

RECONSTRUCTION OF Q2 - Q3 BERTHS AT MATTANCHERRY WHARF OF COCHIN PORT

TECHNICAL SPECIFICATIONS



COCHIN PORT AUTHORITY
Willingdon Island, Cochin-682009
Kerala.

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TECHNICAL SPECIFICATIONS

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1. BORED CAST-IN-SITU PILES

1.1. General

1.1.1. 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.

1.1.2. Scope

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

- (i) Bored cast-in-situ piles supporting the superstructure in the project. 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 berth 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-in-charge'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-in-charge's approval prior to installation of piles.

1.1.3. Materials

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

1.1.4. 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.

The Contractor shall report immediately to the Engineer-in-charge 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.



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1.1.5. 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/ Reverse Circulation Drilling.

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.

1.1.6. 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-in-charge each day of the intended programme of piling for the following day.

1.1.7. 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 along 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-in-charge-in-charge being notified at least one week in advance.

1.1.8. Damage to piles

The Contractor shall ensure that, during the execution of the Works, no displacement or damage occurs to completed piles that could adversely affect their performance or durability.

The Contractor shall submit the proposed sequence and timing for pile installation to the Engineer-in-charge for review and approval prior to commencement. Such sequence and timing shall be planned and executed in a manner that prevents damage to adjacent or previously installed piles.

1.1.9. Tolerances

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

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



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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 more than 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.

1.1.10. Records

The Contractor shall keep records as indicated by an asterisk in Table 1-1 or as directed by the Engineer-in-charge for the construction/ installation of each pile and shall submit two signed copies of these records to the Engineer-in-charge 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 1-1: 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 Seabed 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	*
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	*



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As constructed positional records vertical and horizontal	*
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1.2. Bored Cast-in-place Piles

1.2.1. 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.

1.2.2. 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-in-charge shall not relieve the Contractor from his responsibility.

1.2.3. Diameter of Piles

The diameter of a pile shall not be less than the specified diameter for the piles shown in the construction drawings.

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

1.2.4. Boring

Boring shall generally be carried out by recommended procedure as set in IS-2911 by either rotary or percussion equipment, grabbing equipment or by reverse or direct mud circulation method if the soil is found to be unsuitable, the boring tools should be such that suction effects are minimized. Walls of borehole shall be stabilized by using either casing/liner with drilling fluid (Bentonite Slurry) depending upon the soil conditions as provided in this specification. In the case of boring with casing should be used preferably from the existing ground level or as directed, the bottom of the liners should be kept ahead of the boring in all cases to prevent the entry of soil into the bore for preventing the formation of cavities and settlement in the adjoining ground. Continuous pumping shall not be done for excavating inside the borehole. While below sub-soil water level, precaution shall be taken so that no bailing of the bottom of the hole occurs due to difference in hydrostatic head.

Where the stabilization of the size of the borehole is affected by the use of drilling fluids, the fluid level shall be maintained at a level not less than 1.5m above the level as the case may be and the hole shall then always be kept almost full while the concreting is completed.

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



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

Casing or liner plates shall be provided up to the required depth of the pile shaft for vertical piles where required. The method of boring and providing casing shall be such that the finished cross section of the concrete pile shaft at any location except at shoe (if required) shall not be less than that shown in the Drawing.

The Contractor shall submit with the tender his method of boring and of providing liner plates of casing where required. The Contractor shall take into account the special precautions to be adopted and the liner plates required for boring piles through the rubble bund.

The contractor shall be entirely responsible for ensuring that the piles are bored to required lines positions and depths.

Boring shall be carried out up to the depths shown in the drawing or as directed by the EIC. If the contractor makes the borehole deeper than, the designed founding level of the pile shall only be considered the final level of the pile. Concrete and reinforcement for the additional boring shall not be paid. No claim for empty boring on account shall be entertained.

Before driving the liner, contractor shall verify the seabed for any obstruction, debris, rocks, boulders or other underwater or underground obstruction in the vicinity of proposed pile and the same shall be removed by the contractor without any additional cost or time extension.

1.2.5. Pile termination

For soft and hard clay

The piles shall be constructed up to the termination level indicated in the construction drawing or as directed by the Engineer in-charge irrespective of the soil strata encountered during boring. The decision of Engineer-in-charge is final.

1.2.6. 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.



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1.2.7. Permanent casing

Permanent casing shall be required for the piles.. The permanent casing shall be installed to such level as shown in the drawings. The depth to which the permanent casing is installed may be increased if in the Contractor's opinion such increase is 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-in-charge.

Before driving the liner, contractor shall verify the seabed for any obstruction, debris, rocks, boulders or other underwater or underground obstruction in the vicinity of proposed pile and the same shall be removed by the contractor without any additional cost or time extension.

1.2.8. Bentonite Slurry (Drilling Mud)

Bentonite used in the work shall be of the best quality. Bentonite shall mix thoroughly with clean fresh water to make a suspension which will maintain the stability of pile boring for the period necessary to place concrete and complete construction. The bentonite slurry used as a drilling mud during boring and casting of piles shall conform to the specifications given in IS:2911 (Part I/Sec.2). Polymer solutions may also be used to stabilize sides of bore holes in conjunction with bentonite or used as standalone support fluid as per EN 1536.

Periodical inspection and testing of the bentonite slurry shall be carried out to ensure the quality of the slurry. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed. The measuring device shall be calibrated to read to within 0.005 gm/ml. Tests to determine density, viscosity, shear strength and PH value shall be applied to bentonite supplied to the pile boring. The concreting operations should not be taken up when the specific gravity of the of the bottom slurry is more than 1.12 and the slurry should be maintained at 1.5m above the ground water level.

Settling tanks of adequate capacity shall be provided for the collection of discharge from the piles and the recovery and re-use of the liquid after allowing settlement of soil particles. The contractor shall furnish his detailed scheme for the mud circulations for approval by Engineer-in-charge-in-Charge. Pumps used for boring by direct mud circulation shall have adequate capacity to maintain vertical flow velocity of 2cm/sec. inside the pile while boring is carried out.

Immediately after the completion of boring, flushing of the borehole shall be done with the chisel in position for a period not less than one hour. After removing the chisel, the bore hole shall be further cleaned with a suitable bailer having adequate weight. After lowering and placing in position the reinforcement, final cleaning of the bore hole shall be done with fresh drilling mud liquid for a period not less than 2 hours. In case, the recovered liquid is less contaminated, it can be used for continuing the flushing with the approval of the Engineer-in-



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charge-in-Charge. Finally, the full depth shall be filled with fresh drilling mud liquid. The pump system used for final cleaning shall have sufficient capacity for ensuring complete removal of loose materials. Characteristics of bentonite suspension for re-use shall be as per IS:2911 (Part1/ Section 2)

After the drilling mud liquid circulation for a minimum period of 2 hours as aforesaid, air lift system shall be employed for removing the lumps etc. likely to be deposited at the bottom of pile bore and clean pile bore bottom shall be ensured before commencement of concreting. Following procedure shall be followed with suitable modifications as per site requirements for the air lift system of pile bore bottom cleaning.

- (i) On completion of satisfactory flushing of bore hole with fresh drilling mud as per specifications and filling of bore hole with fresh drilling mud liquid, suitable bend shall be connected to the top of tremie and the tremie bottom has to be kept initially approximately 1m above the pile bore bottom. 25 mm dia pneumatic air pipe fitted with 25 mm dia perforated G.I. pipe of 1-1.50 m length at the bottom shall be inserted through a separate opening on the top of the bend. The bottom level of the air pipe has to be suitably adjusted so as to ensure continuous suction from the bottom of bore hole. An air compressor having a capacity not less than 250 cfm shall be deployed for compressed air supply.
- (ii) As the flushing progresses the tremie has to be gradually lowered so as to remove the lumps, settled muck etc. and to ensure clean pile bore bottom. Fresh drilling mud shall be pumped to bore hole from top of liner, so as to maintain the required head of drilling mud in the pile bore at all times.

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

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

Where the construction sequence is such that the time of 12 hours will be exceeded even if no delays are considered, a realistic time 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-in-charge's approval a method for restoring the pile capacity. This may include



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re-drilling the pile bore at a larger diameter, lengthening the pile, etc.

Cold joint in the pile between the toe to pile cut-off level is not permitted. Such piles will be rejected, and additional piles shall be cast to rectify the situation.

1.2.10. 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-in-charge, which shall be designed to clean while at the same time minimising ground disturbance below pile bases.

1.2.11. Reinforcement

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

1.2.12. Concreting of pile

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. 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 onshore/floating batching plant for carrying out piling.

1.2.13. 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.



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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 150mm to 200mm.

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.

1.2.14. 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 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 0.6 metre. Only quantity of concrete shall be considered from the founding level of the pile to 0.6m above cutoff level for payment purpose.

If more than one tremie pipe are used in the same pile, it shall be ensured during the pouring



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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.

The rates quoted by the contractor shall be for completing the piling in all respects to the required depth by socketing in the hard strata as specified by the Engineer-in-charge's Representative irrespective of the subsoil strata that may be encountered as per actual during boring.

The setting up of piling equipment generally involves at the top of the piling works as well as change in direction to 90 degrees. Hence any change in direction within 90 degree shall not be accounted at any case and any claim whatsoever on shifting of equipment / change of direction / setting up of equipment etc., shall be entertained.

In addition to the normal precautions to be taken in tremie concreting as per relevant section of B.I.S. Specifications, the following specifications shall be particularly applicable for the use of tremie concrete in piles.

- a) The concrete shall be coherent rich in cement content and of slump as approved by the Engineer-in-charge's Representative.
- b) All concreting should be done by using Batching plant only. Weighment of cement and aggregates should be arranged by the contractor at his own cost.
- c) The concrete shall be produced in a mechanical mixer of capacity of suitable size having integral weigh batching facility and automatic water measuring and dispensing device.
- d) Under no circumstances volumetric method of mixing of concrete shall be allowed.
- e) The tremie shall be large enough with due regard to the size of the aggregates. For 20 mm aggregates, the tremie should be of diameter not less than 150 mm.
- f) Aggregates more than 20 mm shall not be used.
- g) The hopper and tremie shall be a closed system embedded in the placed concrete, through which water cannot pass.
- h) The first charge of concrete shall be placed with a sliding plug pushed down the tube ahead of it or with steel plate of adequate charge to prevent mixing of concrete and water. However, the plug shall not be left in the concrete as a lump.
- i) The tremie pipe shall always remain penetrated well into the concrete with an adequate margin of safety against accidental withdrawal of the pipe when surged to charge the concrete.
- j) The pile shall be concreted wholly by tremie and the method of deposition shall not be changed, to prevent the laitance from being entrapped within the pile.
- k) All tremie tubes shall be scrupulously cleaned after each concreting.
- l) Concrete shall be placed and compacted until green concrete is obtained above the cut-off level. Concreting of each pile shall be done in one continuous operation.



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1.2.15. Obstruction

If any obstruction to boring or driving is encountered, the Contractor shall notify the Engineer-in-charge 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.

1.2.16. Finishing Pile Heads

The top of the pile shall be brought up sufficiently above the finishing level and a minimum of 600mm 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.

1.2.17. Cutting off pile heads

Cutting and trimming of pile heads shall be carried out after 14 days of pile concreting or the concrete achieving 90% strength whichever is earlier. 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-in-charge prior to commencement of works.

1.2.18. Disposal of pile muck and other waste material

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

1.3. Dynamic Pile Load Testing

1.3.1. Scope

The tests shall be carried out for concrete cast-in-situ working piles 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 with their bid.

1.3.2. Method of testing



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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-in-charge's approval.

1.3.3. 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.

1.3.4. Preparation of pile heads

Where method of testing requires the positioning of sensing equipment on the pile head, the head shall be broken down to expose sound concrete and shall be clean, free of water, laitance, loose concrete and blinding concrete and shall be readily accessible for the purpose of testing. Pile shall be cast additional 2m in addition to 0.6m overflow for laitance and the 0.6m shall be cut and removed before testing. No extra payment shall be made for the pile head preparation as it shall be included as part of the pile testing.

1.3.5. Post-construction integrity testing of damaged piles

If based on the post-construction survey the Engineer-in-charge 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-in-charge for testing in order to ensure the pile performance within the structure including the seismic conditions.

1.3.6. Low Strain Pile Integrity Testing

As part of the verification of quality of construction, pile integrity testing (NDT) shall be carried out on piles selected by Engineer-in-charge's Representative. 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



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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 Engineer-in-charge's Representative immediately after conducting the test.

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

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

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

1.3.7. 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-in-charge' 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



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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.

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 Engineer-in-charge's Representative as soon as completion of the test. This method is covered under ASTM D4945-00 - Standard Test Method for High Strain Dynamic Testing of Piles.

1.3.8. 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-in-charge 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.

1.3.9. Reporting

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



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The test results and the interpretation shall be reported to the Engineer-in-charge 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.

1.3.10. 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-in-charge immediately. The Contractor shall demonstrate to the Engineer-in-charge 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-in-charge 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.

1.3.11. Specialist Sub-Contractors/ Agency

The contractor should appoint specialised agency for pile integrity tests with the approval of the Engineer-in-charge.

1.4. Vertical Load Testing of Piles

1.4.1. General

Initial Static load testing (Vertical 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) Initial vertical load test
- (b) Routine vertical load test (if specified in BOQ)

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

1.4.2. Initial vertical load test

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

- a) The spacing between test pile and the reaction pile shall not be less than 3 times the test pile diameter.



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- b) Test load of 2.5 x working load shall be used for testing. The loading shall be direct loading method using sang bags or equivalent.
- c) Design of steel kentledge frame and arrangement shall be in accordance with IS 800.

The design of kentledge frame for supporting test setup shall include platform for stacking the loading and also to secure the displacement reference frame. The support system shall be designed using corresponding load. Symmetry in such arrangement shall be maintained to avoid undue to results during testing.

1.4.3. Acceptance criteria

The acceptance criteria for initial load test shall be in accordance with IS 2911 -(Part 4) clause 7.1.5 and are as follows. The safe working load shall be taken as per the following criteria.

- (a) Two-thirds of test load at which the total displacement attains a value of 12mm or fifty percent of test load at which the total displacement attains the value of 10% of pile diameter whichever is lesser for pile diameter up to and including 600mm.
- (b) Two-thirds of test load at which the total displacement attains a value of 18mm or 2% of pile diameter whichever is lesser or fifty percent of test load at which the total displacement attains the value of 10% of pile diameter whichever is lesser for pile diameter more than 600mm.

In case of failure of test pile , the initial test pile shall be constructed at another location after the redesign of pile penetration with increased toe level.

1.4.4. 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.

1.4.5. 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-in-charge prior to installation of the test piles.

Initial static pile load test shall be carried out on pile constructed for this purpose. 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, support piles if



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any projecting above the seabed shall be cut and removed after the completion of test. The spacing between the test pile and the support pile shall be at least 2.5 times the diameter.

The test pile shall be located close to the borehole BH-1 or BH-2 so that the tested capacity can be compared with that obtained from the calculated capacity using the borehole data. Contractor shall compute the pile load carrying capacity in accordance with the nearest borehole and compare the same with the tested capacity.

1.4.6. Kentledge support Piles

Kentledge support piles shall be designed to support the weight of kentledge and the test loads such as sandbag or other loading method. Working piles shall not be used as support piles for either initial vertical load test for testing purposes.

Alternate schemes such as O-cell method, inclined guy ropes or other alternate methods are not permitted for transfer of test loads to ground/seabed.

1.4.7. Notice of construction

The Contractor shall give the Engineer-in-charge at least 48 hour's notice of the commencement of construction of any initial test pile.

1.4.8. Boring or driving records

For each initial test pile which is to be tested 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-in-charge requires soil samples to be taken or in-situ tests to be carried out, the Contractor shall present the results without delay.

1.4.9. 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.

1.4.10. Preparation of working pile to be tested



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

1.4.11. 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 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.

1.4.12. 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.

1.4.13. Notice of Test

The Contractor shall give the Engineer-in-charge 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.

1.4.14. Presentation of Results

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



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- i) A preliminary copy of the test records to the Engineer-in-charge 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;
- ii) The completed schedule of recorded data, as specified below, within ten days of completion of the test.

1.4.15. Test Compliance

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

1.4.16. 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-in-charge & 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
 - 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

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- 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

1.4.17. Completion of Test

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

Regular piling can be commenced only on successful completion of Initial Pile Load test.

2. CONCRETE

2.1. General Specifications

2.1.1. 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.

2.1.2. Concrete for the Works

Concrete for the Works shall be produced on Site using onshore/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-in-charge for approval prior to the preparation of the trial mixes. Once design mix is approved, the Engineer-in-charge 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.

2.1.3. 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 ³ .
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.

