shall bear all the expenses of each initial qualification.

#### Requalification

Welders and welding operators are subject to requalification during fabrication at the discretion of Engineer where their work appears to be below the requirements of this General Specification. If subject welder fails the requalification test, Contractor shall be responsible for all costs for the test. If welder passes the requalification test, Engineer shall be responsible for welder time, radiographic, ultrasonic, and laboratory testing costs for the test.

#### Disqualification


Welders and welding operators who have been disqualified by Engineer for defective work may be retested at Contractor's request if they have received additional training and documentation of the additional training is acceptable to Engineer. Expenses for this qualification test shall be borne by Contractor whether the welder passes or fails.

#### Qualification Tests

For welding qualification tests, each welder and welding operator shall be assigned an identifying number or symbol that they shall use to identify all welding performed by them. Contractors shall ensure that numbering systems and/or symbols are not duplicated between the material supplier, Contractor, and various Subcontractors. A welder or welding operator may not change this symbol, with which he is qualified, after qualification or during the Work.

Records of the test results for qualification of welders and welding operators shall be established and certified by the Engineer. Records shall be kept by the Contractor and shall be available to those authorized to examine them. A list of welders and welding operators qualified shall be established and furnished to the Engineer before start of fabrication. The records shall be maintained and updated by the Contractor as required and furnished to the Engineer throughout the term of the Contract.

- a) All qualification tests shall be in accordance with IS 816 / AWS D1.1. Welding operators shall be qualified in the appropriate position for the work to be performed.

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- b) Engineers shall specify the material to be used for qualification tests. The tests shall be witnessed and approved by Engineer / Welding Inspector before the welder or welding operator is permitted to work on the structure. The decision of Engineer / Welding Inspector regarding the qualifications of any welder or welding operator shall be final.
- c) The Contractor shall provide all equipment and material for the qualification tests and shall bear all costs for cutting, machining, and testing the test specimens.
- d) Welders and welding operators who do not pass the tests are disqualified from working on the job.


#### 16.8.8. Welding Procedure Qualification

##### General

Prior to beginning production welding, Contractor shall establish detailed procedures for welding the various parts of the structure as per the connection details of the Contract Drawings, and in accordance with the applicable requirements of IS 816 / AWS D1.1, and as specified hereafter. All proposed welding procedures shall be submitted to Engineer for preliminary approval prior to carrying out the qualification tests. No qualification test shall be carried out until approval from the Engineer has been received.

##### Procedure Qualification Testing

- a) General requirements for welding procedure qualifications shall be specified in IS 816, IS 822 /AWS D1.1 unless otherwise indicated herein.
- b) Welding procedure qualification tests shall be at the sole expense of the Contractor.
- c) Procedures shall be tested and certified by an approved testing laboratory, agency, or equivalent. Engineers shall witness all welding and testing.
- d) Procedure testing shall be valid in the range of diameters and thicknesses as given in GFC drawings.
- e) Welding procedures which conform in all respects to the provisions of this Specification, and the GFC Drawings, and any other welding proposed by the Contractor for application in the fabrication of structures shall be subject to the mechanical tests described below prior to use in production welding.
- f) Each completed welding procedure to be used shall be compiled by Contractor in a Procedure Specification Manual; three (3) copies of which shall be submitted to Engineer for approval four (4) weeks prior to start of fabrication. The minimum acceptable written procedure specification shall detail information on the following parameters:
  - Scope of Work performed under each procedure,
  - Base metals, applicable specifications, and relevant characteristics,

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- Welding process and equipment,
- Type, size, classification, and composition of electrodes or filler metals (specify wire/flux combinations for submerged arc welding),
- Type of current characteristics (pulse type, etc.) and current range,
- Heat input and welding speed where applicable,
- Joint preparation and cleaning procedures,
- Preheat and inter-pass temperatures and control,
- Weld type and sizes,
- Root preparation prior to welding from second side where applicable,
- Sketch of joint showing pass sequences employed to control warpage, distortion, and excessive accumulations of residual stresses and range of thicknesses covered,
- Removal methods of weld defects,
- Repair welding procedures,
- All other pertinent details.

#### Previously Certified Procedures

Where procedures exist for similar materials and thicknesses, which have been previously certified, retesting may be waived only at the discretion of Engineer.

#### Method of Test

Provision must be made for procedure trials and testing to be carried out in accordance with IS 816 and IS 822 / AWS D1.1.


Trials shall include specimen welded details from the actual construction which shall be welded in a manner simulating the most unfavorable situation which will occur. Where priming coats are to be applied to the work before fabrication they shall similarly be applied to the samples before trials are made. After completion, the welds shall be held at approximately 16°C for not less than 72 hours and shall then be sectioned and examined for cracking.

Procedures shall be adopted to enable welds to be traced to the welder by whom they were made.

Method of testing specimens shall be in accordance with the following requirements:

- a) Visual Inspection - as per applicable sections of IS 816 / AWS D1.1,
- b) Reduced Section Tension Tests, Root, Face, and Side Bend Test and Macrotech Tests shall be performed in accordance with IS 816 /AWS D1.1.



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- c) Charpy V-notch Tests shall be performed in accordance with ASTM A370 and ASTM E23.
- d) Radiographic or Ultrasonic Inspection (chosen by Engineer when required) - as per IS 816, IS 822 / AWS D1.1.

#### 16.8.9. Joint Preparation and Welding

##### General

Surface to be welded shall be free from loose scale, slag, rust, hydrocarbons (oil, grease, etc.), paint, and any other foreign material, except that mill scale which withstands vigorous wire brushing may remain.

If painted before erection, the paint on surfaces adjacent to joints to be welded shall be thoroughly removed to expose clean steel for a distance of at least 51mm on either side of the joint.

##### Joint Preparation

###### a) Edge Preparation

Preparation of edges by gas cutting shall, whenever practicable, be done with a mechanically guided torch. Edges shall be ground to bright metal and cleaned of all slag. The edge preparation shall meet the requirements of IS 816, IS 822/AWS D1.1.