2.2. Site Specific Requirements

2.2.1. Permitted Types of Cement

Type	Standard Specification
Ordinary Portland Cement of 53 grade (or) Portland Slag Cement with compressive strength satisfying the requirements of OPC grade 53	IS:12269 / I.S: 455 (1989)

2.2.2. Cement Properties

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

2.2.3. Permitted Aggregates

Type	Standard Specification
Natural River Sand/M-sand/crushed sand	I.S. – 383, IS 456 and other codal requirements

2.2.4. 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



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Property	Maximum Permissible Value	Test
Water Absorption	2% by weight	I.S. - 2386 Part III
Aggregate Abrasion Value	30%	I.S. - 2386 Part IV
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 1	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 ₃)	0.5% by weight of aggregates dried at 105°C	I.S. - 2386 Part VII/ DIN 4226 Part 3 Clause 3.6.4

2.2.5. 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 ²	20	40	40	20	40	30	
Min. Cement content kg/m ³	280	450	450	350	450	375	
Sample rate m ³ /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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Concrete Grade	M 20	M 40	M 40	M 20	M40	M30
water/cement ratio						
Max. cement content kg/m ³	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
	Permitted	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-in-charge				
Air content	Zero	Zero	Zero	Zero	Zero	Zero
Air Temperature on Placement °C	Maximum	38	38	38	38	38
	Minimum	5	5	5	5	5
Density of Concrete kg/m ³	Minimum	2400	2400	2400	2400	2400
Fibres	Kg/m ³	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

- Water reducing admixtures, retarders, plasticizers all of approved make, will be permitted. Prior approval of Engineer-in-charge is required before use.
- Bi-polar Concrete Penetrating Corrosion inhibiting admixture shall be provided for all RCC works

2.2.6. Concrete Mix Properties

Property	Value
Total water-soluble sulphate content, expressed as SO ₃	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

2.2.7. Information to be submitted to the Engineer-in-charge

Certificates of Conformity
Personnel, Foreman, Mixer Operators, Vibrator Operators.
Approval of Cement Supply



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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

2.2.8. Personnel, Foremen, Mixer Operators, Vibrator Operators.

Personnel: A fully qualified and experienced concrete quality control Engineer-in-charge 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-in-charge, 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-in-charge.

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

2.3. Cement

Cement to be used for civil, marine and structural works shall be Ordinary Portland Cement of Grade 53 or Portland Slag Cement as per IS:455 with compressive strength not less than grade 53 Ordinary Portland Cement. Fly ash mixing with cement is NOT permitted.

2.3.1. 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-in-charge subject to re- design of concrete mix design.



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2.3.2. 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-in-charge.

The approval of the Engineer-in-charge to any type of cement shall not relieve the Contractor his responsibility and at any time the Engineer-in-charge 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-in-charge 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).

2.3.3. Manufacturer's Cement Test Certificates

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

2.3.4. Sampling and Testing of Cement

Notwithstanding the submission by the Contractor of the information detailed above, the Engineer-in-charge 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-in-charge. 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-in-charge shall take samples from different containers, and he will despatch them to a laboratory having NABL Accreditation, approved by him for testing.



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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-in-charge.

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.

2.3.5. 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-in-charge all work containing unapproved cement.

2.3.6. Delivery of Cement

The cement shall be delivered to the Site in such consignments to 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-in-charge. 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-in-charge to the method of delivery and shall provide all information required by the Engineer-in-charge concerning off-site storage and loading arrangements. He shall also provide reasonable facilities for the Engineer-in-charge to inspect these arrangements for approval and routine inspection purposes. The temperature of cement delivered in bulk shall not exceed 65°C.



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2.3.7. Storage of Cement

From the time that a consignment of cement is brought on the Site and tested and approved by the Engineer-in-charge 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-in-charge 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-in-charge, 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-in-charge show that the loss on ignition exceeds 4%. Cement shall be adequately protected at all times from rain and spray. Cement which has set or partially set shall not be used in the Works.



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Notwithstanding the above provision, any cement which the Engineer-in-charge 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.

2.3.8. 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.

2.4. Aggregates

2.4.1. 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".

2.4.2. Aggregates - Standard Specifications

Aggregates supplied to the Site shall generally be naturally occurring gravel and/or crushed rock for coarse aggregates and naturally occurring river sand/M-Sand/Crushed Sand for fine aggregates complying with the requirements of I.S. 383, IS 456 and other codal requirements. Lightweight aggregates shall not be used without the written approval of the Engineer-in-charge 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.

2.4.3. Sources of Aggregates

The Contractor shall supply the Engineer-in-charge 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-in-charge shall have the right to inspect all proposed quarries and other sources of aggregate.

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



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Engineer-in-charge.

The Engineer-in-charge 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-in-charge shall be immediately removed from the Site by the Contractor at his own cost.

2.4.4. 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-in-charge, 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

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



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2.4.6. Testing of Aggregates

Each Production Sample shall be tested in the following respect in an approved laboratory having NABL accreditation: -

- 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-in-charge. Stockpile samples shall be compared with production samples and if differences are observed the Engineer-in-charge will require appropriate tests to be carried out on the Stockpile samples.

The Engineer-in-charge 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)

2.4.7. 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-in-charge.

2.4.8. 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.

2.4.9. Staining

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

2.4.10. 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.

2.4.11. 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-charge, in accordance with relevant parts of I.S. 2386 except as specifically provided otherwise in the Specification.

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

2.4.12. 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.



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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.

2.4.13. 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-in-charge 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-in-charge 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 off 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 sun-shades), subject to the approval and/or discretion of the Engineer-in-charge. Spraying the aggregates with water will not be permitted.

2.4.14. 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).



2.5. Water for Concreting

2.5.1. 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 S04)	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.

2.5.2. Source of Water

As soon as possible after receipt of the order to commence the Works, the Contractor shall supply the Engineer-in-charge 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-in-charge's approval to use of a proposed source shall be obtained before water from that source is used for the Works.

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

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

2.5.3. Testing of Water



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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-in-charge may direct. The Contractor shall arrange for the despatch of samples of water to an approved testing laboratory having NABL accreditation and for the testing required.

2.6. Admixtures & Additives

2.6.1. 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-charge 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-charge. 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.. 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-in-charge, the admixture shall be tested at an approved laboratory at no extra cost.

The Engineer-in-charge 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 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-in-charge 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.



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2.6.2. 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.

2.6.3. 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-in-charge, 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-in-charge and the Contractor based on performance tests.

Any batch of concrete which has received an incorrect dose of an admixture, or which shall show deterioration after placing because 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 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-in-charge. 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.



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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-in-charge.

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

2.6.4. 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.

2.7. Mix Requirements

2.7.1. Concrete Grades

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

2.7.2. 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.

2.7.3. Prior Approval of Mix Proportions

Within 15 days after the commencement of the Contract, the Contractor shall produce in writing, for the Engineer-in-charge'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.

The Contractor must note that ample time should be allowed for testing and obtaining the approval of the Engineer-in-charge 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-in-charge to any mix, the Contractor shall not be relieved of any of his responsibility



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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-in-charge.

2.7.4. 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-in-charge. The Contractor shall afford facilities to the Engineer-in-charge to enable the Engineer-in-charge 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 condition, then it may be made in a laboratory but only with the express permission of the Engineer-in-charge 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 shall have a tolerance of + 15 mm or + 1/5 the required value, whichever is greater.

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.

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-in-charge, 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-in-charge, appropriate existing data as evidence of satisfactory recent



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previous performance for target mean strength with the proposed ingredients and 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 consider 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 not satisfied as above and required by the Engineer-in-charge, 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.

2.7.5. Compressive Strength Requirement for Trial Mixes

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

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

$$f_{ck} + (1.65 \times S)$$

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

S is standard deviation as per table 8 of IS 456 = 5 MPa.

For all cubes tested for strength, the density of the concrete represented by the cube shall first be determined before testing for strength and shall not be less than 2400 kg/m^3 .

2.7.6. 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 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-in-charge, be inferior to the standard specified.

To satisfy the Engineer-in-charge that the workability of the proposed mixes is adequate for the requirements of the Specification, the Contractor shall carry out a series of workability



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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-in-charge. 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-in-charge 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-in-charge, 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.

2.7.7. 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-charge 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-in-charge may withdraw approval for this mix and direct the Contractor to produce an alternative. In either case the Engineer-in-charge will require that additional trial mixes for the altered mixes be made and tested, all in accordance with the requirements of the preceding Clauses.

2.7.8. Minimising the Risk of Damaging Alkali-Silica Reaction

The Contractor shall submit to the Engineer-in-charge 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. Aggregates which are chemically reactive with alkalis of cement shall not be used.

2.7.9. 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



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exceed the limits given in concrete mix-schedule.

2.8. Batching

2.8.1. 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-in-charge before any work commences on site.

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

2.8.2. 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-in-charge to ensure maintaining it in accordance with the grading used in approved mix design.

2.8.3. 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-in-charge on request records of all check tests and adjustments made to the plant. The Engineer-in-charge 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.

2.8.4. 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-in-charge 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-in-charge to suit local weather conditions. In



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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.

2.8.5. 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.

2.8.6. Rejection of Batched Materials

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

2.9. Mixing

2.9.1. 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-in-charge.

Where small quantities of high-grade concrete are required, the Contractor shall, if the Engineer-in-charge 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-in-charge may direct and all the conditions covering the mixing of concrete for large scale concreting shall apply to any mix prepared in pan mixers.



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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.

2.9.2. 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-charge. In any event, concrete shall be mixed for at least 2 minutes or for the period and at the drum speed 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-in-charge, 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-in-charge 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.



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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.

2.9.3. 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-in-charge.

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 of water shall then be added through a hose 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.

2.10. Transportation, Placing and Compaction

2.10.1. 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-in-charge 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-in-charge, 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.



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2.10.2. 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-in-charge, 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.

2.10.3. 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 loose rust, scale and windblown salts and spray.

Placing of concrete shall not be commenced until the Engineer-in-charge 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. Also, bonding agent dosage as per the manufacturers specification shall be applied. This preparation shall be subject to inspection by the Engineer-in-charge.

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

2.10.4. 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



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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-in-charge 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-in-charge. Sequence of placing shall be such as to avoid disturbance of partially set concrete.

In cases where the approval of the Engineer-in-charge is obtained and where delays of more than one hour occur between successive concreting when, in the opinion of the Engineer-in-charge, 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-charge.

In the event of rainstorms 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



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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 rainstorms or other weather conditions, the Engineer-in-charge 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-in-charge 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.

2.10.5. 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 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. Restamping 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.



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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.

2.10.6. 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-in-charge.

2.10.7. 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-in-charge, this checklist shall be completed in advance of each pour, and submitted to the Engineer-in-charge 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-in-charge shall be permitted to inspect or request copies of these records at any time.



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2.10.8. 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-in-charge 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.

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

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

2.10.9. 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.

2.10.10. 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-in-charge all calculations, layout and detailed drawings necessary for construction in stages. All these calculations and drawings shall be approved by the Engineer-in-charge/ Employer before commencement of concreting work in stages.

2.11. Curing

2.11.1. 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-in-charge.



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Following the completion of the above period, a further period of controlled drying out will be required as directed by the Engineer-in-charge. 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-in-charge. The requirements of this Clause do not apply to concrete placed under water.

2.11.2. Curing Methods

All methods to be used for curing and protection of freshly placed concrete must receive the prior approval of the Engineer-in-charge. These methods shall include the use of curing membranes, continuous sprays of water or ponded water, or continuously saturated coverings of sacking, hessian, or other absorbent materials, shades and any other precautions that are required for the Contractor to ensure satisfactory curing of the concrete.

2.11.3. 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-in-charge 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.

2.11.4. 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-in-charge, also covered with plastic sheeting to reduce loss by evaporation. Water for curing shall comply with Clause 2.5.1. 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.



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2.11.5. 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.

2.11.6. 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 appearance before continuing with curing.

2.11.7. Curing of Concrete in Hot Weather

When the daytime ambient temperature is greater than 25°C or at such other times as the Engineer-in-charge 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



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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 2.11.6 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.

2.11.8. Thick Sections

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

2.11.9. 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.

2.11.10. Curing of Repairs

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

2.12. Reinforcement

2.12.1. Reinforcement Steel Specifications

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 (CR) Grade Fe500D / Fe550D may be used in accordance with provisions of IS: 1786. Steel shall be procured only from primary steel producers / reputed manufacturers using iron ore as the basic raw material and having in-house iron making facilities followed by production of liquid steel and crude steel with in-house rolling, adopting BF-BOF route or DRI-EAF technology as per Ministry of Steel



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guidelines. Approval shall be obtained from Engineer-in-charge incharge before procurement of steel reinforcement from manufacturers / suppliers.

2.12.2. Binding wire

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- 2006 "Specification for Mild Steel Wire".

2.12.3. Testing of Reinforcement Steel

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

2.12.4. Storage of Reinforcement Steel

Reinforcement shall be stored on racks clear of the ground/water and shall be protected to prevent accumulation of dust, wind-blown 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.

2.12.5. 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-charge in triplicate for approval, at least two weeks before bars are to be cut and bent. The Engineer-in-charge will check and return one copy with any corrections noted in red ink.

Notwithstanding any comments or approval of these schedules by the Engineer-in-charge, it is the sole responsibility of the Contractor to ensure their accuracy and compliance with good detailing practice and, where appropriate, the Engineer-in-charge's Drawings. The Contractor shall allow sufficient time and resources to ensure that any deficiencies in the reinforcement



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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-in-charge is obtained for hot bending. Any reinforcing bar that has already been bent shall not be rebent at the site of the original bend without the Engineer-in-charge's permission. High strength deformed steel bars shall not be re-bent or re-straightened without the Engineer-in-charge'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-in-charge 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-in-charge 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-in-charge only if the means used for straightening or re-bending have been approved by the Engineer-in-charge.

Storage of cut and bent reinforcement shall comply with Clause 2.12.3. If instructed by the Engineer-in-charge, the surface of the cut and bent reinforcement shall be treated with cement wash.

2.12.6. 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



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length. Crossing bars shall not be tack-welded for assembly of reinforcement without the Engineer-in-charge'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-in-charge's approval. Splices / laps in adjacent bars shall be staggered.

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

2.12.7. Spacers

Spacers shall be as small as practicable with sides not exceeding 50mm/75mm 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



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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-in-charge, 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.

2.12.8. Welding

Generally welding of reinforcement shall not be permitted. However, in specific cases, welding of reinforcement may be permitted provided the Engineer-in-charge'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-in-charge shall be taken in the welding of high strength deformed reinforcing bars. Prior to giving approval the Engineer-in-charge 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.

2.12.9. 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-in-charge 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-in-charge may direct that site tests be carried out on the use and strength of such joints.

2.12.10. Concrete Cover

The minimum concrete cover to reinforcement including stirrups and binders shall be in accordance with drawings.

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 (+) 10 mm, (-) 0 mm.



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2.12.11. 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 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-in-charge 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-charge 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.

2.12.12. Steel Fixer in Attendance

The tied in-place reinforcement shall be checked and approved by the Engineer-in-charge 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.

2.13. Formwork

2.13.1. 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.



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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, 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-in-charge. 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 formwork 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-in-charge, the drawings and calculations for the design of the formwork shall be submitted to the Engineer-in-charge 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-in-charge. 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



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separately elsewhere in this Specification.

2.13.2. Internal Ties

Wire ties shall not be allowed; instead bolts passing through plastic sleeves shall be used where permitted by the Engineer-in-charge. 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-in-charge.

2.13.3. Permanent Void Formers

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

2.13.4. 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.

2.13.5. 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 2.13.1 by approved means to the satisfaction of the Engineer-in-charge. 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-in-charge, 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-in-charge 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.

2.13.6. 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
Soffit formwork to slabs, (with props left under)	3 days
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
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-in-charge 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 25m³ shall be submitted to the Engineer-in-charge 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-in-charge.



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-in-charge 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-in-charge, the concrete contained has not attained sufficient strength.

2.13.7. Tolerances for Concrete Surfaces

Permissible tolerances for concrete surfaces are given in Table 1-1 If permissible tolerances are exceeded, the acceptance or otherwise of the concrete shall be decided by the Engineer-in-charge. 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 1-1 - 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	+5	+10
		-10	-10	-5	-10
	Variations in cross-sectional dimensions	+10	+10	NA	NA
		-5	-10		
Abrupt	0	5	5	5	
Deviations from template in long dimensions	+5	+10	+10	+10	
	-5	-10	-10	-10	
Exposed concrete where steelwork is to be fixed; also, tolerance for cast in steelwork	Departure from alignment and grade as shown on Drawings	+5	NA	+3	NA
		-5	NA	-3	
	Variations in cross-sectional dimensions	+5	NA	NA	NA
		-3			
Abrupt	3	NA	3	NA	
Deviation from template in long dimensions	+5	NA	+3	NA	
	-5		-3		

(Note: NA denotes not applicable)

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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).

2.14. Finishes

2.14.1. 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-in-charge 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 2.13.4. 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.

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



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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.

2.14.2. Remedial Treatment to Formed Surfaces

Any remedial treatment to formed surfaces shall be agreed with the Engineer-in-charge 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-in-charge 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-in-charge 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-in-charge 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-in-charge at no extra cost. The use of epoxy for bonding fresh concrete shall be carried out as directed by the Engineer-in-charge.

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-in-charge, 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.

2.14.3. 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.



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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-in-charge.

2.14.4. 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-charge. In the case of severe damage that may affect the serviceability of the concrete section involved or where unsatisfactory appearance of permanently exposed surfaces may result from repairs, the Engineer-in-charge may order the breaking out and reconstruction of any section.

2.15. Joints

2.15.1. Construction Joints

The position and form of construction joints, except where shown on the Drawings, shall be agreed with the Engineer-in-charge 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



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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-in-charge.

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-in-charge. 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 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-in-charge and the treatment of concrete surface at the stop-end shall be as for construction joints.

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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.

2.15.2. 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-in-charge.

2.15.3. 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.

2.15.4. 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 ± 1.5 mm, 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.

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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-in-charge.

2.15.5. 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-in-charge.