###### b) Bevel Preparation


- All bevels shall be ground to bright metal before welding.
- Where practical all pipe bevels shall be made by beveling machine.
- Any beveled edge that has been damaged shall be restored to minimum tolerances.
- The contractor shall visually and ultrasonically inspect all edges prepared for welding. The limits of acceptability and the repair of edge defects shall be in accordance with IS 816, IS 822/AWS D1.1.

###### c) Joint Details

Joint details shall be in accordance with GFC drawings/IS816, IS 822/AWS D1.1, and shall be subject to approval by Engineer. Approval may be obtained by Contractor by submitting to Engineer details of joints, showing welding symbols, along with the weld procedures for approval. Drawings of complete joint details shall be provided by Contractor for Engineer's use.

###### d) Joint Alignment and Gaps



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- The parts to be joined by fillet welds shall be brought into as close contact as practical. The gap between parts shall not exceed 5mm. If the gap is larger than 1.5mm the leg of the weld shall be increased by the amount of the gap.
- The separation between faying surfaces of lap joints shall not exceed 1.5mm. The use of fillers is not allowed.
- The parts to be joined by butt welds shall be carefully aligned. The dimensions of the cross section of groove welded joints as shown on the GFC Drawings shall be within the tolerances specified in IS 816/AWS D1.1.
- No welding shall be commenced until the structural members have been properly aligned. The structural members shall be aligned and held in position during welding by bolts, clamps, wedges, tack welds, or other suitable means.

e) **Backing Rings**

Unless specifically approved by Engineer in writing, backing rings shall not be used unless they are completely removed to sound metal and the back side of the weld is rewelded. Ceramic backup tape is permitted, provided, Engineer approved welding procedure using the specific tape type is used.

### Splices


- a) All splices shall be prepared for continuous full penetration welds with V-butt joints, single or double, depending on the size/thickness of the member.
- b) Welded joints of axially aligned structural members of different material size, thicknesses, diameters, or widths, shall be made in such a manner that the slope through the transition zone does not exceed 26mm thickness change in 76mm (1:3) along length of pipe. The transition shall be accomplished by chamfering the thicker part, tapering the wider part, sloping the weld metal, or by any combination of these.
- c) The mismatch of mating surfaces of the joint preparation root face on tapered member splices shall not exceed 1.5mm.

### Connections between Structural Tubulars and Shape Sections

- a) When one (1) or more structural rolled shape sections are connected to a tubular member which is the continuous member, the rolled shapes shall be appropriately coped and positioned to allow welding all around the edges.
- b) Preparation of the ends of shapes shall be made in such a manner that the flanges shall be fully penetrated butt welded to the tubular and the webs shall be fillet welded to the tubular member.

### Tubular Joints

- a) All tubular joints shall be prepared for full penetration welds.

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- b) Tubular members shall be carefully contoured to obtain accurate alignment and the bevel shall be formed so as to provide a continuous transition from maximum to minimum bevel angle around the circumference. Bevels shall be feather edged. Root faces shall not be permitted. Root openings shall be not less than 1.5mm and not more than 5mm.

#### Inspection of Joints before Welding

- a) For major structural joints, no welding shall commence until Engineer Representative has had the opportunity to inspect the fit up of the joint. The Contractor shall be responsible for informing Engineer forty-eight (48) hours in advance of the fit up in order to schedule an inspection of these joints.
- b) The Engineer's Representative shall notify the Contractor of his intent to inspect certain joints prior to the scheduled weld time.


#### Welding Sequence

The sequence in assembling, joining, and welding the various parts of the structure shall be carefully designed and scheduled to minimize distortion, warpage, and accumulations of residual joint stresses in each part of the structure. Special care shall be taken to minimize through thickness residual stresses. Suitable heat treatments shall be provided for and performed successively after each weld when distortion, warpage and residual joint stresses cannot be avoided. Contractor shall provide and exert all necessary supervision to ensure that the planned sequences are observed.

All structural welding shall conform to approved welding procedures. The Contractor shall post copies of the procedures in a conspicuous location in each fabrication area and provide adequate supervision to ensure strict adherence to Engineer approved procedures.

#### Repairing of Defects

- a) All costs connected with repairs and retests are at Contractor's sole expense.
- a) Defects, except cracks, in weld deposits may be repaired without prior authorization by an Engineer. Removal of defects for repair must be carried out in accordance with the approved welding procedure and must produce a clean, uncontaminated surface for installation of the repair of welding. Oxygen-acetylene gouging shall not be acceptable. All air arc gouges shall be power disc ground to remove residual carbon.
- b) All corrective work consisting of removal of defects and deposition of repair welds, shall be in accordance with the approved welding procedure and requirements of ANSI/AWS D1.1. A second repair of the same area shall not be allowed without prior approval of the Engineer. A third repair of the same area will not be allowed. Should the second repair attempt fail to remove the indicated defect, then the entire weldment will be removed from the structure and the joint shall be prefabricated in accordance with the Contract Specifications.

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- c) Details of the weld repair procedure, e. g. Preheat, post heat, type of electrode, etc. must be documented for the Engineer's future reference.
- d) All repaired welds shall be inspected as per original Inspection and Acceptance criteria.

#### 16.8.10. Weld Inspection and Testing

##### General

No defects in welds or fabrication, including fit up shall be permitted which, in the opinion of Engineer's Representative, is detrimental to the strength of the weld. If for any reason Engineer believes that a defect exists in any weld, the Contractor, at the direction of Engineer's Representative, shall cut and test each weld. If the weld proves defective, it shall be repaired and retested to the satisfaction of the Engineer at the Contractor's expense. If the welding tests are satisfactory, the Engineer shall pay the Contractor for cutting and testing the weld and repairing the structure.

All welds, including structural pipe fabricated from plates, may be subject to radiographic, ultrasonic, magnetic particle, and/or liquid penetrant examination in accordance with requirements given in this section. The extent of weld inspection and testing shall be in accordance with Inspection and Testing Requirements specified in this specification. If any weld proves to be defective, it shall be repaired or replaced by and at the expense of the Contractor. Examination of the repaired or replaced weld shall be performed at the expense of the Contractor.

Non-destructive testing shall be performed in accordance with IS 816, IS 822/AWS D1.1.

##### Inspection Requirement

The Contractor shall carry out weld examination to the following minimum levels:


- I. All welds to be visually inspected.
- II. 50% of all fillet welds to be tested using dye penetrant or magnetic particle testing.
- III. 20% of all butt welds to be tested using Radiographic or Ultra-Sonic methods.

Welding shall be carried out only on dry surfaces, according to I.S. 822 and welds shall be inspected according to I.S. 822.

##### Acceptance Criteria

Section of welds that are shown by radiographic or ultra-sonic methods to have any of the following imperfections shall be judged unacceptable:

- a) Any crack, incomplete fusion, or incomplete penetration.
- b) Any individual elongated inclusion having a length greater than two thirds of the

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thickness of the thinner plate of the joint except that regardless of the plate thickness any inclusion longer than 20mm. No such inclusion shorter than 6mm shall be the cause of rejection.

- c) Any group of inclusions in line where the sum of the longest dimensions of all such imperfections is greater than T (where T is the thickness of the thinner plate joined) in a length of 6T except where each of the individual spaces between imperfection is greater than three times the length of the longer of the adjacent imperfections. When the length of the radiograph is less than 6T the permissible sum of the length of all inclusions shall be proportionally less than T providing the limits of the deficient welding are clearly defined.

### Ultrasonic Testing

Testing of welds shall be undertaken by an independent accredited testing authority selected by the Contractor to the approval of the Engineer. The Contractor shall be responsible for all costs of such testing. All welds shall be tested.

The Contractor shall inspect each welded joint for edge fusion and the possibility of cracking. Testing of welds shall be by ultrasonic examination and shall be carried out by the Contractor in accordance with standards to the approval of the Engineer. The Engineer shall have the opportunity to witness any or all of the tests. The Contractor shall give adequate prior notice before the commencement of any tests. All ultrasonic operators shall be fully qualified, and each weld shall be examined with sufficient probe angles to guarantee full coverage of the joint.


The Contractor shall produce a test report for each weld joint or weld repair examined, comprising:

- a sketch of all flaws
- the location and size of each flaw
- dB level used.
- conclusions as to acceptance or rejection of the flaw with reference to these Engineer's Requirements

The Contractor shall make an initial assessment of defects against acceptance criteria. All ultrasonic reports including recommendations shall be reviewed by the Engineer. Acceptance criteria shall be in accordance with IS 4260 or other approved standards. The standard on which the slag indication acceptability is to be finally determined is to be agreed and confirmed prior to any ultrasonic testing. When positive flaw type interpretations cannot be ascertained in any instance the flaw shall be considered planar and in need of repair.

## **16.9. Painting**

### **16.9.1. Painting Generally**

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All preparation, priming and painting, in colours selected by the Engineer, shall be deemed to be included in the Contract price.

Painting shall generally be in accordance with ISO 12944 and IS 14428:1997.

All items of equipment shall be suitably protected and packed to resist corrosion and impact damage. Machined surfaces are treated with a proprietary sealing agent for transportation and storage.

Paint materials shall be in accordance with the appropriate Indian Standard and shall be obtained from approved manufacturers and applied in accordance with the manufacturers' instructions or as ordered by the Engineer. All materials shall be delivered to the Site in sealed and labelled containers.

The paint for each coat shall be from the same manufacturer, compatible with the underlying coat and shall be a different colour for ease of identification.

Particular regard shall be paid to the maintenance of the recommended temperature and humidity during application and curing. Painted steelwork shall not be overcoated or handled until the recommended curing period has elapsed. No finished paint coating will be accepted until the specified dry film thickness has been achieved to the entire surface including edges.

All steel surfaces shall be completely dry and free from oil and grease and all welds ground smooth and weld spatter removed. All fins at saw cuts, burrs and sharp edges shall be removed, and the edges shall be rounded off.

Where steelwork is to be blast cleaned, an approved method shall be used in accordance with BS 7079 so as to achieve Swedish Standard SA 2.5. The average blast profile is to be 75 microns; below 25 microns or above 100 microns is not acceptable. After blasting, all spent shot or grit shall be removed by vacuum cleaning or by air line and brush.

An approved primer to a minimum dry film thickness of 75 microns in one coat shall be applied after blast cleaning before visible deterioration has occurred as compared with a freshly blast cleaned area. The primer proposed must be compatible with all other paints used and full details must be submitted to the Engineer for approval. If this preparation is done before fabrication a blast primer shall be applied within four hours of the preparation. The Contractor shall put his proposals for such a primer to the Engineer for prior approval. If shot blasting is carried out after fabrication the application of a blast primer may be omitted but the first coat of paint shall be applied within four hours of shot blasting.

For all painted items, the Contractor shall submit for approval a 'Paint System Sheet' stating

full details of each paint system proposed indicating the following information.

- surface preparation.
- system reference together with manufacturer's brand name and product reference
- dry film thickness
- colour
- time to repaint.

#### 16.9.2. Coating system

Steel shall be protected from corrosion in accordance with EN ISO 12944. Durability shall be high (H). The environment category shall be C5M and Im2, i.e. the selected protection system shall provide high durability for both environment categories. The Contractor shall furnish the details of the painting / coating system he proposes to adopt to the Engineer for his prior approval.

The painting / coating system proposed for all steel surfaces shall be as follows:


System parameters	System 2
Environmental class	Im2 as per ISO 12944
Surface preparation	SA 2.5
Design life	10 years
Primer	2 coats of Epoxy primer, 75 microns each
Coating	4 coats of Ultra High Build Glass Flake Epoxy 150 microns each
Total thickness	750 microns
Finishing color	Black
<b>Application</b>	<b>Fender frame (external surfaces)</b> <b>Guide Pin Piles (external surface)</b>

#### 16.9.3. Application of Painting

Steelwork will be primed and painted under shop conditions before delivery to site unless the Engineer approves an alternative approach.