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

2.15.6. 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-in-charge. Joint sealants of expansion, movement or other joints, shall be applied to the dimensions indicated on the Drawings or as otherwise approved or directed by the Engineer-in-charge.

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-in-charge 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-in-charge the groove shall be primed with an



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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.

2.16. Testing and Control

2.16.1. Inspection and Tests

The Contractor shall ensure that the Engineer-in-charge 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.

2.16.2. 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-in-charge 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-in-charge, 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-in-charge may direct that checking of mix proportions used shall be made by analysis of hardened concrete in accordance with I.S. 1199.

2.16.3. 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 ³	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 ³ 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-in-charge

From each sample, taken as provided for above, Six 150 mm cubes shall be made for testing for strength.

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.

2.16.4. 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.



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2.16.5. 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-in-charge. 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-in-charge 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-in-charge) meet all the conditions given in the respective clause.

2.16.6. Records

Cube test results shall be submitted in duplicate to the Engineer-in-charge on standard certificate forms completed in ink and signed by both the laboratory manager and the Engineer-in-charge’s representative. They shall be presented to the Engineer-in-charge as soon as possible after the test results are known to the Contractor.

Works Cube Test Certificates, when presented to the Engineer-in-charge, 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.



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In addition to the above detailed records, the Contractor shall make such records, in a standard form to be agreed with the Engineer-in-charge, 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-in-charge 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-in-charge, and shall be submitted on a regular basis, all as directed by the Engineer-in-charge.

2.16.7. 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-in-charge 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-in-charge 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-in-charge.

2.16.8. Concrete Core Testing

As and where directed by the Engineer-in-charge, following the failure by Works test cubes to meet the strength requirements or at such other times when the Engineer-in-charge 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-in-charge for the purpose of examination and testing.

The cutting equipment and method shall be subject to the approval of the Engineer-in-charge and shall, unless otherwise directed or approved, produce specimens of diameter 150 mm and height 300 mm.

If required by the Engineer-in-charge 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-in-charge.

Cores from suspect areas shall be tested as required by the Engineer-in-charge, those tests will



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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-in-charge for each specimen and the Engineer-in-charge 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-in-charge'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 not accepted, the Engineer-in-charge may review and decide (i) whether remedial measures are feasible so as to render the work acceptable. The Engineer-in-charge 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-in-charge's directions. In case the Works are accepted in spite of deviation from the Specification, the Engineer-in-charge may make a reduction in rate of appropriate items with the consent of Employer.

2.17. Precast Concrete units

2.17.1. 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 Fe500D / Fe550D as per IS: 1786. Cover to the main reinforcement shall be 50 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



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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.

2.17.2. 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-in-charge'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-in-charge 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-in-charge 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.

2.17.3. 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-in-charge's intention and are to be submitted to the Engineer-in-charge for approval before production of units or moulds etc. begins. The Contractor shall also supply to the Engineer-in-charge, as soon as possible after the start of the Contract, a schedule of weights for each type of unit.

2.17.4. 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-in-charge for approval before any work is commenced on the manufacture.

2.17.5. 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.



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All such lifting and fastening devices shall be subject to the prior approval of the Engineer-in-charge and shall be shown on the Drawings prepared by the Contractor for the Engineer-in-charge'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-in-charge's approval.

2.17.6. Moulds

All moulds shall be of adequate strength and stiffness to carry without deformation the loads 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-in-charge 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-in-charge 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.

2.17.7. Manufacturing Tolerances

Unless otherwise detailed on the Drawings or directed by the Engineer-in-charge, manufacturing of precast units shall be strictly within the tolerances specified below: -

a)	Length Up to 3m 3 to 4.5m	±6mm ±9mm ±12mm
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	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 shall apply to the two major dimensions (i.e. side, length).	±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 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 accordingly.	3mm 5mm 6mm
d)	Straightness or Bow (deviation from Intended Line) Up to 3m 3 to 6m 6 to 12m Additional for every subsequent 6m	
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 Over 600mm wide and for any length	6mm 12mm
f)	Flatness The maximum deviation from a 1.5m straight edge placed in any position on a nominally plane surface should not exceed 5mm.	
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 possible.	
h)	Reinforcement Reinforcement shall be fixed in accordance with Clauses mentioned	

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	<p>_ in this Specification</p>	
<p>i)</p>	<p>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.</p>	

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.

2.17.8. 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.

2.17.9. 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.

2.17.10. 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-in-charge's satisfaction.

Reasons for rejection of units shall include the following: -

- a. No cracked, damaged or repaired units will be acceptable
- b. No units shall have broken edges whether reinforcement is exposed or not.
- c. No units shall have any reinforcement with concrete cover not complying with this Specification.
- d. No elements shall have a surface finish inferior to that indicated on the



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Drawings and defined in this Specification.

- e. No units outside the dimensional tolerances shall be acceptable.

2.17.11. 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. h. Location in the Works.

These records shall be in a format agreed by the Engineer-in-charge and shall be available for his inspection at all times. Copies of these records shall be supplied to the Engineer-in-charge on completion.

2.17.12. 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.

2.17.13. Erection Programme

Prior to erection of precast concrete units, the Contractor shall submit to the Engineer-in-charge 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-in-charge has approved the methods to be used.

2.17.14. Handling and Erection - General



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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.

2.17.15. 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-in-charge. 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-in-charge.

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 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.

2.17.16. 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-in-charge 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.

2.17.17. 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-in-charge and when so directed the Contractor



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shall dismantle the work and re-erect and make good to the satisfaction of the Engineer-in-charge. 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-in-charge.

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-in-charge.

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-charge in each and every case.

2.17.18. 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 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).

2.17.19. Bearings

Bearings for all units shall be as shown on the Drawings and as required by the calculations.

2.18. Screed Concrete

Weathering course (screed) shall be applied over the entire deck slab using cement concrete M40 grade using graded course and fine aggregates for an average thickness of 75mm and slope and construction joint with filler as shown in the drawings and the screed concrete shall be mixed with secondary reinforcement of 'polyester triangular fibre' of approved quality at 0.975 kg/m³ and finishing the surface with floor hardener of approved quality monolithically to the base of concrete.

The surface shall be scrubbed with wire brush and all loose particles, foreign matters etc. shall be removed and the surface shall be made clean. Any undulations in the concrete shall be chipped off or made good with additional concrete of the same grade used for the under layer. The surface thus prepared shall be wetted and smeared with a coat of cement slurry using cement at the rate of 2kg /m² of area just before the application of the mortar, so as to get good bond between base course concrete and plastering.



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For ensuring even thickness and true surface, gauges of M40 concrete mix of 15cm x 15cm shall be laid at intervals not more than 1.5 m in both directions to serve as guide area for floor weathering concrete. Surface of this guide area shall be truly in plane of the base surface. The concrete mix shall then be spread uniformly to a thickness slightly more than the specified thickness and shall then be brought to true and even surface by working a wooden straight edge reaching across the gauges. Finally, the surface shall be finished spreading with floor hardener of approved quality @ 5kg/m² by working a trowel or a wooden float directed by the Engineer-in-charge-in-Charge. Excessive trowelling shall be avoided. Sprinkling of dry cement or sand mixture on the surface to stiffen the mortar or to absorb excessive moisture shall not be permitted.

Final finishing shall follow immediately after trowelling. For this a thick cement slurry using cement at the rate of 2 kg /m² of area shall be spread over the flooring while the surface is still wet. The cement slurry shall then be properly pressed with a trowel and finished smooth.

The junctions of floor with walls shall be rounded off as per directions of the Engineer-in-charge-in-Charge. While plastering the flooring, care shall be taken to see that the edge of the previously laid panels is not damaged, and fresh mortar is not splashed over them. The joints between panels shall be truly finished. The finished plastered surface shall be thread lined to the pattern, if so, directed by the Engineer-in-charge-in-Charge.

Curing shall be done for a minimum of 7 days after the floor surface is hardened. Covering with gunny bags shall be avoided as the colour is likely to be bleached with the remnants of the cement matter from the bags.

Measurement of the work under this head shall be made on the basis of the area of work done and rate quoted shall include the cost of labour, materials, scaffolding etc required for completion of work.

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APPENDIX A – CEMENT RECORDS

CEMENT QUESTIONNAIRE (See Section 2.3)		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 2.3)			
Period covered: From.....20__ To.....20__			
a) Composition	Avg. Value	Max. Value	Min. Value
Silica (SiO ₂) Alumina (Al ₂ O ₃) Total Iron (Fe ₂ O ₃) Calcium (CaO) Tricalcium aluminate (C ₃ A) (C ₄ AF + 2C ₃ A) Magnesium (MgO) Potassium (K ₂ O) Sodium (Na ₂ O) Sulphur trioxide (SO ₃) Sulphide sulphur (S) Chloride (Cl-) Certified Average Alkali Content (Na ₂ O) Guaranteed Alkali Limit (Na ₂ 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 2.3)			
Period covered: From.....20__ To.....20__			
a) Composition	Avg. Value	Max. Value	Min. Value
b) Properties			
Heat of Hydration @ 7 days @ 28 days Fineness (m ² /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

EXAMPLE CONCRETE POUR CARD	
Client: Mumbai Port Authority	
Project: Construction of Marina in Mumbai Harbour	
Contractor:	
Date:	Time:
Structure:	Pour no.:
Dwg. 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:	

EXAMPLE CONCRETE POUR CHECKLIST							
Sl. No.	Item	Contractor's Representative Signature	Engineer-in-charge's Signature	Remarks			
1.	Centrelines 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.	Embedded Parts Checked (Location & Plumb) <table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td>Civil Items</td> </tr> <tr> <td>Mechanical Items</td> </tr> <tr> <td>Electrical Items</td> </tr> </table>	Civil Items	Mechanical Items	Electrical Items			
		Civil Items					
		Mechanical Items					
Electrical Items							
Pour Authorised: Yes / No Site Engineer-in-charge's Signature: Engineer-in-charge'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					
	Site Engineer-in-charge's Name	Site Engineer-in-charge's Signature:					



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Notes:

- Items 1 to 7 (both inclusive) to be checked & signed by the Engineer-in-charge & Contractor's representative.
- Items 8 to 13 (both inclusive) to be filled only by Engineer-in-charge.
- Each pour to have separate cards, in triplicate one each for Employer, Engineer-in-charge & site office.
- Under remarks, indicate deviations from drawings & 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.

3. STEEL FABRICATION AND ERECTION

3.1. 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 project. General requirements and procedures for the Contractor's supply and control of materials are covered in this specification.

3.2. 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.

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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.
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-in-charge's Representative, whose decision shall prevail. In principle the requirements of the most stringent document shall apply.

3.3. 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-in-charge's Representative or its representative does not relieve the Contractor of his responsibility to complete the work in accordance with the contract and specifications.



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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-in-charge'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-in-charge's Representative.

Substitution and modifications shall not be allowed without prior approval by the Engineer-in-charge's Representative. The Contractor shall detail the extent of substitutions and 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 Engineer-in-charge drawings is to be carried out by the Contractor under his Scope of Work.

Contractor shall notify the Engineer-in-charge's Representative in writing, at time of submission, the deviations from requirements of Contract Documents stating the reason for these deviations.

3.4. Submittals

Submit mill certificates, weld procedures, fabrication procedures and Inspection and Test Plans to the Engineer-in-charge'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-in-charge's Representative before the drawings are submitted to the Engineer-in-charge's Representative for his review.

Submit, in accordance with the Contract Schedule and in accordance with the Contract requirements, shop drawings to the Engineer-in-charge's Representative for their review. One print shall be returned by the Engineer-in-charge'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-in-charge's Representative marked "not reviewed", and such shop drawings are to be properly redrawn and resubmitted.



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The Contractor shall make changes in shop drawings, which the Engineer-in-charge's Representative may require consistent with the Contract Documents and resubmit. When the Engineer-in-charge'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-in-charge's Representative. Ensure work and units supplied conform to the final shop drawings.

The Engineer-in-charge'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-in-charge's Representative's review. Any work that proceeds before the shop drawings have been accepted for fabrication by the Engineer-in-charge's Representative is at the risk of the Contractor.

The Contractor shall submit to the Engineer-in-charge's Representative as-built documents in the quantity and format as required by the Contract. As-built documents shall be submitted to the Engineer-in-charge'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.

3.5. *Materials*

3.5.1. 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-in-charge.

No	Application	Specification	Minimum Yield Strength (MPa)
1	Plates and Shapes for pipe rack structures, structures, handrails support, coming, pile liners and miscellaneous applications.	IS 2062 E250 Quality A	250

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No	Application	Specification	Minimum Yield Strength (MPa)
2	Plates and Shapes for steel sheet piles	Indian Grade Steel IS 2062 E350 Quality B	350
3	Anchors bolts for all base plates.	IS5624 & IS 1367 Part 3 – Class 8.8	640
4	Structural bolts for steel connections.	IS3757 & IS 1367 Part 3 – Class 8.8	640
5	Steel Grating	ASTM A36	250
6	Handrail pipes	IS 1161 Yst 250	250
7	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 pipe 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 original or certified copy of 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-in-charge/Engineer-in-charge'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 centres and cross bars at 50mm on centre except as modified on Fabrication Drawings. All gratings shall be serrated and galvanized.

3.5.2. Special Requirements

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.

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. Contractor shall also specify material certification level and inspection requirements to the steel supplier. 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.

3.5.3. 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.

3.5.4. 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.

3.5.5. Plant Inspection



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The Contractor shall provide the Engineer-in-charge's Representative with full access to inspect materials and fabrication. The Engineer-in-charge's Representative may undertake the inspection of materials at the source. Manufacturing plants may be inspected periodically, if so desired by the Engineer-in-Charge 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-in-charge's Representative shall have the cooperation and assistance of the Contractor and the producer with whom he has contracted for materials.
- The Engineer-in-charge'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-in-charge's Representative has requested plant inspection and which are fabricated without such inspection shall be considered unacceptable. Any testing required proving 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-in-charge's Representative's representatives: every item, procedure and connection associated with the work shall be subject to non-destructive inspection by the Engineer-in-charge'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-in-charge's Representative may call for a coupon to be cut out for destructive testing.
- During the progress of the work, the Engineer-in-charge'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-in-charge's Representative.
- The Engineer-in-charge's Representative shall be the sole judges for the acceptability and their decisions shall be final.



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The Engineer-in-charge'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.

3.5.6. Manufacturer's Certification

The Engineer-in-charge's Representative may permit the use, prior to sampling and testing, of certain materials or assemblies when accompanied by manufacturer's certificates of compliance stating that such materials or assemblies fully comply with the requirements of the contract. The certificate shall be signed by the manufacturer. Each lot of such materials or assemblies delivered to the Work shall be accompanied by a certificate of compliance in which the lot is clearly identified.

Materials or assemblies used on the basis of certificates of compliance shall be sampled and tested at any time and if found not to be in conformity with contract requirements shall be subject to rejection whether in place or not.

All steel for the steel work and fasteners shall be supplied with test certificates. The contractor shall submit these certificates to the Engineer-in-charge's Representative prior to the supply of the materials. Materials obtained from stocks may be checked by the Engineer-in-charge's Representative for exterior defects either in the workshop or at the site.

Test requirements for the materials to be ordered are specified in IS 2062 and shall include V notch impact tests at 0° C from each quantity of 20 tonnes or part thereof. The results of these tests shall be included in the test certificates.

3.5.7. 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-in-charge's Representative.

Private property shall not be used for storage purposes without written permission of the owner or lessee. Evidence of permission shall be furnished to the Engineer-in-charge'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.



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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.

3.5.8. 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 stresses.

3.5.9. 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-in-charge's Representative. No rejected material, with defects corrected, shall be used until approval has been given by the Engineer-in-charge's Representative.

3.5.10. 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 procedure to the Engineer-in-charge's Representative for approval.

3.5.11. 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 procedure to the Engineer-in-charge'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-in-charge'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-in-charge's Representative at no extra cost to the Engineer-in-charge's Representative.



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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-in-charge'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.

3.5.12. 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. Identification system shall be furnished to the Engineer-in-charge's Representative and the Inspector before the start of the job. This numbering shall be used on all shop drawings.

3.5.13. Marking

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-in-charge's Representative stamp, if inspected by the Engineer-in-Charge for all primary and special categories steel.

Paint marking shall be as follows:

- A 300mm-by-300mm rectangle with the following data stencilled in 50mm high white letters shall be printed on each item of the material:
 - Project Reference



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- 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)

3.5.14. Inspection by the Engineer-in-charge's Representative

The Engineer-in-charge's Representative shall inspect the material, fabrication, assembly, coating, loading and transport of all items, if desired by Engineer-in-Charge 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-in-charge'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.

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-in-charge's Representative's representative.

The Contractor shall assist the Engineer-in-charge's Representative in the execution of inspections and tests by providing personnel, inspection and test equipment as required.

3.5.15. 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-in-charge's Representative.

3.6. Execution



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This section defines the Engineer-in-charge'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-in-charge'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-in-charge'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.

3.7. Fabrication and Erection

3.7.1. 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-in-charge 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-in-charge 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-in-charge 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-in-charge. Similar approval must be obtained prior to the enlargement of any hole.



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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.

3.7.2. Shop Drawings

The GFC drawings provided to contractor by employer is 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. Engineer-in-charge 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 Engineer-in-charge shall not relieve 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 weld 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.

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.

3.7.3. Welded Connections

All structural welding and welding procedures shall be in accordance with approved drawings and this specification. 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 but 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.



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- 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.

3.7.4. 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-in-charge.
- 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-in-charge. 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.