All joints shall receive the full specified preparatory and painting treatment. All primed areas shall receive sweep blasting before the application of any further coats of paint.

The Contractor shall take all precautions to keep the areas of painting clean and dry and to maintain the recommended temperature and humidity. Care shall be taken during loading, unloading, stacking and erection of any painted steelwork to minimize damage to the protection system. All slings, ropes and chains used to handle the steelwork shall be

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protected with rubber sheaths or similar. The Contractor shall make good to the approval of the Engineer all paint work damaged during fabrication, transport, assembly and erection.

Where a paint system is required, but not specified, the Contractor shall submit to the Engineer for his approval details of a paint system which will meet the requirements of BS 5493: 1977 Table 3 Part 9 minimum 15 years to first maintenance. In proposing a paint system for approval, the Contractor shall take into account the system's resistance to mechanical damage and abrasion as well as the exposure conditions. A minimum total dry film thickness of 450 microns shall be applied. All paints used are to be solvent free. Full technical details of any paint system proposed shall be submitted to the Engineer for approval.

#### 16.9.4. Standard

The pretreatment, workmanship and equipment for painting shall generally comply with the requirements of IS 1477 (Parts I & II) "Pretreatment and Painting" except in so far this specification modified it.


#### 16.9.5. Pre-Treatment

After inspection and approval and before leaving the fabrication shop, the surfaces of all steel work to be painted shall be prepared. Traces of oil and grease shall be removed with solvent and cleaning rags and scales and rust removed by hand tools. Hand tool cleaning consists of chipping and scrapping followed by vigorous wire brushing and emery paper cleaning. The rust and scales shall be removed by the use of electric or pneumatic tools such as sanding machines, scalers, etc. No painting shall commence until the prepared surface has been approved by the Engineer.

#### 16.9.6. Painting Schedule

Immediately after the surface has been prepared, the steel work shall be given one coat of Bison Metal conditioning solution manufactured by Berger Paints or Rust converter developed by Central Electro-Chemical Research Institute, Karaikudi or approved equivalent. The first coat of primer paint shall be applied within 24 hours of the application of the conditioning solution. The primer paint shall consist of one coat of Linosol High Build Zinc Phosphate Primer manufactured by Berger Paints or approved equivalent. The dry film thickness of the primer shall be at least 50 Microns. Thereafter the steel work shall be given one coat of Linosol High Build Micaceous Iron Oxide Paint manufactured by Berger Paints or approved equivalent with dry film thickness of not less than 50 microns. The colour and the shade of the paints shall be as approved by the Engineer. All priming and finishing paints shall, preferably, be obtained from the same manufacturer. The contractor shall guarantee that the paints for priming and finishing coats are compatible with each other, in addition to their



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satisfying the specified requirements. The first and second coats of finishing paint shall have different tints to distinguish one from the other.

#### 16.9.7. Painting at Shop

All painting shall be carried out by brushing spray and roller application of paint shall not be allowed without the written permission of the Engineer. Painting shall be done immediately after surface preparation. The prepared surface shall not be allowed to stand in rain or overnight before painting. Where galvanized surfaces are to be painted, they shall be cleaned and washed with a solution of Copper Sulphate before the application of the first coat of primer. Each coat of paint shall be allowed to dry thoroughly before the subsequent coat is applied. The drying time shall be in accordance with the manufacturer's specifications. The first primer coat shall follow immediately thereafter. Unless otherwise approved by the Engineer, finishing painting shall not commence four days or after thirty days from the application of the second primer coat in the shop. Before the application of the second coat of the primer, all steel work shall be cleaned with emery paper and all damaged areas shall be carefully cleaned and repainted.

#### 16.9.8. Painting after Erection

After erection, the whole of the steel work shall be thoroughly cleaned of all dirt, marks, grease and overspills of primer paint. Areas where the coat has either been damaged or has deteriorated shall be cut back and repainted with primer in the same manner in the fabrication shop. All exposed surfaces of metal, bolt heads and connections left unpainted in the shop shall be similarly treated. After preliminary work of making goods has been approved by the Engineer, all surfaces shall be thoroughly washed down with fresh water and when dried, the finishing coat shall be applied. The finishing coat shall consist of one coat of Linosol Chlorinated Rubber Paint manufactured by Berger Paints or approved equivalent.

### 16.10. Galvanization of Steel

All steel work on jetty head and as mentioned in the tender drawings should be galvanized. All hot dip galvanizing shall be in accordance with I.S. 2629 / ASTM A153.

Before galvanizing, all components shall be grit blasted to give a clean roughened surface as a pre-treatment.

The minimum nominal thickness of coating shall be **120 microns** and shall conform to IS: 4759: 1996- Hot dip zinc coatings on structural steel and other allied products.

Samples of galvanized steelwork shall be tested at the galvanizer's works prior to dispatch to ensure compliance with the coating requirements.



### 16.11. Quality Control

The Contractor shall be responsible for Quality Control (QC) inspection and testing services carried out by CSA or applicable certified testing agencies. The Engineer's Representative shall carry out Quality Assurance (QA) reviews and testing where necessary.

The Engineer's Representative reserves the right to audit and verify the Contractor's QC procedures and services.

Procurement documents shall ensure the Engineer's Representative's right of access.

Contractor's documents, instructions, procedures, drawings, specifications, ITP's and test records shall be made available to Engineer's Representative for review.

The Contractor shall establish and provide the Engineer's Representative with schedules for inspections, surveillance, witness points, hold points, tests and final inspections for the release of fabricated materials.

Maintain identification procedures for all materials including those that are partly assembled in accordance with Supply and Control of Materials Section.

The Contractor shall identify all processes and provide the Engineer's Representative with copies of all applicable records that require procedure and personnel qualifications.


The Contractor's inspection plan shall define inspections, tests and hold points from start to completion of fabrication at which conformance shall be verified. Hold points for those inspections that are rendered inaccessible shall be verified before the start of the next operation.

The QC Work includes but is not necessarily limited to:

- Paint testing.
- Weld testing.
- Dimension controls.

The Contractor shall appoint and pay for services of independent testing agencies, approved by Engineer's Representative for the following:

- Paint testing, Weld testing and Dimension controls.
- Inspection and testing required by laws, ordinances, rules and regulations or orders of public authorities.
- Inspection and testing performed exclusively for the Contractor's convenience.
- Mill tests and certificates of compliance.

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No separate payment shall be made for testing. Payment shall be considered incidental to the Work and shall be included under other appropriate items.

Where tests or inspections reveal Work not in accordance with Contract requirements, the Contractor shall pay costs for additional tests or inspections as the Engineer's Representative shall require verifying acceptability of corrected Work.

The Contractor's Responsibilities shall be to furnish labour and facilities to:


- Provide access to Work to be inspected and tested.
- Provide details of all quality plans and testing programs to the Engineer's Representative for approval
- Carry out all QC inspections and tests.
- Provide an experienced QC supervisor to supervise and administer the QC program.
- Contractor's records shall identify inspector, test type, procedure, test equipment, traceability certificate, acceptance criteria, results, signature and date.

Where materials are specified to be tested, deliver representative samples in the required quantity to the testing agency's laboratory.

Pay costs for uncovering and making good Work that is covered before required inspection or testing is completed and approved by the Engineer's Representative.

Copies of all test results with both electronic and paper submissions shall be issued to the Engineer's Representative to witness sampling and testing and additional Q/A testing if required.

The Engineer's Representative shall be responsible for Quality Assurance, including review and approval of the Contractor's Q/C plans, witnessing the Contractor's Q/C sampling and testing, reviewing the Contractor's Q/C test results and arranging for additional independent Q/A testing were considered necessary.

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## **17. SPECIFICATION FOR GUIDE PIN PILES INSTALLATION**

### **17.1. Scope**

The scope of this specification includes procurement of material, fabrication and assembly, installation and connecting all accessories for successful operation of the pontoon.

### **17.2. Material**

The structural steel material for the guide pin pile shall be confirmed according to clause 15.5.

### **17.3. Fabrication and Finish.**

The fabrication of pile shall be in accordance with API Specification 2B. The longitudinal and circumferential seam welds shall be inspected 100% using UT and X-ray methods. The inspection shall be carried out with the third party to be approved by the Engineers' representative. All the inspection records shall be subject to third party approval.

The fabricated tubular shall be blast cleaned and painted before transporting to the site. The coating system shall be in accordance with clause 15.9. Any damaged part of the coating during transportation to site shall be repaired before lowering the guide pin pile into the drilled hole.

### **17.4. Welding**

The longitudinal and circumferential welding for the pipe pile shall be full penetration double groove weld in accordance with AWS D1.1. The welding specification, procedure, qualification test, welder approval shall be in accordance with AWS D1.1. All procedures and specifications shall be submitted for the approval of the Engineer's Representative.

### **17.5. Fender supports and anodes.**

The stiffeners and base plates for the arch fender support and anode attachments on the guide pin piles shall be welded and coated prior to the assembly of guide pin piles into one single piece. The location of these attachments and anodes shall be in accordance with the construction drawings. The complete assembly of the guide pin pile and its attachments shall be erected in position as a single piece using a suitable capacity crane with sufficient boom length and height.

### **17.6. Outer casing driving**

The outer casing of diameter larger than the guide pile (at least 600mm larger than diameter of guide pin pile) shall be erected into the seabed and driven to the penetration using suitable

hammer capacity. The hammer required shall be evaluated by the Contractor based on the soil data provided as part of the bid. During driving of the outer casing, the soil plug shall be removed using drilling, chiseling, bailing or other methods. The cost of all temporary works to support the temporary outer casing shall be included in the scope of the contractor.

### **17.7. Drilling**

The drilling of pile hole shall be carried out using either RCD type pile top drilling machine or suitable chisel and bailer to the target depth with a diameter as per construction drawings. The drilled hole shall be cleaned thoroughly and all debris and loose material at the bottom shall be removed.

### **17.8. Lifting and erection of guide pin pile**

The guide pin pile shall be lifted and handled carefully using padeye attachments welded to the pipe and these padeyes shall be cut and removed prior to the erection of reinforcement cage inside the pile.

### **17.9. Grouting**

The annular gap between the drilled hole and the pile shall be filled with underwater grout of minimum compressive strength of 100 MPa immediately after the alignment is carried out. Grouting shall be done only after plugging the bottom of pile with inside using same underwater grout for a minimum thickness of 300mm. Grouting shall be done using pressure grouting technique with positive displacement and overflow shall be observed above the seabed through a weep hole drilled just above the seabed in outer casing.


### **17.10. Alignment and tolerance**

The pile position in relation to the jetty and the spacing of two guide pin piles shall be in accordance with the construction drawings and the tolerance indicated on the drawings. The deviations indicated are maximum and the same shall not exceed the limits specified. The following summary of tolerances is given and the same shall not exceed.

Out of roundness	: should be less than 1%.
Out of verticality	: Less than 1: 500
Out of position	: $\pm 10$ mm (in any direction) in relation to the other guide pin pile

### **17.11. Concrete fill and reinforcement**

The guide pin pile shall be filled with concrete and reinforcement up to the top as per construction drawings. The construction procedure shall be followed as per bored concrete in situ RC piles discussed in earlier section.

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#### **17.12. Removal of temporary liner**

The outer casing shall be cut and removed after the grouting of the annular space between the guide pin pile and the rock/soil. This shall be carried out using underwater cutting technique without affecting the guide pin pile and its attachments (either using weld rod or using water jet cutting). The outer casing shall be lifted carefully without damaging the anodes or brackets fitted for fender assembly. The removed part of the outer casing shall be re-used for second and subsequent piles by adding additional length. Damaged part if any can be cut and removed.

## 18. SPECIFICATION FOR CATHODIC PROTECTION

### 18.1. Scope

This specification describes the minimum requirements for an aluminum alloy sacrificial Anodes for cathodic protection system to be installed on the pontoon (external and internal) and guide pin piles. The detailed scope of the work is as below.