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- 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.

3.7.5. Structural Pipe Splices

3.7.5.1. General

- a) Segments of pipe of the same diameter may be spliced. 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.

3.7.5.2. Welds

- a) Splices in 762 mm diameter and larger pipe members shall be full penetration double-V-groove butt joints. Ends of members shall be bevelled 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. Ends of member shall be bevelled 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.

3.7.5.3. Location of Splice or Weld Seam

- a) Longitudinal weld seams of adjoining sections shall be staggered a minimum of ninety (90) degrees apart.



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- 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 weld seams on jacket leg or skirt pile sleeve node cans shall be approved by Engineer-in-charge. 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. Where this requirement cannot be met, the circumferential seam shall be within a zone as agreed upon by Engineer-in-charge.
- 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-in-charge.
- 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 centre line of either of the incoming braces.

3.7.6. 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.

3.8. *Welding*

3.8.1. 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-in-charge or his appointed representative. Any work not to the satisfaction of the



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Engineer-in-charge 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.

3.8.2. 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-in-charge for review and approval. All welds shall be sized to develop the full strength of the smaller of the two (2) members being joined.

3.8.3. Welding Equipment

All welding equipment shall be in good condition and subject to inspection by Engineer-in-charge. 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 Engineer-in-charge.

3.8.4. Electrodes

Electrodes for SAW shall conform to IS 816 and subjected to following conditions.

- All electrodes shall be subject to inspection by Engineer-in-charge and electrodes which show signs of deterioration or damage shall be rejected.
- The maximum size of electrodes shall be 4mm for stringer or starting beads and 5mm for passes following starting beads in multi-pass welds.
- Jet rods shall not be used for any field welding and shall only be permitted in yard welding upon prior approval by Engineer-in-charge.
- 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-in-charge. Fabrication Contractor's electrode handling procedure must be submitted to Engineer-in-charge for approval.

3.8.5. 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



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qualified and tested operators.

All welds shall be designed to seal the joints between sections completely unless specified otherwise by the Engineer-in-charge. Welding operations shall be completed before any final machining or other fitting work is 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-in-charge but all spatters shall be cleaned off and all slag removed on completion of the weld and before examination by the Engineer-in-charge.

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.

3.8.6. 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.



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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 the flux covering broken away or damaged shall be discarded.

3.8.7. Welder and Welding Operator Qualification

Initial Qualification

It is the intent that only qualified welders and welding operators shall be used in the fabrication of structural steel work. Engineer-in-charge 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 by Engineer-in-charge within the past one (1) year.

Contractor shall bear all expense of each initial qualification.

Requalification

Welders and welding operators are subject to requalification during fabrication at the discretion of Engineer-in-charge 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-in-charge 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-in-charge 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-in-charge. 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. Contractor 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 Engineer-in-charge. Records shall be kept by 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 Engineer-in-charge before start of fabrication.



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The records shall be maintained and updated by Contractor as required and furnished to Engineer-in-charge throughout the term of the Contract.

- a) All qualification tests shall be in accordance with the IS 816 / AWS D1.1. Welding operators shall be qualified in the appropriate position for the work to be performed.
- b) Engineer-in-charge shall specify the material to be used for qualification tests. The tests shall be witnessed and approved by Engineer-in-charge / Welding Inspector before the welder or welding operator is permitted to work on the structure. The decision of Engineer-in-charge / 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 not passing the tests are disqualified from working on the job.

3.8.8. 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-in-charge for preliminary approval prior to carrying out the qualification tests. No qualification test shall be carried out until approval from Engineer-in-charge 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 Contractor.
- c) Procedures shall be tested and certified by an approved testing laboratory, agency, or equivalent. Engineer-in-charge 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.



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- 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-in-charge 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,
 - 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-in-charge.

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 weld details from the actual construction which shall be welded in a manner simulating the most unfavourable 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,



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- 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.
- c) Charpy V-notch Tests shall be performed in accordance with ASTM A370 and ASTM E23.
- d) Radiographic or Ultrasonic Inspection (chosen by Engineer-in-charge when required) - as per IS 816, IS 822 / AWS D1.1.

3.8.9. 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 bevelling machine.
- Any bevelled edge that has been damaged shall be restored to minimum tolerances.
- 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-in-charge. Approval may be obtained by Contractor by submitting to Engineer-in-charge, 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-in-charge's use.



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d) Joint Alignment and Gaps

- 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. 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-charge 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-in-charge 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 full penetration butt welded to the tubular and the webs shall be fillet welded to the tubular member.

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Tubular Joints

- a) All tubular joints shall be prepared for full penetration welds.
- 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-in-charge Representative has had the opportunity to inspect the fit up of the joint. The Contractor shall be responsible for informing Engineer-in-charge forty-eight (48) hours in advance of the fit up in order to schedule an inspection of these joints.
- b) Engineer-in-charge'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-in-charge 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 Engineer-in-charge. 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 weld. 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 Engineer-in-charge. A third repair of the same area will not be allowed. Should the second repair attempt fail to remove the indicated defect, then



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the entire weldment will be removed from the structure and the joint shall be prefabricated in accordance with the Contract Specifications.

- c) Details of the weld repair procedure, e. g. preheat, post heat, type of electrode, etc. must be documented for Engineer-in-charge's future reference.
- d) All repaired welds shall be inspected as per original Inspection and Acceptance criteria.

3.8.10. Weld Inspection and Testing

General

No defects in welds or fabrication, including fit up shall be permitted which, in the opinion of Engineer-in-charge's Representative, is detrimental to the strength of the weld. If for any reason Engineer-in-charge believes that a defect exists in any weld, the Contractor, at the direction of Engineer-in-charge's Representative, shall cut and test each weld. If the weld proves defective, it shall be repaired and retested to the satisfaction of Engineer-in-charge at the Contractor's expense. If the weld tests are satisfactory, Engineer-in-charge 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 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:

- II. All welds to be visually inspected.
- III. 50% of all fillet welds to be tested using dye penetrant or magnetic particle testing.
- IV. 20% of all butt welds to be tested using Radiographic or Ultra-Sonic methods.

Welding shall be carried out only on dry surfaces, according 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:



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- a) Any crack, incomplete fusion, or incomplete penetration.
- b) Any individual elongated inclusion having a length greater than two thirds of the 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-in-charge. 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-in-charge. The Engineer-in-charge 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-in-charge'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-in-charge. Acceptance criteria shall be in accordance with IS 4260 or another approved standard. 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.



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3.9. *Painting*

3.9.1. Painting Generally

All preparation, priming and painting, in colours selected by the Engineer-in-charge, 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 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-in-charge. 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 works shall not be over coated 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 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-in-charge 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-in-charge 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.

3.9.2. 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-in-charge for his prior approval. The painting / coating system proposed for all steel surfaces shall be as follows:

System parameters	System 1	System 2
Environmental class	C5M as per ISO 12944	Im2 as per ISO 12944
Surface preparation	SA 2.5	SA 2.5
Design life	10 years	10 years
Primer	1 coat of Zinc Rich Primer, 75 microns	2 coats of Epoxy primer, 75 microns each
Coating	3 coats of High Build Epoxy 150 microns each	4 coats of Ultra High Build Glass Flake Epoxy 150 microns each
Total thickness	525 microns	750 microns
Finishing colour	Orange	Black
Application	Pipe rack structures	Sheet piles

3.9.3. Application of Painting

Steelwork will be primed and painted under shop conditions before delivery to site unless the Engineer-in-charge 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 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 minimise 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-in-charge 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-in-charge 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-in-charge for approval.

3.9.4. 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.

3.9.5. 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 machine, scalers, etc. No painting shall commence until the prepared surface has been approved by the Engineer-in-charge.

3.9.6. 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-in-charge. All priming and finishing paints shall, preferably, be obtained from the same manufacturer. The contractor shall guarantee that the paints for priming



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and finishing coats are compatible with each other, in addition to their satisfying the specified requirements. The first and second coats of finishing paint shall have different tints to distinguish one from the other.

3.9.7. 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-in-charge. 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-in-charge, finishing painting shall not commence before 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.

3.9.8. 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 good has been approved by the Engineer-in-charge, 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 manufacturer by Berger Paints or approved equivalent.

3.10. Galvanization of Steel

All steel work on jetty head and as mentioned in the tender drawings should be galvanised. All hot dip galvanising shall be in accordance with I.S. 2629 / ASTM A153.

Before galvanising, 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 galvanised steelwork shall be tested at the galvaniser's works prior to despatch to



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ensure compliance with the coating requirements.

3.11. *Quality Control*

The Contractor shall be responsible for Quality Control (QC) inspection and testing services carried out by CSA or applicable certified testing agencies. Engineer-in-charge's Representative shall carry out Quality Assurance (QA) reviews and testing where necessary.

The Engineer-in-charge's Representative reserves the right to audit and verify the Contractor's QC procedures and services.

Procurement documents shall ensure the Engineer-in-charge's Representative's right of access. Contractor's documents, instructions, procedures, drawings, specifications, ITP's and test records shall be made available to Engineer-in-charge's Representative for review.

The Contractor shall establish and provide the Engineer-in-charge's Representative with schedules for inspections, surveillance, witness points, hold points, tests and final inspections for 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 Engineer-in-charge'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-in-charge'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-in-charge'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-in-charge'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 required quantity to 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-in-charge's Representative.

Copies of all test results with both electronic and paper submissions shall be issued to the Engineer-in-charge's Representative to witness sampling and testing and additional Q/A testing if required.

The Engineer-in-charge'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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4. STEEL SHEET PILES

4.1. Scope

The scope includes procurement of material, fabrication and assemble installation and connecting all accessories for successful installation of steel sheet pile retaining wall system. The scope shall include,

- Procurement of steel sheet piles as per specifications, transporting, aligning and erecting the sheet piles in alignment and driving to the required depth by adding sections as and when required.
- Welding as per the design requirements specified in the construction drawings.
- All welding shall be continuous and full penetration welds unless specified otherwise and spot welds and discontinuous welds are not permitted,
- All joints shall be fabricated in accordance with construction drawings using full penetration butt welds and tested using NDT such as Ultrasonic test and other tests specified in the specification elsewhere in this document and drawings.
- Hammering and installation of steel sheet piles till the termination depth.

4.2. Material

The structural steel material for the Steel Sheet Piles shall confirm to clause 3.5. The steel shall have the minimum percent copper to provide corrosion resistance against seawater, as specified in IS 9527.

4.3. Codes and Standards

Any information not contained in these specifications shall be in accordance with the codes specified herein or as per the direction of Engineer-in-charge incharge.

- (a) IS 2062: Hot rolled medium and high tensile structural steel — specification
- (b) IS 9527 (Part 3): Code of practice for design and construction of port and harbour structures: Part 3 Sheet pile walls
- (c) IS 2314: Specification for steel sheet piling sections

4.4. 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 Engineer-in-charges' representative. All the inspection records shall be subjected to third party approval.



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The fabricated sheet pile shall be blast cleaned and painted before transporting to the site. The coating system shall be in accordance with clause 3.9. Any damaged part of the coating during transportation to site shall be repaired before lowering the guide pin pile into the drilled hole.

4.5. 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-in-charge's Representative.

4.6. Lifting, handling, erecting and driving

The sheet piles shall be of one single length as far as possible, as rolled in the mill, without any joint in between. It should be straight with tolerance limit as permitted by code and shall not have any defect. It shall be procured from reputed manufacturer whose name, address, name of the project where it has been used, manufacturer's catalogue on various sections available and recommended procedure shall be enclosed with bid document.

The sheet piles are to be driven as per norms and according to standard practice. In general sheet piles are to be driven in stages starting from one end using 2 levels of guide wailings to maintain vertically. The bidder shall enclose a write up with his bid document, giving details on how he is going to install the sheet piles.

Hammers shall be impact / vibratory type as per manufacturer's specifications. Pile driving hammers shall be correctly positioned on the pile so that the hammer is aligned as near to the axis of the pile as is practically possible. Freely suspended piling hammers shall be equipped with correctly adjusted leg guides and inserts. Where a hammer is mounted on a rigid leader, the leader shall be stable. The anvil block or driving plate shall be of sufficient size to cover as much as possible of the cross-section of the pile.

Pilings shall be carefully located as directed. Pilings shall be placed plumb with out of plumbness as per tolerance limit specified to manufacturer EN / ASTM specifications. Temporary Wales, templates, guide structures shall be provided to ensure that the pilings are placed and driven to the correct alignment. At least two templates shall be used in placing each piling and the maximum spacing of templates shall not exceed 6m. Pilings properly placed and driven shall be interlocked throughout their length with adjacent pilings to form a continuous wall throughout the length or run of piling wall.



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Adequate precautions shall be taken to ensure that pilings are driven plumb. If the forward or leading edge of the piling wall is found to be out-of-plumb, the piling being driven shall be driven to the required depth and tapered pilings shall be driven to interlock with the out of plumb leading edge. If approved, other corrective measures may be taken to insure the plumbness of succeeding pilings.

Pilings in each run or continuous length of piling wall shall be driven alternately, in increments of depth, to the required elevation. No piling shall be driven to a lower elevation than those behind it in the same run, except when the pilings behind it cannot be driven deeper. If the piling next to the one being driven tends to follow below final elevation, it may be pinned to the next adjacent piling. If obstructions restrict driving, a piling to the specified penetration the obstructions shall be removed or penetrated with a chisel beam. If the Contractor demonstrates that removal or penetration is impractical, the Contractor shall make changes in the design alignment of the piling structure as directed to ensure the adequacy and stability of the structure. Pilings shall be driven to depths shown and shall extend up to the elevation indicated for the top of pilings.

4.7. Corrections

Pilings driven to refusal or to the point where additional penetration cannot be attained and are extending above the required top elevation more than the specified tolerance shall be cut off to the required elevation. Pilings driven below the required top elevation and pilings damaged by driving and cut off to permit further driving shall be extended as required to reach the top elevation by splicing when directed at no additional cost to the Owner

The contractor shall inspect the interlocked joints of driven sheet piles extending above ground. If contractor find out that the sheet piles are out of interlock, then the sheet piles have to be removed.

The pulling and re-driving of piles, the Contractor shall pull selected pilings to determine the condition of the underground portions of pilings. Any piling pulled and found to be damaged to the extent that its usefulness in the structure is impaired shall be removed and replaced at the Contractor's expense. Pilings pulled and found to be in satisfactory condition shall be re-driven when directed.

4.8. Fitting of Anodes

The stiffeners and base plates for the anode attachments on the sheet piles shall be welded and coated prior to the driving of sheet piles into the ground. The location of these attachments and anodes shall be in accordance with the construction drawings. However, the anodes shall be



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fitted to the location using under water positioning on to pre-welded base plate using bolts and nuts and electrically connected using lead wite welded to both anode and the sheet pile.

4.9. Tolerances

The tolerance for sheet pile shall be as per the following.

- No deviation is permitted along the length of the retaining wall. Transverse direction the maximum permitted deviation in transverse direction shall be less than 50mm. However, all sheet piles shall be properly connected.
- The deviation from the true vertical axis shall not be more than 1.5% of total length of sheet pile from cut-off elevation to the toe level of sheet piles.
- Cut-off levels of sheet piles shall be within ± 25 mm of the required top level.

If forcible corrections are made to steel sheet piles the Contractor shall demonstrate to the satisfaction of the Employer that the integrity, durability and performance of the piles have not been adversely affected.

4.10. Connection to the capping beam

The sheet pile shall be embedded into the capping beam concrete with adequate lapping of reinforcement as shown in construction drawings. The reinforcement shall be welded to the sheet pile as per the welding procedure specified in the specification under fabrication of structural steel work in this contract.

4.11. Inspection

All full penetration welds major brace/chord interface shall be inspected 100% visual and 100% NDT using ultrasonic testing (UT) methods. All other minor welds shall be inspected 100% visually and 50% using UT methods.

4.12. Installation Records

The data to be corded shall include:

- The identification of the piles & its dimensions
- The disposition of approved piling
- Driving equipment performance data
- Piling penetration rate date
- Top and bottom elevations of installed piling

The format of driving records shall be as directed by Employer's representative.



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Any deviation from the designed location, alignment of any pile shall be noted and properly reported to the Employer's representative.

5. CATHODIC PROTECTION

5.1. Scope

This specification describes the minimum requirements for an aluminium alloy sacrificial Anodes for cathodic protection system to be installed on the sheet pile. The detailed scope of 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 Aluminium-Indium-Zinc Alloy Sacrificial Anodes with 100mm wide and 25mm thickness plate.
- Zinc Reference Electrodes.
- Identical Monitored Anodes.
- Monitoring Panel including 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.

5.2. 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 6.1 Codes and Standards

DNVGL-RP -B401	Recommended Practice for Cathodic Protection Design.
API RP-2A WSD	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms (21 st 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.
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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”. This standard and other project specifications referenced herein shall be considered complementary to this specification and similarly binding on the Contractor/Vendor/Manufacturer.

5.3. System design

A cathodic protection system, utilizing sacrificial aluminium alloy anodes suitable for protection of steel in a submerged marine environment.

5.3.1. Environmental Conditions

Following environmental conditions are used for the design of cathodic protection design of the sheet pile.

Location	:	Cochin, Kerala
Seawater Depth	:	13.5 m
Maximum Tide	:	1.00 m
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

5.3.2. Design Parameters

The design parameters used for the anodes is summarised in table below.