- Procurement, Manufacture, Inspection, Testing, Delivery, Installation, Pre-Commissioning and Final Commissioning of following packages complete with all accessories and attachments as per Codes, Standards, Data Sheets and Specifications as attached.
- Slender Standoff Type Aluminum-Indium-Zinc Alloy Sacrificial Anodes with 4” diameter schedule 80 seamless steel pipes.
- Zinc Reference Electrodes.
- Identically Monitored Anodes.
- Monitoring Panel includes all control & monitoring instruments/devices.
- All relevant cables for the Monitoring System mentioned above, from each reference electrode and monitored anode to junction box, and from junction boxes to Monitoring Panel.
- Metallic Weatherproof / waterproof Junction Boxes.
- Conduits, mounting, supports and accessories.
- Filling Compound, etc.

### 18.2. Standards and codes

The cathodic protection system shall be in accordance with good marine practice in corrosion protection, and in compliance with the following codes and standards to the extent applicable:

**Table 17.1 Codes and Standards**

DNVGL-RP -B401	Recommended Practice for Cathodic Protection Design 2017.
API RP-2A WSD	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms (21 <sup>st</sup> latest edition).
SSPC-SP-10	Steel Structure Painting Council Near-White Blast Cleaning.
ASTM A36	American Society of Testing and Material, Specification for Structural Steel.

Any aspect of cathodic protection not specifically addressed in this specification, or for which specification requirements are ambiguous, shall comply with the Recommended Practice DNVGL-RP-B401 “Cathodic Protection Design”, 2017. This standard and other project specifications referenced herein shall be considered complementary to this specification and similarly binding on the Contractor/Vendor/Manufacturer.

### 18.3. System design

A cathodic protection system, utilizing sacrificial aluminum alloy anodes suitable for protection of steel in a submerged marine environment.

#### 18.3.1. Environmental Conditions

The following environmental conditions are used for the design of cathodic protection design of the pontoon and guide pin piles.

Location	: Vadinar, Gujarat
Seawater Depth	: 22 m
Maximum Tide	: 5.549m
Seawater Temperature	: 70°F (at sea bottom) 95°F (at surface)
Ph Value	: 8.1
Dissolved Oxygen	: 3.5 to 5.3 ml/l
Resistivity	: 18 to 22 ohm/cm

#### 18.3.2. Design Parameters

The design parameters used for the anodes is summarised in table below.

Design Life	: 25 years
Current Densities Initial	: 150 mA/m <sup>2</sup> (seawater) 20 mA/m <sup>2</sup> (below mudline)
Maintenance (Mean)	: 75 mA/m <sup>2</sup> (seawater) 20 mA/m <sup>2</sup> (below mudline)
Final	: 100 mA/m <sup>2</sup>

#### 18.3.3. Design Protective Potential

The cathodic protection system when complete shall have a polarization potential of 0.80 volts, negative as referred to a standard silver/silver chloride (Ag/AgCl) reference cell.

#### 18.3.4. Number of Anodes Required

The system shall consist of Aluminum Alloy Anodes (GALVALUM III), or equivalent, as located on the contract drawings. Factors such as anode end face geometry (trapezoidal,

rectangular, circular, etc.) and anode length shall be considered and optimized in order to provide the most efficient current distribution about the structure.

#### 18.3.5. Preferred Anode Locations

Anodes shall be located to achieve maximum efficiency of current distribution and uniform structure polarization. Anodes shall be located such that a uniform distribution is attained. Anodes shall be attached to the structure as per drawings.

### 18.4. Anodes

#### 18.4.1. Anode Composition

The anode shall be Indium Activated Aluminum Alloy and shall confirm to following compositional requirement.

Zn	In	Fe	Cu	Si	Al	Hg
2 - 6%	0.01 - 0.03%	0.12% max.	0.005% max.	0.2% max.	Remainder	Nil

Certain additional alloying elements (proprietary additives) such as Ti or Ga are permissible but shall be documented in the elemental analysis.

#### 18.4.2. Electro-Chemical Value

The protective quality of the anode material shall be 2500 ampere-hours per kg.

#### 18.4.3. Closed-Circuit Potential

The potential of the sacrificial alloy material shall be no greater than (-) 1.05 volts referred to the Silver/Silver Chloride (Ag/AgCl) reference cell.

#### 18.4.4. Construction


Anode shall be the standard offshore stand-off type.

Size and weight - Anodes shall be of weight and dimensional shape suitable for a minimum 10years protection. The size and weight shall be as per contract drawings.

Core - The core shall consist of nominal  $\phi 114 \times 6$  A106 GR B pipe. Anode material shall completely surround the core.

The anode material in general is made by casting the anode around a steel core. Prior to casting the melt, these cores shall be de-scaled, degreased, grit-blasted and cleaned to a



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"near-white" finish in accordance with SSPC-SP-10 within 24 hours of casting or before rust blooming appears.

As most of the alloys do not at all fuse with the steel core, they shall be provided with indentations or other means to mechanically key the anode material adequately.

The design of the core in the anode material shall be such that excessive loss of anode material, caused by crumbling away of the anode from the core, is unlikely before 90% depletion of the anode has been reached.

Steel core bar type anodes shall have sufficient exposed steel to allow for easy installation by means of welding.

The steel core should be of sufficient strength to support the anode material in combination with 16.75 MPa storm force. Particular attention should be paid to the attachment details of core to the marine structure.

Stand-off - Legs shall be offset per manufacturer requirements from the core center-line. Stand-off legs shall be fabricated by (2) smooth bends of the core through anode end faces; curvature of the core to begin no closer than 25 mm from each anode end face. Fabrication of legs by bending the anode core through the lower anode face is prohibited.

The free ends of the legs will be welded to the bottom of the pontoon with four 10mm gusset plates on each pipe stand-off unless otherwise shown on the Drawings. CONTRACTOR shall shape the gusset plates to fit the contour of respective doubler plates and weld all around the gusset and doubler plates.