Design Life	:	10 years
Current Densities Initial	:	150 mA/m ² (seawater) 20 mA/m ² (below mudline)
Maintenance (Mean)	:	75 mA/m ² (seawater) 20 mA/m ² (below mudline)
Final	:	100 mA/m ²

5.3.3. Design Protective Potential



The cathodic protection system when complete shall have a polarisation potential of 0.80 volts, negative as referred to a standard silver/silver chloride (Ag/AgCl) reference cell.

5.3.4. Number of Anodes Required

The system shall consist of Aluminium 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.

5.3.5. 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.

5.4. Anodes

5.4.1. Anode Composition

Anode shall be Indium Activated Aluminium Alloy and shall conform to following compositional requirement.

Zn	In	Fe	Cu	Si	Al	Hg
2.5 – 6.75%	0.015 - 0.04%	0.9% max.	0.003% max.	0.12% max.	Remainder	Nil

Certain additional alloying elements (proprietary additives) such as Ti or Ga are permissible but shall be documented in the elemental analysis.

5.4.2. Electro-Chemical Value

The protective quality of the anode material shall be 2500 ampere-hours per kg.

5.4.3. 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.

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5.4.4. Construction

Anode shall be the standard offshore stand-off type.

- a) 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.
- b) Core - The core shall consist of 100mm wide and 25mm thickness plate with the grade of ASTM A106 GR B. Anode material shall completely surround the core.
- c) 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 "near-white" finish in accordance with SSPC-SP-10 within 24 hours of casting or before rust blooming appears.
- d) 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.
- e) 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.
- f) Steel core bar type anodes shall have sufficient exposed steel to allow for easy installation by means of welding.
- g) 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.
- h) Stand-off - Legs shall be offset per manufacturer requirements from the core centreline. 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 sides of the sheet pile otherwise shown on the Drawings.

5.5. 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.

5.6. Material information



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VENDOR shall furnish the following information relative to the anodes:

5.6.1. 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 ± 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.

5.6.2. Electro-Chemical Value

VENDOR shall supply guaranteed minimum Electro-chemical values in ampere-hour per kg for the anodes.

5.6.3. 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.

5.6.4. Electric Potential

VENDOR shall supply minimum, maximum, and average closed-circuit potential in volts for each pair.

5.6.5. Anode Composition

CONTRACTOR shall supply chemical components and percent by weight.

5.6.6. Handling

Proper anode storage, handling and transportation procedures shall be followed to prevent physical damages to the anodes or corrosion to the anode core steel legs.

5.6.7. Certificates



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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.

5.7. 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.

5.8. Monitoring system

Monitoring system shall be provided for the 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.

System shall include 4 Nos. monitored anodes and 12 Nos. reference electrodes, electrically connected to a monitoring panel located on the control room.

Monitoring system shall meet the following requirements as applicable.

5.8.1. 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.

5.8.2. 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 electrodes 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.

5.8.3. Monitoring panel

The monitoring panel shall be located in the control room or other suitable location in 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 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



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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`.

5.8.4. Cabling

All cabling from each reference electrodes and monitored anode shall be brought to a metallic waterproof junction box, mastik 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 mm² tinned copper conductor and shall be armoured. All cable connections shall be watertight. Each junction box shall be suitable for termination of all cables from reference electrodes and monitored anodes and one no. 19 X 2.5mm² tinned copper conductor armoured cable from junction box to monitoring panel. Cables from junction box to monitoring panel shall be FRLS type.

5.9. 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.

5.10. 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



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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 independent accredited laboratory.

After casting, the inspection of the anodes shall be done 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 Ckt. 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 are 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.
 - The above-mentioned cracks if penetrating more than three fourth 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.

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- 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 shall 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 subjected to inspection by company at all reasonable times. Inspection by the company shall not relieve the vendor of his responsibility under terms of 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 load 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 non-destructive testing by radiography may be used to check for lack of bond or slag/dross inclusions.



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6. BOLLARDS

6.1. *Material*

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.

6.2. *Codes and standards*

The following latest edition of standards and codes or approved equivalent international codes shall be followed for the manufacturing and testing of cast steel bollards.

IS 210 - Specifications for grey iron castings.

IS 1387 - General requirements for supply of metallurgical materials.

IS 1599 - Method for bend test for steel products other than sheet, strip, wire and tube.

IS 1608 - Method of tensile testing of steel products

IS 3664 - Code of practice for ultrasonic Pulse Echo Testing by contact and Immersion methods.

IS 3381 - Specification for cast vertical bollards with and without lugs.

IS 1600 - Tensile testing of steel products other than sheet, strip, wire and rope.

6.3. *Design Life*

The design life of the bollard shall be minimum 25 years with a warranty for 5 years.

6.4. *Scope of supply*

Providing and fixing in position to lines and levels **100 T capacity double horn cast iron bollard** type as shown in the drawing including supplying and fixing in position anchor bolts, nuts, grouting inside with cement concrete of M40 grade excluding reinforcement and also including painting the bollard, the exposed surface shall be shot blasted and all steel works with zinc rich primer of 50 microns and two coats of high build epoxy solid paint (150 microns each) etc. complete as per drawing, detailed specifications and directions of Engineer-in-charge incharge.



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The capacity of the bollard shall be 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 numbers of bollards shall be in accordance with Bill of quantities (BOQ) specified in the form of tender and the location shall be as per drawings.

6.5. *Design Features*

Simplicity of design with standard parts to ensure economic maintenance shall be the first consideration. Notwithstanding the foregoing, the bollards shall incorporate the following designed features, as a minimum:

The factor of safety on the design of the bollard shall be 3 on shear, bending and axial stress and overall capacity for combined stresses. The anchorages bolt group shall be designed to I.S. 800 with a factor of safety of 1.4. Bollards shall be designed for a horizontal operating range of 180 degrees and a vertical operating range of ± 25 degrees for high tide and low tide.

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.

- Bollards will be Twin-Horn, T-Head or Sloping Lobe type.
- Each bollard will be capable of supporting, at least, Three mooring lines, of approximately 36 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.

Holding down bolt verification shall be done in accordance with relevant IS codes. Concrete verification against bolt pullout shall be done in accordance to IS 456. Bollards shall be supplied with certificates that confirm their resistance to the test pulls with no reservations and that the results of the x-ray examinations performed at 100% are satisfactory. This certificate shall be issued by an internationally recognized company.

Absence of goose pen and inclusions shall be proved.

6.6. *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 who possess adequate testing facilities and equipment and employ competent staff for detailed testing and examination as specified herein.



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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-in-charge's Representative for his review before the bollards are ordered out. The Contractor shall also furnish to the Engineer-in-charge's Representative (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 Authority Engineer-in-charge's approval.

6.7. *Casting*

The iron shall conform in quality, strength, hardness etc. to IS 210. The casting shall be made under strictly controlled conditions to ensure chemical composition, soundness, uniformity, correct grain size to develop shock resistance properties and to avoid blowholes. The casting shall conform to IS 1030.

The casting shall be accurately moulded in accordance with the drawing. The dimensional tolerance that can be allowed for all important dimensions shall be ± 1.6 mm. The castings shall be sound, clean and free from sand. They shall be free from distortion, blowholes, twists and other injurious defects. They shall be properly flattened and dressed.

All casting shall be supplied in the heat-treated condition, which shall be carried out at suitable temperature to give the mechanical properties as specified. The casting shall thoroughly be annealed to refine the crystalline structure throughout the casting by heating to uniform temperature no less than the normalizing temperature and allowing them to cool slowly from maximum temperature in a uniform manner or alternatively normalizing by heating in a similar manner and allowing it to cool in air away from draughts. In no case shall it be allowed to conduct heat treatment process more than two times on the same casting. The method of heat treatment and all relevant records shall be furnished.

6.8. *Marking of bollards*

Each casting shall be legibly marked with

- Number or identification mark by which it can be traced to the melt from which it was made, and
- The manufacture's initial and trademark.
- The capacity of the bollard in bold letters. **(100T)**



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6.9. Defects and rectification

If the casting is found defective during the course of any subsequent preparation or machining, it shall be rejected even if it has been found satisfactory during earlier testing, if any. No casting shall be repaired or welded without the prior permission of the Employer or his representative. When repairs that might have been so sanctioned are completed, the concerned casting shall be again presented for inspection. When welding is carried out, the welding technique and preparation of the casting for repairs shall be accordance with IS 5530.

6.10. Samples, Testing and Inspection

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

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

Samples shall be tested in approved laboratory.

Mechanical tests shall be carried out in accordance with I.S. 210 or equivalent ASTM or British Standard and the results reported to the Engineer-in-charge's Representative. Mechanical test pieces shall be cast from the same batch of material and at the same time as the bollards.

a) Tensile Test

The tensile test shall be carried out in accordance with IS 1608. The minimum tensile strength and elongation shall be as given earlier in this specification.

b) Bend Test

The bend test shall be carried out in accordance with IS 1599. This test piece shall be capable of being bent without fracture to the angle specified earlier in this specification. It should be bent round a former having a radius of 25 mm.

c) Non-destructive Tests

The following non-destructive tests at Cross-sections decided by the Employer shall be carried out. Ultrasonic flaw detector test as per IS 3664 for checking the thickness of the castings and detect defects in the casting.



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- Magnetic particle test
- Ringing test

The Engineer-in-charge-in-charge shall indicate the location to be examined on the casting and the stage of manufacture at which such examinations are to be made.

The technique, inspection and interpretation of results shall be laid down and agreed before the manufacture commenced.

d) Test by Chemical Analysis

Chemical analysis test shall be conducted to ascertain the percentages of Sulphur and phosphorous content in the material of which the casting is going to be made. A certificate of chemical analysis of such cast shall be supplied when required to do so by the Employer.

e) Testing Facilities

The manufacturer shall supply the casting required for testing free of charge and shall at his own cost furnish and prepare the necessary test pieces and supply labour and appliances for conducting all tests at his own premises in accordance with this specification. If such facilities are not available at the place of manufacture for conducting the prescribed tests, the manufacturer shall bear the cost of transportation for the test pieces or casting and for carrying out the tests at a place approved by the Employer.

f) Re-test

If any of the test piece fails to pass any of the mechanical tests specified under tensile test and bend test, two further samples which represent that particular casting or castings shall be selected and tested in the same manner. The manufacturer shall have the option, if he so desires, to re-heat-treat (not more than twice) the casting before the two further samples are accepted. Should either of these tests fails, the casting represented shall be liable for rejection.

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.

6.11. 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.

6.12. Anchorage Hardware



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Anchorage bolts shall be of minimum Class 8.8 to IS 5624 & IS 1367 Part 3, 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.

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

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

Steel for the anchorage hardware shall be designed in accordance with shall be in accordance with IS 800 and IS 456 guidelines.

Once the installation of bollards is finished, the Engineer-in-charge's Representative shall carry out all the tests as necessary to prove its correct operation.

6.13. Installation

Bollards shall be fixed in the Works as shown in the drawings and in the manner approved by the Authority Engineer-in-charge. 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-in-charge's Representative for approval before being used in the Works.

Bollards supplied by the manufacturers with apertures for the introduction of cement grout shall be grouted after fixing. The bollards shall be installed on a minimum bed of 20 mm approved cementitious grout. The bollard shall be filled with approved cementitious grout or M40 grade concrete and the bolts re-tightened after the grout under the base has set. The templates shall be carefully marked to show the centre –line of the bollard and the leading edge that is to face the quay edge.

Any bolt protruding above the top of the base-plates 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.

6.14. Documentation

CONTRACTOR shall submit, at least, following information for approval prior to manufacturing bollards and hardware:



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- 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

6.15. Certificate From Approved Classification Society

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

The design of the bollard shall be as approved by the Classification Society appointed by the contractor with the approval of Chief Engineer-in-charge and the bollard shall be built under their supervision. Such approval issued by the Classification Society along with a copy of the design calculations of each component of bollard and fixing bolt and a copy of the detailed drawing shall be furnished to the Chief Engineer-in-charge and consent obtained before the commencement of the casting of the bollard. The required tests shall be conducted under the supervision of the classification society. A certificate to the above effect as well as the bollards conform to the technical requirements stipulated in the contract, issued by the classification society shall be furnished along with bollards supplied. All cost and fee payable to the classification society for rendering the above services and costs for any rectification works carried out as required by the classification society shall be borne by the contractor and shall be included in the rate quoted.



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7. RUBBER FENDERS

7.1. *Scope*

The scope of this section includes the description and the basic Engineer-in-chargeing parameters and technical specifications for the fender system.

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. The fender types shall be installed at the positions shown on the Construction Drawings.

The contractor shall procure the rubber fenders only from reputed manufactures, approved by the department. The department shall approve only those manufactures who shall produce certificate for the satisfactory performance of the fenders not less than 5 years from the owner.

7.2. *Design Life*

The design life of the fender system shall be minimum 10 years with a warranty for 5 years.

7.3. *Responsibilities*

The Vendor shall be responsible for ensuring correct and safe configuration, functionality and operability of the supplied and installed fender System. The Vendor shall ensure that no omissions from, or compliance with the specifications, data and documentation supplied by others shall prejudice this responsibility.

The Vendor shall ensure that the fender installation complies in all respects with the requirements of the fender system supplied. The scope of Vendor includes but not limited to the following.

- a. Design and Engineering.
- b. Procurement of raw material & bought out components.
- c. Manufacturing and Assembly at works.
- d. Inspection and Testing.
- e. Surface preparation, protective coating and painting shall be done as per Manufacturer's Standard suitable for site condition including supply of paint.
- f. Touch-up/ repair painting at site including supply of paint.
- g. Packing and Supply.



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- h. Unloading at site, local handling, transportation from store to work site, storage at work site, assembly at site.
- i. Erection, hook-up, testing, commissioning, and performance Guarantee Test of all systems at job site.
- j. “On-site” training at project site to Owner’s personnel for operation and maintenance.
- k. Necessary assistance to Owner in obtaining the statutory approvals as required/ applicable, by providing drawings & documents as required.

7.4. Objectives

The objective of the fender system is to provide safe and acceptable berthing support for the vessel at the jetty. The functions of the fender are:

- To absorb the impact energy due to berthing vessel as specified in section 1.6.3
- To absorb the wind load during berthed condition.

7.5. Scope of Supply

The scope of supply of fender under this specification includes the following.

- (a) Providing and fixing in position super cone fender of size 1200 H having minimum energy absorption capacity of 80.5 Ton-m per metre at max 72% deflection and max reaction force 135 Ton with frontal frame of size 1950mm x 3000mm of approved quality with all fixtures and accessories, fascia pad, necessary chains, anchor bolts etc. complete all as per detailed specifications and directions of Engineer-in-charge in Charge.
- (b) Providing and fixing in position D-type rubber fenders 150mm (H) x 150mm (D) having minimum energy absorption capacity of 0.25 Ton-m per metre at max 52.5% deflection and max reaction force 9.6T per metre including bolts, nuts and washers of stainless steel SUS 316 grade, all fixtures, rigidly in correct alignment and position all as per drawings, handling, transportation, third party inspection, materials, labour, staging, tools, equipment, plants, machineries etc. complete as per detailed specifications and directions of Engineer-in-charge-in-charge.

Fender assemblies are to be supplied with anchor bolts suitable for use when mounting to concrete jetty structure. The supply shall include complete fender assembly, tension chains, shear chain, weight chain and its anchorage hardware.



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7.6. *Design and Performance Requirements*

7.6.1. Fender System

The fender system proposed is super cone fenders and shall be fully vulcanized and homogeneous, having sufficient resilience, anti-aging weather resistant and wear resistant properties to meet all normal service conditions.

The berthing energy and the fender reaction should be restricted to the values applicable for the above listed fenders. The fender units, 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.

7.6.2. 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 57% for super cone fender and 45% for D fender. Load deflection characteristics shall be obtained by testing of the fender samples.

Samples for verification testing shall be actual fender elements fabricated for the project following the PIANC WG211(2024) Guidelines for the Design of Fenders Systems.

Effect of contact angle and durability tests should be carried out as per PIANC WG211(2024) Guidelines for the Design of Fenders Systems recommendations.

Supporting Protocols shall cover temperature stabilization, Velocity Factor (VF) and Temperature Factor (TF) as mentioned in PIANC WG211(2024) Guidelines for the Design of Fenders Systems.

7.7. *Fender Units*

The types and locations of fenders to be provided and installed under this Contract are shown on the Construction Drawings.

Prior to procurement or installation of the fenders the Contractor shall provide to the Engineer-in-charge's Representative 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.



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The Contractor shall supply to the Engineer-in-charge's Representative 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.

Design calculations and fully detailed fabrication drawings shall be submitted to the Engineer-in-charge's Representative for approval prior to manufacture. Responsibility for the design shall remain with the Contractor notwithstanding any approval of the Engineer-in-charge's Representative.

7.8. Rubber Characteristics

Rubber fender units shall be compression moulded from natural or synthetic or both compounds resistant to ageing, weathering and wearing and shall have the properties stated in the Table 9.1 and 9.2 in compliance with Section 7.3 of Appendix A of the "WG 33 - Guidelines for the Design of Fender Systems: 2002", published by the Permanent International Association for Navigation Congress (PIANC).

The rubber shall be fully vulcanised and homogeneous with no foreign particles and free from defective impurities, pores and cracks, voids, and cuts. Steel plates shall be fully embedded and fully adhered to the rubber during the vulcanizations process to avoid separation between the rubber and steel.

Rubber for fenders shall be natural or synthetic rubber. The material shall be homogeneous and a minimum submerged density of 275 kg/m³ is required.