Doubler plates of 12mm ASTM A36 are required where anodes are attached to pontoon or guide pin piles. The stand-offs shall be seamless ASTM A106 GR B or API-5L GRB.

### **18.5. Guarantee**

The VENDOR shall guarantee the minimum Electro-chemical value of the anode material offered, in ampere-hours per kg, and this guarantee shall be furnished with the information shown required in 7.0 below. Furthermore, the VENDOR shall warrant that all data, calculations, assumptions, etc. used in the subject cathodic protection system are applicable and in accordance with responsible engineering practices and industry standards. A listing of all pertinent design criteria, assumptions and sample calculations demonstrating the effectiveness of the subject system shall be supplied with any and all proposals.

### **18.6. Material information**

VENDOR shall furnish the following information relative to the anodes:

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#### 18.6.1. Dimensions

Dimensions of drawings of all anodes and supporting parts or accessories and as follows:

- Dimensional Tolerances: The maximum deviation of anode dimensions shall not exceed  $\pm 12$  mm of that specified.
- Surface Defect Tolerances: The anode surface should be generally free from defects affecting the anode efficiency. Anodes with the following defects will be rejected:
  - Cavities exceeding 12.5 mm in the largest dimension and 6 mm in depth.
  - Cracks exceeding 2 mm in width, 300 mm in length and intersect each other.
  - Cracks penetrating to the core.
  - Apparent slag or dirt inclusion.

#### 18.6.2. Electro-Chemical Value

VENDOR shall supply guaranteed minimum Electro-chemical values in ampere-hour per kg for the anodes.

#### 18.6.3. Anode Weights

The weight of each anode shall be within 2% of that specified and the total weight of anodes shall be within 1/2% of that required, based on parameters stipulated herein.

#### 18.6.4. Electric Potential


VENDOR shall supply minimum, maximum, and average closed-circuit potential in volts for each pour.

#### 18.6.5. Anode Composition

CONTRACTOR shall supply chemical components and percent by weight.

#### 18.6.6. Handling

Proper anode storage, handling and transportation procedures shall be followed to prevent physical damage to the anodes or corrosion to the anode core steel legs.

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#### 18.6.7. Certificates

All anodes shall be supplied with foundry certificates. The certificates shall contain all relevant data, including purchase order number, manufacturer name, batch (charge, heat) number, chemical composition, and inspection and test reports. The certificates shall be in English with units clearly stated.

Endorsement of anode certificates by a certification agency is required as per the purchase order/Fabrication Contractor or governmental requirements of India.

#### 18.7. Installation

The CONTRACTOR shall install the anodes in accordance with COMPANY approved construction drawings at the locations indicated and with the connection details shown. Installation procedures including, but not limited to, welding processes, welder qualifications, and welding procedure qualifications, shall be in accordance with COMPANY general specifications.

#### 18.8. Monitoring system

A monitoring system shall be provided for cathodic protection. The system shall be designed to provide the following:


- The measurements of the effectiveness of the cathodic protection system, as judged by potential measurements.
- The performance of the sacrificial anodes, as judged by measurements of current output of monitored anodes.

The system shall include 4 Nos. monitored anodes and 12 Nos. reference electrodes, electrically connected to a monitoring panel located in the control room.

The monitoring system shall meet the following requirements as applicable.

##### 18.8.1. Monitored Anodes

The monitored anodes shall be identical to those supplied for the structural protection system and have the same physical characteristics but suitably modified so that current outputs can be electrically measured at the monitoring panel. The anodic material of the monitoring anodes shall be electrically insulated for those parts of the anode core, to be welded to the structure, with an insulation resistance, when dry, of not less than one mega ohm reducing when wet, to not less than one thousand ohms. Prefabricated isolating joints, with suitable mechanical properties, shall be utilized. The vendor may offer alternative means of isolation, subject to approval of the Company. A single shunt, affixed to the anode and having a resistance of not

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more than 0.005 ohm, shall bridge this insulation, and the shunt voltage drop shall be carried to the monitoring panel via a two (2) conductor cable.

The monitoring system shall be supplied with four (4) monitored anodes which shall be located at two (2) different elevations on the structure with two (2) anodes at each elevation. The monitored anodes shall be in addition to the sacrificial anodes required for structural protection.

#### 18.8.2. Reference Electrodes


Potential reference electrodes shall be of the dual faced, 99.99 percent zinc block epoxy encapsulated within a plastic P.V.C. coated steel housing & designed for direct welded attachment to the structure. Each reference electrode shall be supplied with sufficient cable length to run between the selected location and the junction box. The reference electrodes and the electrodes housing shall each be connected uniquely to one core.

The electrodes shall be located in areas where the potential is expected to be least negative. 4 Nos. electrodes shall be installed in vertical planes. The vertical plane electrodes shall be installed at two different planes with two electrodes in each plane. 8 Nos. electrodes shall be installed in horizontal planes. The horizontal plane electrodes shall be installed in two different elevations with four electrodes in each elevation.

#### 18.8.3. Monitoring panel

The monitoring panel shall be located in the control room or other suitable location in a safe area. The panel shall be of sheet steel (14 SWG) construction with an enclosure protection equivalent of IP-51. The monitoring panel, as a minimum, shall contain the following.

- Selector Switches-Manually operated selector Switches-One (1) for each set of the reference electrodes and monitored anodes. However, all signal switching shall be through Reed relays which, in turn, shall be selected through these switches.
- Voltmeter-Panel mounted high sensitivity voltmeter of not less than 100,000 ohms per volts which shall have the capability of measuring the potential difference between the structure and each of the zinc reference electrodes. Range (+) 1 volts to (-) 1 volt.
- Ammeter- Panel mounted ammeter with the capability of reading the current output of each of the monitored anodes. Range 0 to 10 Amp.
- Meter calibration – The panel shall have the built-in capability for checking the calibration and accuracy of the instruments.
- Mimic diagram - On the front of the panel mimic diagrams showing the sheet pile to be cathodically protected shall be included. Positioning of all reference

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electrodes and monitored anodes shall be marked distinctly on it. Different colours shall be used for marking structures, monitored anodes and reference electrodes. Positions of reference electrodes, monitored anodes, shall be illuminated on mimic diagram when they are selected for voltage or current readings respectively. This should be achieved by providing preferably light emitting diodes display.