The following particulars of the proposed rubber fenders shall be submitted:

- i) Manufacturer's literature, including a list of physical properties of the rubber for the fenders.
- ii) A report on compression load tests and characteristic load-deflection and energy-deflection curves.
- iii) The temperature at which the compression load test was carried out with a graph showing how the buckling load varies with temperature.



- iv) The rate of compression used in the test with a graph showing how the buckling load varies with rate of compression.

The rate of compression curve may be obtained using exact scale models of the fenders provided the models are not less than 100mm high.

The particulars shall be submitted for approval of the source and type of rubber fenders at least 40 days before the first delivery of the rubber fenders to the Site.

A certificate showing the manufacturer's name, the date and place of manufacture and showing that the rubber fenders, including the rubber used in manufacturing the fenders, comply with the requirements stated in the Contract, shall be submitted for each batch of rubber fenders delivered on the site. Samples will be taken from the 10% of the total fenders delivered to site and to be tested in an approved laboratory having NABL Accreditation.

The rubber characteristics before and after ageing shall meet the following minimum requirements.

Table 9.1 Rubber Properties – Before Ageing

Property	Requirement	Testing standard
Tensile Strength	Minimum 15.7MPa	ASTM D412 Die C/BS 903 A.Z.
Elongation	Minimum 300%	ASTM D412 Die C/BS 903 A.Z.
Hardness	Maximum 84 Deg.	ASTM D2240 shore A durometer / BS 903 A.Z

**Table 9.2 Rubber Properties after aging
(70° C X 96 hrs aging through air heating)**

Change in Tensile Strength	Not less than 80% of original value	ASTM D 573 Die C/BS 903 A.Z.
Change in Elongation	Not less than 80% of original value	ASTM D 573 Die C/BS 903 A.Z.
Hardness	Original value +8° max	ASTM D2240 shore A durometer /BS 903 A.Z
Tear Resistance	Minimum 70 KN/m	ASTM D 624 Die B/BS 903 A.3
Compression set. 70° x 22 hours heat treatment.	Maximum 30%	ASTM D 395/BS 903 A.6A
Abrasion Resistance	Maximum 1.5 CC	BS 903 A9 method C 3000 revolutions
Anchor bolt (Super Bolt) & nuts, Washer, etc.	Stainless steel EN Grades 1.4401	AISI 316/BS970 Gr.316

7.9. Frontal Frame



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Frontal frame shall be of fabricated steel construction and painted with sufficient area to limit the hull pressure at 35.00 T/m². These steel work for the frontal frame shall be cleaned by sand blasting etc. and applied with first coat of Zinc anode primer of thickness not less than 75 microns and second coat of bitumen epoxy paint of thickness not less than 150 microns and third coat of bitumen epoxy paint of thickness not less than 150 microns.

7.10. *Frontal Pad*

Frontal pads having proper and integrated arrangements with the fender body and frontal frame shall be provided. The pads shall be made of high molecular polyethylene, having low friction coefficient to avoid spark during berthing. It shall have the following physical properties.

Density	: 0.95 to 1.05 gm/cc
Tensile Strength	: Not less than 250 kg/sq. cm
Elongation	: Not less than 20%
Compressive strength	: Not less than 200 kg /sq. cm
Friction Coefficient	: Not greater than 0.2

7.11. *Weight/Tension Rubber flex chain*

Suitably designed anchor chain has to be provided to the fenders to prevent any sagging. The chain provided shall have units of not less than 20 mm dia. Rubber cushion arrangement is not provided for those chains. The chain and other accessories provided shall be rolled / carbon steel and hot dipped galvanized as per ASTM A 575 Gr.1075 or equivalent. A typical arrangement of rubber flex chain is attached. U-anchor where required shall be of MS grade 8.8 Galvanized or equivalent.

7.12. *Fixtures*

All bolts, nuts, washers, sleeves etc. shall be of Stainless steel of 316 Grade of approved quality. The material for resin anchor sleeve, if required shall be made of synthetic resin and proved satisfactory to the following requirements.

7.13. *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

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quay/berths. For all fenders, full records of manufacture and installation are to be kept on forms to the approval of the Engineer-in-charge's Representative, including:

- d) Manufacturer, location of manufacture
- e) Method of manufacture
- f) Mould reference where appropriate, supervisor in-charge
- g) Date(s) of manufacture
- h) Location of fender unit in Works, and date of installation
- i) Confirmation that the fender has been subjected to a "break in" cycle, including details.
- j) Any other relevant information
- k) Authorised signatures confirming details are correct.

Preliminary forms shall be submitted to the Engineer-in-charge's Representative prior to delivery of the fender units to Site. Final forms shall be submitted within two weeks of installation of the fenders.

7.14. Anchorage Hardware

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 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.

Calculations shall be provided to justify fixings and will be subject to the approval of the Engineer-in-charge's Representatives or his nominee. Where stainless steel bolts or fender anchors make contact with other dissimilar metals, they shall be electrically insulated to prevent bi-metallic corrosion.

7.15. 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.



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Fenders shall normally be stored in the protection packing 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 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.

7.16. *Permitted Tolerances*

Tolerances on fender performance and physical dimensions shall not exceed the following.

- i) Performance:
 - Energy absorption (E) = +/- 10%
 - Reaction force (R) = +/- 10%
- ii) Physical Dimensions:
 - Height of fender (H) = +4/- 2%

The rated reaction and energy absorption specified in this specification excludes the tolerances and shall be selected while selecting the suitable fender.

7.17. *Fender Inspection Requirements*

The testing, with the exception of 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 classification society approved by the Employer. The cost of Third-Party Inspection shall be borne by the contractor and shall be included in the rate quoted.

The Contractor shall supply 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.



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7.18. *Verification/Quality Assurance Testing*

a) Energy/Reaction Compliance Testing

Samples for verification testing shall be actual fender elements fabricated for the project following the PIANC Guidelines for the Design of Fenders System – 2002.

b) Break in Deflection

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

c) Other Testing

Effect of contact angle and durability tests should be carried out as per PIANC Guidelines for the Design of Fenders Systems – 2002 recommendations.

d) Dimensions

Fenders shall meet manufacturer's specified dimensional tolerance.

e) Steel frame, Frontal Frame, Hardware, Chains and Related Accessories

All steel hardware for securing of fenders shall be stainless steel grade AISI 316 or equivalent.

7.19. *Compression 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 "WG 33 - Guidelines for the Design of Fendering Systems: 2002", published by the Permanent International Navigation Association (PIANC).

CONTRACTOR shall submit Factory Acceptance Test (FAT) procedure for approval prior to testing. Quality Control Agency shall be present at FAT in order to approve and verify proper test methods are being applied. Warranty letters for fenders and material certificates shall be provided.

At least 10% of total fender units or 2 units whichever is maximum shall be tested. These tests shall be witnessed by Engineer-in-charge's Representative 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-in-charge's Representative.



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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-in-charge's Representative 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-in-charge's Representative or his nominee to witness the tests to be conducted in India if he so desires and the cost of visiting test will be borne by the Port (Employer).

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 "WG 33 - 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.

7.20. Drooping Testing Requirements

Fender drooping is a phenomenon that often happens due to the heavy steel frame that is supported by the fender due to slackness of weight chain. The shear and bending capacity of the rubber fenders shall be sufficient enough to support such weight.

Drooping test for each fender shall be carried out with the weight of the fender frame assembly and the load shall be maintained for at least 1 week to determine the maximum deflection of the fender. The maximum deflection shall not exceed 25mm or L/100 whichever is lower.

Full details of the tests shall be provided, including certification of the test equipment used.

7.21. Documentation

7.21.1. 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.



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- Panel structural justification
- Chains and accessories structural justification
- Anchor bolt calculations for fenders and chains

7.21.2. Drawings

Including, at least, following drawings:

- Fendering system plans (plan view, front and side elevations)
- Anchor bolt layout
- Insert details.
- Panel details
- Chain padeye details
- Bolts, nuts and washers' details
- UHMW panel details
- Chain assemblies
- Chain turnbuckles
- Bill of material

7.21.3. Fabrication related Procedures

- Fitting justification
- PE-UHMW pads technical data sheets.
- Fender performances curves
- FAT procedure and PIANC procedure
- Handling, transportation, and storage procedure
- Installation and maintenance procedure
- Painting procedure
- Inspection and tests plan

7.21.4. 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

7.22. *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.



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- 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 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, if 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 Engineer-in-charge's Representative or his representative.
- x) The decision of the Engineer-in-charge's Representative 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 Engineer-in-charge's Representative 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 Engineer-in-charge's Representative.
- xii) The specification of all other materials shall be as per the relevant Indian Standard specifications as applicable. All BIS specification referred to in this schedule shall be the latest version.

7.23. Defect Liability Period for Fenders & Bollards

The Contractor shall warranty the complete fender system and Bollards for a period of 60 months from the date of completion of work, for any kind of manufacturing defects or deviations from specified performance. An amount of 10% of the value of the marine fender work and Bollards will be held towards the satisfactory performance of the fenders until expiry of five years from the date of its installation. However, the Contractor may also submit a Bank



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guarantee for an equivalent amount (as stated above) issued from any Nationalized Bank having its branch in Kochi or enforceable and encash-able at Kochi for a period of 5 years. The rates entered shall be inclusive of inspection, testing as above.

7.24. Certificate from Approved Classification Society

The fenders shall be certified by independent testing agency such as IRS or Lloyds or BV or other approved classification society. The design of the fender unit shall be as approved by the Classification Society appointed with the concurrence of Chief Engineer-in-charge and the fender unit shall be built under their supervision. Such approval approved by the Classification society along with the copy of the design calculations and detailed drawing shall be furnished to the Chief Engineer-in-charge and the consent obtained before commencement of the casting of fenders. The performance test shall also be conducted under the supervision of the classification society in the presence of an Engineer-in-charge from the Port Authority deputed by the Chief Engineer-in-charge. A certificate to the above effect as well as the fender units conform to the technical requirements stipulated in the contract, issued by the Classification Society shall be furnished along with fenders supplied. Chemical composition of the rubber shall be tested in an approved laboratory as per ASTM D297/D6370 and the test shall be witnessed by the above Classification Society. All cost and fee payable to the classification society for rendering the above services shall be borne by the contractor and shall be included in the rate quoted.



8. ELECTRICAL WORKS

8.1. Scope

The brief scope of work is given below.

- a) SITC of 11 m long GI octagonal pole made of MS steel having necessary sections if required as per manufactures design with suitable base plate and necessary single arm each, min sheet steel thickness 3mm, foundation bolts, suitable for providing 200 W Flame proof light fittings – 2 NOS, as required and all related works as directed by the EIC.
- b) Supply and laying of 3.5C X 50 sq. mm LT FR cable through cable tray, clamping along walls etc. from existing MV panel at substation as required.
- c) Supply and laying of 300 mm width GI cable tray with GI angles.
- d) SITC of HDPE/GI pipes for laying HT and LT cables.
- e) SITC of LT cables for taking supply to street light poles, berth lights etc. through open trench etc including its termination with junction boxes, MV panels etc.
- f) Supply, Installation, Testing and Commissioning of 200W LED Flame proof Lights.
- g) Supply, Installation, Testing and Commissioning of Street Light Panel with timer control.
- h) Supply and providing End termination /Straight joint for LT cables.
- i) Earthing of the installations with pipe/rod earthing such as light poles etc.
- j) Testing and commissioning of the entire system.

The bidder shall visit the site, ascertain the site conditions and scope before bidding

8.2. Electrical Distribution System

8.2.1. General technical particulars

Fault level at W/Island at 11 KV	: 25 KA
Anticipated Max. fault level	: 50 KA
Rated system voltage	: 11 KV
Rated frequency	: 50 Hz
Neutral earthing	: effectively earthed.



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Installation of cable	: Underground burial.
Rated short circuit current at 11 KV side	: 25 KA
Proximity of extraneous heat source	: Nil
Max. Permissible operating temp. of conductor under normal Operation	: 90° C
Under short circuit	: 250° C
Ground temperature	: 40° C
Type of installation	: Earthed
Maximum temperature of air	: 40 degree C
Minimum temperature of air	: 22 degree C
Maximum relative humidity	: 95%
Minimum relative humidity	: 10%
Average No. Of thunderstorm days	: 40 days
Average number of rainy days per annum	: 90 days

8.2.2. Type of Soil along the Cable Route

General condition of the earth is soft marshy. Some portions are tarred with rubble soling. However, the contractor shall conduct route survey before submitting their quotes.

8.2.3. General Conditions

In addition to the above, the scope intends to cover but not restrict to the following activities, services and works.

- (i) Complete design and Engineer-in-chargeing of all the systems, sub-systems, equipment, material and services.
- (ii) Providing Engineer-in-chargeing data, drawing and O&M manuals for Employer's review, approval and records.
- (iii) Supply, testing, packing transportation and insurance the equipment from the manufacturer's work to the site.
- (iv) Receipt, storage, insurance, preservation and conservation of equipment at the site.
- (v) Fabrication, pre-assembly (if any), erection, testing and putting into satisfactory operation of all the equipment/ material including statutory clearances & successful commissioning.
- (vi) In addition to the requirements indicated in Technical Specifications, all the requirements as stated in relevant regulations stipulated for successful commissioning of the installation also be considered as a part of this specification and Contractor is bound for compliance the same.
- (vii) The Contractor shall be responsible for providing all material, equipment and services specified or otherwise which are required to fulfill the intent of ensuring

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operability, maintainability and the reliability of the complete work covered under this specification.

- (viii) For individual equipment specifications reference shall be made to the relevant Technical Specification of the equipment as per contract condition.
- (ix) The Contractor shall be responsible for the overall management and supervision of works. He shall provide experienced, skilled, knowledgeable and competent personnel for all phases of the project, so as to provide the Employer with a high-quality system.
- (x) A project execution schedule called Master Network (MNW) in the form of PERT / Gant chart/ network and based on _ Work break down structure shall be prepared by the Contractor for Employer's approval. The MNW shall identify milestones of key events for each work/ component in the areas of Engineer-in-chargeing, procurement, manufacture, dispatch, erection and commissioning.

8.3. *Project Management & Site Supervision*

In case the contractor intends to subcontract the electrical works, the subcontractor who will be employed shall be a class A contractor / EHT contractor issued by state electrical inspectorate/ central electricity authority. The contractor shall submit all the required credentials of the subcontractor to the employer for approval of the appointment of subcontractor.

8.3.1. Testing And Commissioning

The scope includes testing and commissioning of all equipment, sub-systems and systems of the project and putting them into successful commercial operation. The scope shall include but not limited to the requirements given elsewhere in the specification. The Contractor shall be responsible to provide all necessary testing and commissioning personal, tools and plant, test equipment, etc.

The Contractor shall identify all interface issues with Employer and other agencies, and shall be responsible for each interfacing, coordination and exchange of all necessary information.

The Contractor shall submit to the Employer all drawings for review. He shall list out the detailed requirements of interface between Contractor's work and the material and services to be supplied by Employer.

The interpretation of the Employer in respect of the scope, details and services to be performed by the Contractor shall be binding, unless specifically clarified otherwise by the Employer in writing before the award of the contract.



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The drawings (enclosed), forming a part of the specification shall supplement the requirements specified herein. These are preliminary/ tentative drawings for bidding purpose only and are subject to changes that may be necessary during detailed Engineer-in-chargeing after award keeping the basic parameters as specified.

Failure of any equipment to meet the specified requirements of tests carried out at works or at site shall be sufficient cause for rejection of the equipment. Rejection of any equipment will not be held as a valid reason for delay in the completion of the works as per schedule. Contractor shall be responsible for removing all deficiencies and supplying the equipment that meet the requirement after furnishing of necessary fresh type test report, as per relevant ISS Standard from NABL Accredited Laboratory.

8.4. Compliance Of Electricity Act, Regulations, Etc.

Contractor is required to follow statutory regulations stipulated in Electricity Act 2003, Indian telegraph act 1889, Electricity (Supply) Act 1948, Indian Electricity Rules 1956, CEA (Regulation relating to safety of electrical installation) regulation 2010, with all amendments till date and other local rules and regulation referred in this specifications.

The Contractor shall comply with all the statutory rules and regulations prevailing in the state of Kerala including those related to safety of equipment and human beings.

The successful Contractor (individual) or any of the partner of joint venture who has qualified, should obtain “A” class electrical license from Electrical inspectorate of Govt. of Kerala/GoI/ any other state/ Union territory etc, before award of contract and to be kept valid till such time all the erected work as per scope of the award is taken over by the Employer.

The Contractor shall do complete coordination with all local and statutory agencies for execution of complete works including obtaining clearance for energizing of the HT system upon completion of entire works.

The Contractor shall obtain approvals & clearances and right of way from all agencies involved. All cable routes shall generally be routed through public land/ along the road.

The Contractor shall be responsible for transportation to site all the materials to be provided by the Contractor as well as proper storage and preservation of the same at his own cost, till such time the erected installation is taken over by the Employer.

8.5. Methodology Of Procurement

All equipments/material shall be sourced from reputed manufacturers only. All equipment/ material offered shall be of reputed manufacturers only as per the list of approved make



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mentioned in the tender document and who have designed, manufactured, completely tested for relevant Indian Standards and supplied the equipment/ material to various State Electricity Boards or other reputed utilities which are in trouble free services at least two different locations for a period of more than two (2) years as on the date of bid opening.

8.6. *Quality Assurance, Inspection and Tests*

The Contractor shall offer proven and type tested equipment for the project. The type test Certificates shall be complete as per the relevant I.S., carried out by NABL, CPRI or any other statutory bodies responsible for testing of equipment and it shall not be older than 5 years.

If required, Sub-vender's credentials, copies of valid BIS license, past supply & performance certificates as per requirement will also be required for sub-vender's approval, if not already approved for a specific item.

In case during post award detail Engineer-in-chargeing stage, if any equipment is found to be not type tested or partially type tested, as per I.S., the Contractor shall carry out complete type test for the items at his own cost.

The Contractor shall arrange all type, routine and acceptance tests at manufacturer's works as per approved Material Quality Programme with CoPA's officer. Any expenditure in connection with deputing the representative to the manufacturer's work site will be borne by CPT. The Contractor shall arrange the inspection program in consultation with Engineer-in-charge-in-charge to give sufficient advance intimation of the manufacturing and testing schedules to facilitate timely inspection of the equipments by CoPA. Fake inspection call will attract penalty as per the discretion of the employer. The Contractor shall provide one set of tests reports to Employer on successful completion of the tests.

8.7. *General Technical Specifications*

8.7.1. Supply Of Materials -General

All materials required to complete the work as per given specifications & drawings etc, must be manufactured and supplied using fresh raw materials. Re-moulded, re-circulated materials are not acceptable. The procurement of materials must be made directly from manufacturer or through authorized dealer / distributors. Documentary evidences to this effect are to be made available to the Engineer-in-charge-in-charge for necessary checks / verification of source of supply of materials. Second hand materials / partial used materials / used materials would not be acceptable. The offer should be as per Technical Specification without any deviation. But any deviation felt necessary to improve performance, efficiency and utility of equipment must be mentioned in the Deviation Schedule with reasons duly supported by documentary evidences during pre-bid meeting. Such deviations suggested may or may not be accepted by



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the employer. Any deviations projected after the pre bid meeting shall not be entertained at any cost.

8.7.2. Installation Of Equipments – General

8.7.2.1 Standards

Erection, testing and commissioning of the equipments covered shall be done as per standard codes of practice and shall comply with requirements of following Indian Standards and other relevant standards, Indian Electricity Rules and acts and also to the regulations that are in force at the place of installation.

- IS: 1255 - Code of practice for installation and maintenance of power cables upto and including 33 kV rating.
- IS: 5216 - Guide for safety procedures and practices in Electrical work.
- IS:100118 - Code of practice for selection, installation and maintenance for Switchgear and control gear-Part-III Installation.
- IS13408 - Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining application of explosives processing and manufacture).
- IS: 3043/87 - Code of practice for installation and maintenance of earthing of installation.

8.7.2.2 Reference

Following documents shall be read in conjunction with this specification

- (i) Scope of work and special requirements
- (ii) Schedule of items of work
- (iii) Engineer-in-chargeing Specification and Data sheet of General requirements of Electrical system.

8.7.2.3 General Conditions for Installation of Equipments

- (i) The erection/installation, testing and commissioning shall be carried out in accordance with specification, data sheets, drawings, manufacturer 's recommendations, and relevant standards or as directed by owner/Engineer-in-charge- In-Charge. Requirements regarding erection/installation, testing and commissioning of switchboards, cables, etc, are generally explained here in. It is the responsibility of the contractor to supply all equipment, items, accessories, materials, tools, tackles, transporting, and lifting vehicles, consumables etc. required for unpacking, checking, transportation, storage, safe custody,



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installation, erection, testing, commissioning, return of unused equipment/items which are supplied from owner's stores and handing over of the installation to the entire satisfaction of owner.

- (ii) The erection scope shall include supply of all hardwares and accessories such as bolts, nuts, washers, gaskets, cable termination accessories, lugs, paint, primer, sand etc. required for completeness of the work. All consumable materials such as insulation, tape, cleaning and paint brushes, welding electrodes, rust preventive materials, jute, cotton waste, hack saw blades, bolts, nuts, inhibitive grease, fuel, lubricants, etc, and any other material required in carrying out the work but not for incorporation in to the permanent work, shall also be included in the scope of contractor.
- (iii) The equipment/items to be erected shall be handled with care by experienced workers under the guidance of the competent supervisor. Proper handling and transporting equipments are to be used and dragging is to be avoided.
- (iv) The equipment/items supplied by the owner, shall normally be kept at their stores. The contractor shall inspect these items at the stores by unpacking the containers, if necessary. Responsibility of safe custody of materials after delivery and till handing over shall rest with the contractor. Unused materials and containers shall be returned to the stores. The items supplied by the owner shall be transported from the point of storage to the point of erection / installation using proper capacity transporting vehicles. The scope shall include unpacking the containers, assembling parts, fixing loose items, components, etc. Materials supplied by the contractor or issued by the owner shall be given suitable protection against weather, dust and vermin. In storage places, equipments shall be placed over wooden sleepers to keep them above ground. Before carrying out erection/installation works of any item, proper care regarding levelling, alignment, access to working parts, facilities for removing the items for repair, statutory clearance, etc. shall be taken.
- (v) Foundation bolts, nuts, lock nuts, washers, etc. will normally be supplied by the equipment supplier. Any further requirement of these items shall be under the scope of contractor. The equipment shall be installed on the foundation bolts firmly such that there will not be any vibration during operations. For mounting of equipment/items on the walls/ columns / supports, suitable MS/GI brackets shall be fixed / grouted.
- (vi) Electrical connections shall be done with great care using spring washers, bimetallic strips, conducting grease, etc. wherever required to ensure good contact without creating undue stresses. Copper bus bar joints shall be made after tinning the contact area. Supply of all required accessories or electrical connections shall be included in the contractor's scope. Discrepancies if any found between drawings/statutory requirements and actual conditions at the site, shall be immediately brought to the attention of owner's representative. If any modification is found required in the writing or to suit site condition the same

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shall be carried out as per the instruction of the Engineer-in-charge-In-Charge without any extra cost.

- (vii) All equipments under erection shall be kept properly cleaned and free of dust, vermin, moisture, etc. After erection, it shall be ensure that non-foreign materials, tools or tackles are left in the equipment. All unused cable entries, cutouts, etc. shall be sealed properly. For hazardous area, blanking plugs suitable for the area classification applicable shall be used.
- (viii) All tests shall be carried out in the presence of owner's representative and test shall be recorded on an approved proforma duly certified. The records of all tests shall be submitted to the purchaser's representatives. All interconnected wiring shall be checked thoroughly for correct connection with the wiring and schematic drawings of the manufacturer and the drawings supplied by owner before energizing.
- (ix) All power and bus bar connection shall also be thoroughly inspected and checked for connections, foreign materials, tightness, etc. before energizing the equipment. All components within the main equipment shall be tested for proper performance and correct operation before commissioning the equipment.
- (x) All labelling shall be checked for correctness. All nuts, bolts, clamps, joints, connections, etc. shall be checked for tightness and tightened wherever required. All moving parts shall be checked for its correct movement and proper lubrication. Apply lubrication wherever required. All equipment containing liquid shall be checked for correct quantity filling and all gaskets, walls, etc, shall be checked for leak proof. Oil filling, if found required, shall be done with dry and clean oil. Gaskets shall be replaced if found required. It shall be ensured that all CT leads are loaded or shorted prior to testing and commissioning. Insulation tests shall be carried on all electrical devices, whether specifically mentioned or not, as per this work after properly cleaning these devices.
- (xi) All the relays and its settings after commissioning shall be furnished to owner detailing relay type number, panel number etc. In case of any component of an equipment supplied by the owner is found to faulty/ unsuitable, the same shall be replaced by the new one issued by owner. All relays, before installation, the rating, range and auxiliary supply voltages for the relay should be checked against drawings/ schematic/ schedule.

8.7.2.4 Civil and structural works

- (i) Miscellaneous civil works associated with the erection/installation such as excavation, dewatering and refilling of earth work for earth pits and cable trench structures, chipping, grouting, small cutting, etc. on floors/ walls/ columns / and bringing back the same to original finish, grouting of supports, providing suitable fixing arrangements for cables, push button stations, DBs etc. shall be included in the rates quoted for erection of the respective items, unless

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specifically excluded in the —Schedule of Items of Work. All structural works associated with cabling, earthing, equipment erection and supporting arrangements shall be included in the scope of the contractor. All the welding and cutting works shall be carried out by certified welders. Painting shall be done on all MS materials provided, by the contractor such as base channels, frames, supports, pedestals, cable trays/racks/risers, enclosures, boxes, conduits, chequered plates etc. Before painting, the surface should be thoroughly scraped and cleaned to remove dust, grease, plaster or any other foreign materials. It is the responsibility of the contractor to supply and install all the required materials for painting including paint. Cement concrete footing shall be provided for, cable trays/racks/risers, pedestals, supports, etc. Footing shall be provided using 1:2:4 PCC with 20mm broken stone. It is responsibility of the contractor to supply and install all materials such as river sand, reinforcement rods, 20mm broken stone, etc. without any extra cost to owner. All concrete works and grouting shall be cured for a minimum period of 48 hours.

- (ii) Chipping, grouting, etc as recommended shall be done for completion and installation work on the finished floor, wall, roof, etc. It is the responsibility of the contractor to supply all necessary materials and to bring the disturbed surface to the original finish. Touch painting of scratches found on equipment, other painted metallic surfaces, galvanized etc. associated with this work is also included in the scope of contractor without any extra cost. Base steel structures shall be painted with 2 coats of epoxy primer and 2 coats of epoxy paint.

8.7.2.5 Standard requirements for testing and commissioning

- (i) The standard requirements for testing and commissioning are furnished below.
- (ii) All tests shall be carried out in the presence of Owner's representative and tests shall be recorded on an approved format duly certified. The records of all tests shall be submitted to the purchaser's representative.
- (iii) All interconnected wiring shall be checked thoroughly for correct connections with the wiring and schematic drawings of the manufacturer before energizing. All Power and bus bar connections shall also be thoroughly inspected and checked for correctness, foreign materials, tightness, etc. before energising the equipment.
- (iv) All components within the main equipment shall be tested for proper performance and correct operation before commissioning the equipment. All labelling and nameplates shall be checked for correctness. All nuts, bolts, clamps, joints, connections, etc shall be checked for tightness and tightened wherever required. All moving parts shall be checked for its correct movement and proper lubrication. Apply lubrication wherever required. All equipment containing liquid shall be checked for correct quantity filling and all gaskets,

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valves, etc. shall be checked for leak proofness. Oil filling if found required shall be done with dry & clean oil. Gaskets shall be replaced if found required. The condition of oil shall be tested in accordance with IS- 335.

8.8. Detailed Technical Specification-Supply of Materials

8.8.1. Lighting Poles

8.8.1.1.General

11-meter height lighting poles to be provided in the reclamation area road lighting. Lighting pole shall be octagonal type, galvanized steel, supplied with base plate, foundation bolts, and necessary fixing-bracket for fixing the luminaries. Street lighting pole shall have integral junction box. All poles shall be provided with heavy square nuts on the anchor bolts under the pole base plate and hex nuts on the top. GI conduits shall be embedded in muff for incoming and outgoing cables. Height of poles shall be as per design calculation. Height of poles shall be as per design calculation. MCB and neutral link for fixing in JB. Suitable CU UR armoured FR cables for giving interconnection between poles for giving supply to pole and lights shall be in the scope of supply. Minimum 30 M CU cable / pole. Junction box shall be with MCB, Terminal connector and neutral link. The Foundation shall be casted in the berth slab or Kerb as per instruction of EIC.

(a) Design:

The Octagonal Poles shall be designed to withstand the maximum wind speed as per IS 875. The top loading i.e. area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BSEN 40-3:2000, EN-40-3-3 or equivalent.

(b) Pole Shaft:

The pole shaft shall have octagonal cross section and shall be continuously tapered with single longitudinal welding. There shall not be any circumferential welding. All octagonal pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside.

(c) Material:

Octagonal Poles HT Steel Conforming to grade S355JO or equivalent. Base Plate Fe 410 conforming to IS 226 / IS 2062, Foundation Bolts EN.8 grade or equivalent.



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(d) Welding:

The welding shall be carried out conforming to approved procedures duly qualified by third party inspection agency. The welders shall also be qualified for welding the octagonal shafts.

(e) Pole sections:

The Octagonal Poles shall be in single section. There shall not be any circumferential weld joint.

(f) Galvanization:

The poles shall be hot dip galvanised as per IS 2629 / IS 2633 / IS 4759 standards with average coating thickness of 70 micron.

(g) Fixing Type:

The Octagonal Poles shall be bolted on a pre-cast foundation with a set of foundation bolts for greater rigidity.

8.8.1.2.Manufacturing:

The pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 or equivalent certified to ensure consistent quality & environmental protection.

(a) Base Plate:

Suitable size base plate and foundation bolts to be supplied along with the lighting pole.

(b) Tests:

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. For the various bought out item test certificates from equipment Manufacturer shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.

8.8.2. Flame Proof LED Street Light – 200 W

200 W led flame proof streetlight with pressure die-cast housing, high performance polycarbonate optics and ip66 ingress protection. 4kv inbuilt surge protection with top opening driver cover for easy maintenance, suitable for ZONE - 1 & ZONE- 2, GAS/VAPOUR GROUP II A, II B, II C, CIFMR - BIS - PESO CERTIFIED, efficiency 120 lm/w for lights at Q2 & Q3



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berths. The guarantee for Fittings shall be 5 years and certificate shall be provided. The Driver shall be of OEM make.

8.8.3. Flame Proof Junction Box

FLAMEPROOF Junction Boxes 16 A, Size 200mmx 150MM X 120 MM suitable for ZONE-1 & ZONE - 2, GAS/VAPOUR GROUP II A, II B, & II C , CIMFR - BIS - PESO CERTIFIED supply detail:

1. Cable size 4C X 4 sqmm CU / 3.5CX50 SQ MM, UG Armoured cable.
2. Holes Qty- 4 nos., preferably side holes suitable for cable sizes.
3. 16 A terminal 4 P. 2 P MCB,

8.8.4. HDPE (High Density Polyethylene) Pipe

HDPE pipe shall be provided for laying the HT cable at road crossing/hard surfaces. The HDPE pipes shall be 110 mm. dia: with thickness of not less than 5 mm. The HDPE pipe shall be made from high-density polyethylene (HDPE) resins meeting the following requirements:

The HDPE material supplied under this specification shall be high density, high molecular weight conforming to relevant IEC/BIS. The HDPE material shall conform to IS 14930/IS 4984/ASTM D 3350. Suitable size PVC flexible pipe with collar shall be provided for the end portion of HDPE pipe. In case for laying in cable tray, berths etc shall be clamped with 3 MM X 20MM GI clamp with SS Nut and bolts.

8.8.5. 1.1 KV LT Power Cable

The cable shall be 1.1 KV grade(E), XLPE Aluminium conductor cable of size 3.5C x 50 sq.mm. The cable shall be of best quality and as per the approved makes. The cables shall confirm to relevant Latest Indian Standards as applicable. The length of the cables mentioned in the schedule is only approximate and is likely to change. The payment for the cable work will be made on the actual length of the cable used for the work. All routine tests shall be conducted as specified in the relevant standards and test certificate shall be furnished.

(a) Scope

This specification provides for manufacture, testing at works before dispatch and delivery of 1.1 KV grade XLPE insulated, PVC FR cables as required.

(b) Application

The 1.1 KV cable is intended for use on Distribution network, lightings purpose etc. for outdoor application as per latest IS / IEC/ CEA rules



(c) Codes & standards as applicable

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS: codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes for 1.1KV grades if any applicable.

The cables shall comply with the latest edition of the following standards: The cables shall comply with the latest edition of the following standards:

- IS:1554 - PVC insulated heavy duty cables
- IS:7098 (Part –I) - XLPE Cables – LT
- IS:7098 (Part -II) - Cross-linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 kV up to and including 33 kV.
- IS:1255 – 1983 - Code of practice for installation and maintenance of power cables.
- IS:8130 - Conductors for insulated electric cables and flexible cords.
- IS:5831 - PVC insulation and sheath of electric cables
- IS:5819-1970 - Recommended short circuit rating of high voltage PVC cables
- IS:3961-1987 - Recommended current rating
- IS:3975 - Mild steel wires, strips and tapes for armouring of cables.
- IS:2633 - Methods of testing weight, thickness and uniformity of coating on hot dipped galvanized articles.
- IS:209 - Specification of zinc.
- IS:3961 (Part-II) - Recommended current ratings for PVC insulated and PVC sheathed heavy duty cables
- IS:10418 - Wooden drums for electric cables.
- IEC:540 & 540A - Test methods for insulation and sheaths of electric cables and cords

(d) Technical particulars of LT cables (As per Latest IS)

Size of Cable	: 3.5 C X 50 Sqmm
Voltage Rating	: 1100 V
Conductor Material	: Plain Aluminium
Insulation Type	: Type A PVC Compound
Tolerance	: 0.1 mm + 0.1 nominal thickness of insulation
Inner sheath thickness	: As per IS



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Outer sheath : Process of application: Extrusion: Thickness:
As per latest IS

8.8.6. Perforated GI Cable and Supports

This document covers the detailed technical specification for supply, inspection and erection of new GI perforated ladder-type cable trays along with accessories.