- Recording unit provisions -The panel shall be equipped with provision to accept plug-in recording unit for periodic recordings of current & voltage.
- Electric Power Supply - 24V  $\pm$  10%, D.C. supply shall be made available at one point by Contractor. Vendor shall indicate total power (WATT) required at the time of bidding.
- Painting - The panel & associated components shall be painted in accordance with the requirements of Specification - `Protective Coating`.

#### 18.8.4. Cabling

All cabling from each reference electrodes and monitored anode shall be brought to a metallic waterproof junction box, mastic filled and mounted in the safe area. Two number junction boxes shall be provided for twenty terminals each. The cables from reference electrodes and monitored anodes to junction box shall have double insulation of EPR and inner & outer sheath shall be of CSP. The cables shall be suitable for operation under conditions of total and continuous immersion in sea water. Shielded cable may be provided, if in the opinion of the vendor, considered necessary. The cables shall be routed through conduits and supported by welded brackets. The main riser conduit shall be clamped at frequent intervals for adequate supporting. All conduits shall be of steel and conform to API-5L grade B seamless schedule 80 pipe.

All cables from reference electrodes and monitored anodes to junction box shall be with 2 X 2.5 mm<sup>2</sup> tinned copper conductor and shall be armoured. All cable connections shall be water tight. Each junction box shall be suitable for termination of all cables from reference electrodes and monitored anodes and one no. 19 X 2.5mm<sup>2</sup> tinned copper conductor armoured cable from junction box to monitoring panel. Cables from junction box to monitoring panel shall be FRLS type.

#### 18.9. Service after installation


The installation contractor shall carry out a potential survey, not later than six months of immersion, to verify that the structure is cathodically protected. If not, suitable remedial action shall be taken. Anode vendor shall provide all necessary support during the potential survey.

## 18.10. Testing and Inspection

Anode composition analysis shall be undertaken by methods agreed upon in advance. Three samples from each melt heat shall be taken for chemical analysis and electrochemical tests. The samples shall be taken in the beginning, at the middle and at the end of casting from the pouring string. Checking of closed-circuit potential and practical mass consumptions shall be done once for every 5 tons of anodes produced. Ampere hour capacity shall be determined by weight loss method only. Tests shall be done as per DNVGL-RBP-401, Annexure-1 for capacity and closed-circuit potential. Open circuit potential shall also be measured every 24 hours for 96 hours before start of test. All Chemical Analysis and Electrochemical Tests to be carried out at an independent accredited laboratory.

After casting, the inspection of the anodes shall do to ensure that:

- i. AH capacity of anodes shall not be less than the figures considered for design i.e. no negative tolerance shall be permitted.
- ii. The anodes have minimum net weight (Gross weight minus core weight) within a tolerance of +2.0% to -1.0%. However, overall negative tolerance shall be 0% to ensure that there is no shortfall in total alloy weight.
- iii. Dimensions are within tolerance limits indicated in the approved drawings. No negative tolerance is allowed in stand-off dimensions.
- iv. Closed circuit Potential shall be within (+) 10 mV and (-) 50 mV of the guaranteed value. For example, for guaranteed value of (-) 1.08v, anodes having closed Cut. Potential less negative than (-) 1.07 volts shall be rejected.
- v. The anodes are free from mechanical defects. For these following criteria shall be used:
  - In general, the anode surface shall be free from cracks which reduce the performance of anode. The combination of cracks and lack of bond to the anode core is detrimental and will not be accepted. Criteria for accepting the cracks in anode will be:
    - Any crack which follows the longitudinal direction of elongated anodes is not acceptable.
    - Smaller cracks in the transverse direction of elongated anodes and in anodes of other shapes may be accepted provided the cracks would not cause any mechanical failure during service of the anode.
  - For transverse cracks, the following limits shall be used:
    - Cracks with a length of less than 50mm and width less than 5mm are acceptable.
    - Cracks with a length of 50-200 mm shall be limited to 2 per anode face but maximum 4 Nos. per anode.
    - Cracks with a length more than 200mm or which are more than 5mm in width are not acceptable.

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➤ The above-mentioned cracks if penetrating more than three fourths of the depth to core shall not be acceptable.

- The anodes shall be free from excessive shrinkages. Shrinkage cavities maximum up to 0% of the depth of anode or 50% of the depth of the anode core, whichever is less, will be acceptable. The same will be measured from the edges of one side.
- The anodes shall be free from excessive flash, sharp or other surface projections, laminations, cold laps and surface slag as consistent with good casting practice. In general, the anodes show good workmanship on visual examination.

All the above inspection/tests shall be witnessed by Third Party Inspection Agency DNV, TUV, BV or Lloyds.

All anodes shall be delivered with material certificates from the Vendor stating batch identification number and chemical analysis.

All work, materials, and equipment will be subject to inspection by the company at all reasonable times. Inspection by the company shall not relieve the vendor of his responsibility under the terms of the contract.

- vi. Electrical continuity test between anode and core/insert shall be done for each anode by measurement of resistance between anode and core. Value shall not exceed 0.9 milliohms.
- vii. The monitoring system shall be inspected after completion of fabrication and prior to loading out. This check shall include:
  - Polarity checks on all monitored anodes.
  - Insulation and continuity test of all cables.
  - Calibration tests shall subsequently be carried out on all instrumentation and on reference electrodes.
- viii. At least one anode per delivery or at least 0.5% of the anodes shall be subjected to destructive testing to check that the casting is to an acceptable standard. Each anode should be cut at 3 of the most relevant locations. The cut surface should generally be free from visible pores and slag/dross inclusions. The lack of bond or void between anode core and anode material should not exceed 5%.

Alternative to a destructive testing, a nondestructive testing by radiography may be used to check for lack of bond or slag/dross inclusions.