8.8.6.1.Scope of Work:

Scope of work includes

- (i) Supply of perforated GI cable tray of 300mm width, 50mm depth and 1.6mm thickness nut and bolts of suitable size etc. For measurement RUNNING METER will be considered including all accessories
- (ii) Erection of perforated GI cable tray along the wall etc. with clamping, jointing and fixing with GI angle supports, SS fastens/ SS cable tie etc.
- (iii) Fabrication and Erection of GI Cable tray GI Supports with all consumables.

8.8.6.2.Scope of Supply:

The scope of supply through this specification includes GI perforated cable trays, GI accessories such as bends, tees, crosses, reducers, Connector Coupler Plate and SS 316 hardware, cable tray supports and accessories like bolts, nuts, etc. **Running length will be taken for measurement.**

8.8.6.3.General Requirement:

- (i) The bidder shall quote indicating cost towards:
 - (a) Supply (GI cable trays - ladder, supports, fittings, SS hardware)
 - (b) Erection (Erection of GI Cable Trays along the walls etc. with GI angle supports)
- (ii) GI cable trays shall be manufactured in accordance with NEMA and ASTM standards.
- (iii) All Cable should be corrosion resistant and Fire retardant in accordance with the latest ASTM Each section of tray shall be complete with necessary GI coupler plates and associated stainless steel hardware for joining of trays bends etc.
- (iv) The coupling plate shall also be manufactured of the GI Tolerance on width and length shall be +/- 6mm and height +/- 2mm for cable trays of 150mm and above.
- (v) All rung to side member connection shall have both a mechanical and chemical (adhesive).
- (vi) Trays shall be assembled by use of locking pin. Required horizontal, vertical bends, tees, crosses, reducers shall be fabricated out of pultruded sections.



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8.8.6.4. Factory Acceptance Test

- (i) All cable trays and accessories shall be offered for inspection (OFFLINE/ONLINE if required). A notice of readiness for inspection shall be given minimum 15 days in advance.
- (ii) The following tests shall be carried out in presence of representative.
 - (a) Dimensional Check
 - (b) Deflection Load Test

8.8.6.5. Standards

As per Latest IS standards applicable.

8.8.7. Polycarbonate Lights Control Panel

Polycarbonate Lights control panel with timer, Contactor, Auto/Manual switch, MCB etc. as required.

Incomings

- 40A FP MCB - 1 NO.
- 32A 4P CONTACTOR - 1 NO.
- 24 Hr DIGITAL TIME SWITCH - 1 NO.
- 2A SP control MCB – 1No

Outgoings

- 10A SP MCB – 2Nos

Hensel make floor Mounting type high quality Glass fiber reinforced Polycarbonate insulated Panel board IP 65 according to IEC 60 529, protection class II made with modular type polycarbonate enclosures having internally embedded gasket made of polyurethane, these enclosures shall be flame retardant, self-extinguishing and glow wire tested at 960degC in accordance with IEC 60 695-2-11 UL subject 94; Impact strength IK 08(5 Joule) in accordance with DIN EN 50102. The Panel is in accordance with IEC 61439-1 & 2. The material should conform to RoHS directive 2002/95/EC, UV resistant according to IEC 61439-1. Panel board shall be with TYPE TEST Report (in accordance with IEC 61439-2 - ASTA certification' by CPRI) in accordance with IEC 60439-1. The CPRI report have mentioned of following tests performed and passed out satisfactorily with: Temperature Rise. Dielectric Properties. Short circuit withstand current – Rated peak & short time withstand current and Rated Conditional Short Circuit Current. Degree of Protection Clearance & Creepage Distance. Mechanical Operation Effectiveness of Protective Circuits The manufacturer / OEM of the Polycarbonate Enclosure and Panel board should be same. With supplied Panel, manufacturer Routine test certificate should be submitted and all mentioned type test certificate of the Panel should be for polycarbonate - as mentioned in specification.



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8.8.8. Earthing

(a) Applicable standards

Earthing Materials shall conform to latest applicable standards

IS: 2062 Grade A Quality Specification for MS angles, MS channel & MS Flat

IS: 2062 Chemical & Physical composition of materials.

IS: 1852 Rolling & Cutting tolerances for Hot Rolled Steel products

(b) Pipe Earthing

Providing pipe earthing for lighting poles with 1 M Cu bonded Rod 100 Micron with 4mm Dia/10 SWG along with required length of CU wire and giving connections to poles etc. as required.

Length: 1 meter (1000mm).

Diameter as per standard

Copper Bonding Thickness: 100 microns (μm).

Base Material: A core of high tensile, low-carbon steel (SAE 1018, BS 970). The steel provides the mechanical strength to be driven into the ground without bending or breaking.

Copper Purity: The copper layer is typically 99.9% pure electrolytic grade copper.

Application: Used for grounding systems in various applications, including residential, commercial, and industrial electrical systems, as well as for lightning protection.

(c) GI Flat for Earthing

The steel sections shall be re-rolled from the BILLETS/INGOTS of tested quality as per latest version of IS 2830. The GI Flat shall be of size 25 mm X 5 mm. The GI Flats shall be free from any defects. The Zinc for galvanizing shall conform to grade Zen 98 specified in IS: 209-1966 & IS: 4826-1979 with up-to-date amendments.

8.9. Technical Specification-Installation of Equipments

8.9.1. Erection of Lighting Poles

Light poles shall be erected on the foundation provided for light poles as per specification. Supply to the light poles shall be taken from the RYB connectors provided in the pole terminal box. The termination of interconnecting cable shall be done with necessary sockets to the terminal point. 16 A RYB connector, Junction boxes etc. and shall be provided inside terminal box for terminating the Cable. MCB shall be supplied and fixed for protection of light fittings in each poles. Internal FR sheathed cables from JB to light poles shall also to be supplied including all items for commissioning the light poles. Suitable anchoring bolt/Reinforcement shall be made for building up the pedestal from berth slab /kerb.



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8.9.2. Foundation for 11m High Lighting Pole

The pedestal for foundation shall be size of 45 CM x 45CM with 45 CM above ground level and also as per OEM Specs. The type of RCC, 12 MM size of tor steel, stirrup, anchor plate etc shall be finalized as per the approval of Engineer-in-charge in charge and as per the pole manufactures design. Suitable PVC pipe for cable entry shall be provided.

The information given above is only indicative. The drawings of foundation may be got approved from the Engineer-in-charge in charge before carrying out the foundation work and as per OEM recommendation.

8.9.3. Laying of Cable

8.9.3.1. Laying of Cables

Cable drums shall be checked for any damage in transit. Insulation test of the cable shall be carried out between phases and phase to earth before unwinding the drum.

Cables shall be clamped to the wall surface using suitable SS clamps as required according to the site conditions requirement. When the cable has been properly straightened, the cores are tested for continuity and insulation resistance and the cable is then measured. In case of PVC cables, suitable moisture seal tape shall be used for this purpose.

8.9.3.2. Cable Tags and Marker

Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule. The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire conforming to IS: 280. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables. Alternately, the contractor may provide cable tags made up of nylon, cable marking ties of 'TY-CAB' or equivalent type with cable number heat stamped on the cable tags. Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate. Location of underground cable joints shall be indicated with cable marker with an additional inscription —Cable joint. The marker shall project 150mm above ground and shall be spaced at an interval 100 meters and at every change in direction. They shall be located on both sides of road and drain crossings. Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry. Cable tags shall be provided inside the switchgear, motor control centers, control and relay panels etc., wherever required for cable identification, such as where a number of cables enter together through a gland plate. The price of cable tags and markers shall be included in the installation rates for cables /conduits quoted by the Contractor.



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Specific requirements for cabling, wiring ferrules as covered in respective equipment section shall also be complied with.

8.9.4. Providing End Termination of LT Cables

Supply and making of end terminations with brass/ pvc glands, lugs etc complete suitable for cables as per schedule of work. the item shall be single compression type tinned/nickel plated (coating thickness not less than 20 microns in case of tin and 10 to 15 microns in case of nickel) brass cable/pvc glands shall be provided by the contractor for all power and control cables to provide dust and weatherproof terminations. they shall comprise of heavy-duty brass casting, machine finished and tinned to avoid corrosion and oxidation. rubber components used in cable gland shall be neoprene and of tested quality. required number of packing glands to close unused openings in gland plates shall also be provided. for copper cable the termination materials shall be copper materials.

8.9.5. Fixing GI Cable Trays, GI Supports and Laying of Cable Along the Tray:

- (i) All cable Trays shall be fixed with suitable GI angle supports along the wall with suitable fasteners etc. GI supports of suitable size to be used in areas as per suggestion from Engineer-in-charge in charge.
- (ii) Proper alignment and fixing/clamping (SS nuts/bolts/washer/SS tie) shall be carried out for all trays.
- (iii) Supply, fabrication and painting of all structural supports for the cable tray is in the scope of supplier.
- (iv) Cables shall properly be laid in ladder /perforated trays of suitable size GI tray. There shall be no multi-tier laying in any of the cable trays. All cables shall be laid in parallel in side-by-side in single layer/tier only.
- (v) The cable laid on the cable tray shall be properly dressed in such a manner that the crossing of cables shall be minimized. The cable in the cable tray shall be clamped with suitable pre-fabricated SS cable tie/clamps/ PVC straps/GI clamps at every 0.5 m in vertical trays and 1 m in horizontal cable tray.
- (vi) Necessary permission will be given for drilling walls for the purpose of bolting the supports or welding to MS Pillars or MS Beams to GI Cable Trays. A combination of mechanical fasteners and adhesive make the strongest most reliable connection.
- (vii) Specifications and drawings are for assistance and guidance, but exact routing, locations, distances and levels will be governed by actual field conditions. Contractor is directed to make field surveys as part of his work prior to submitting offer & system layout drawings.



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8.10. Special Conditions for Electrical Works

- a. All current carrying components in all installation shall be of appropriate rating of voltage and frequency as required at respective areas.
- b. All equipments to be supplied and works to be executed shall conform to the CEA standards including protection and metering accessories. No extra amount will be paid in this regard.
- c. All testing and calibration etc are to be carried out as per requirement of statutory authority concerned.
- d. On completion of work the contractor has to obtain necessary safety/energisation certificate from statutory agency concerned, by submitting necessary completion statement/ drawing, equipment details etc. before energisation.
- e. All costs incurred in obtaining such approval/certificate are to be borne by the contractor. Statutory fees paid shall be reimbursed on presentation of document.
- f. All the Electrical work has to be certified by proper Electrical licensee.

8.11. Preparing Scheme of Installation and Submitting the Same to CEA for getting Approval

The contractor shall measure the soil resistivity and prepare the scheme and get the approval from Engineer-in-charge in charge or authorized officer before the commencement of work. The schemes, drawings and other technical data shall be submitted to statutory bodies for approvals for the installation. The defects if any noticed shall be rectified by the contractor. Approval has to be taken as per standards in connection with the work.



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9. MISCELLANEOUS WORKS

9.1. Demolition works

The contractor shall inspect the site and carry out the required investigation by himself about the present position and condition of the existing structures and assess the difficulties and the work involved in its dismantling and removal. The dismantling shall be done carefully without causing any damage to the remaining portions / structure. Following dismantling works are to be carried out:

- Deck slab (10.70 x 11.0 m size) including, beams of about 1.3m x 0.60m size shall be cut and removed for the area indicated on the drawing of about 111.8m x 10.7m in berth area and 12m x 10.7m in mooring location.
- RCC Screwerete piles of size 1200 mm dia. to be cut up to (-) 2.0 m or as directed by the Engineer-in-charge - in - charge for the length of structure, mentioned above.

Usable materials after dismantling the structures, if any, shall be the property of the Port and serviceable materials shall be suitably stacked as directed by Engineer-in-charge-in-Charge and the unusable dismantled materials/debris shall be suitably disposed off as directed by the Engineer-in-charge-in-Charge. No debris shall be deposited at the Project Site or in Backwaters.

The retrieved steel reinforcement bars of piles, beams and slabs obtained from dismantling shall become the property of the property of the Port and shall be suitably stacked as directed by Engineer-in-charge-in-Charge without any extra payment.

All protective measure and care shall be taken to avoid falling of concrete pieces in the back waters during the course of dismantling and fallen materials if any, shall be removed from the back waters by the contractor.

The debris shall be cleared on completing each day 's work as directed by the Engineer-in-charge-in-Charge.

The cut face shall be kept clean and exposed faces shall be plastered with C M 1:3.

9.2. Protective coating of concrete surfaces

Surface Preparation: The surface of the RCC structures shall be chemically cleaned to remove oil, grease and other contaminants and water jet to remove the chemical cleaning agent along with the contaminants. The loosely bonded previously applied coatings shall be removed by grit /shot blasting /power tool cleaning and attain a surface profile of minimum 25 microns.



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Application of Sealer coat: Sealer coat prepared with addition of 25% thinner shall be brush /roller /spray applied to the prepared concrete substrate in clean, sound and dry condition to seal the pores.

Application of Coating: The single component, moisture cure polyurea based, Corrosion, UV, weather and abrasion resistant Topcoat shall be brush or spray applied over the touch dry surface of sealer coat to a minimum DFT of 75 microns.

9.3. Protective coating of concrete handrail and post

All Handrail and post surfaces shall be thoroughly prepared prior to application of coating to ensure proper adhesion and long-term durability. The surfaces shall initially be chemically cleaned to remove oil, grease, and other deleterious substances, followed by high-pressure water jetting to remove the cleaning agents along with contaminants. All loosely bonded, deteriorated, or previously applied coatings shall be completely removed by grit blasting, shot blasting, or power tool cleaning, achieving a minimum surface profile of **25 microns** or as specified prior to application of coating.

The prepared surface shall be clean, sound, dry, and free from oil, grease, dust, laitance, curing compounds, and any other materials that may adversely affect the bond of the coating system. For newly cast concrete, coating application shall be carried out only after a minimum curing period of 28 days at an ambient temperature of approximately 30°C, and after the concrete has attained the specified compressive strength.

All cracks, honeycombs, joints, and surface imperfections shall be repaired and sealed using approved epoxy putty or repair compound before commencement of painting works. The entire surface shall then be prepared by chipping and wire brushing to ensure complete removal of loose particles and contaminants, followed by final cleaning with potable water or compressed air.

The coating system shall consist of application of **epoxy paint in two or more coats**, including an appropriate epoxy primer, strictly in accordance with the manufacturer's specifications regarding mixing, pot life, application method, drying time, and recoating interval. Each coat shall be applied uniformly to achieve the specified dry film thickness and ensure a continuous, defect-free finish. The work shall include all materials, labour, tools, equipment, surface preparation, priming, and application necessary to complete the coating system.

9.4. Concrete Bonding Agent

Providing and applying epoxy bonding agent for achieving a durable bond between old concrete and new concrete, complete in all respects and as directed by the Engineer-in-charge-in-Charge. The bonding agent shall be of approved make suitable for structural bonding



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applications. The existing precast concrete surface shall be prepared by mechanical means such as chipping, grinding, or sandblasting to remove laitance, loose particles, oil, grease and other contaminants, and the surface shall be clean and dry or as per manufacturer's recommendation. The epoxy bonding agent shall be mixed in the specified proportion as per manufacturer's recommendation until a uniform consistency is achieved and shall be applied uniformly over the prepared surface using brush, roller or suitable method to form a continuous coating, after which fresh concrete shall be placed while the epoxy is still tacky within the manufacturer's specified working time. The material shall be applied at a minimum coverage of 2.2 kg per square metre or as recommended by the manufacturer, whichever is higher, and shall possess high bond strength, low shrinkage, and good resistance to water and chemicals.

9.5. Stainless Steel Ladders

Ladders shall be fixed at location indicated or in such position as directed and in such a way that it is not damaged due to berthed vessels. The ladder shall be formed with 316 grade Stainless steel angles or flat sides with rungs of stainless-steel rods of dimensions shown in the drawing. The ladders shall be fixed by suitable brackets as directed by the Engineer-in-charge in charge. Necessary SS316L grade stainless steel bolts etc. shall be placed for the purpose, while constructing the superstructure.

9.6. Stainless Steel Mooring rings

Mooring rings shall be made from 25mm dia. 316 grade stainless steel bars with an outer diameter of 200mm. Suitable eyebolts shall be supplied with the mooring rings for fixing to the berth face in accordance with the drawings.

9.7. Anchor bolts

Whenever possible, anchor bolts for miscellaneous metal fixing and fenders shall be set in the forms with appropriate templates before concrete is poured. All anchor bolts shall be provided with suitable nuts and washers, whether it has been expressly specified in the Quantities/Drawings or not. The location of anchor bolts and miscellaneous steel shall be checked immediately before and after pouring of concrete by the contractor. Pouring of concrete shall not be done unless the locations have been approved by the Engineer-in-charge-in-Charge. The projecting threaded parts of the anchor bolts shall be protected by means of grease wrapped with clean rag.

9.8. GI Pipe for Rainwater drainage purpose on Berth

GI pipes shall confirm to IS:1239 and of medium class and size as specified in the schedule of quantities. Galvanizing of pipes shall confirm to IS:4736. The zinc coating shall be uniform adherent, reasonably smooth and free from all imperfections.



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9.9. Stainless Sections for Various works

The stainless sections to be used for various works specified in BOQ shall be of grade 316. The size and pattern shall be as specified in the Schedule of quantities and drawings. The stainless-steel sections shall be of brush finish.

9.10. Material Not Specified

All materials not herein detailed and fully specified but which may be required for use on works, shall be subjected to the approval of the Engineer-in-charge-in-Charge without which they shall not be used anywhere in the permanent works.

