SECTION-IX

PILE FOUNDATION

TECHNICAL SPECIFICATIONS

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TECHNICAL SPECIFICATIONS

SECTION-IX

PILE FOUNDATION

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TECHNICAL SPECIFICATIONS

SECTION- IX

PILE FOUNDATION

1.0 Scope and General Information

1.1 General

This section covers the specification for pile foundation work envisaged in the packages under this technical specification.

1.2 Applicable When Design of Pile foundation is in Contractor's Scope

1.2.1 Scope

1.2.1.1 The work to be performed under this specification consists of design of pile foundation as per soil investigation reports, design criteria & other hydrological parameters, boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of cast-in-situ RCC vertical bored piles of diameter of 750/ 1000/ 1200/ 1500 mm of suitable length as per design, providing all labor, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipment's & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with IS Codes, Employer's design criteria and specifications. The nature of work shall generally involve design, construction/ installation of cast-in-situ RCC vertical bored piles of suitable diameter of any length, pile caps, pedestals, tie beam (if required) etc. as per the site condition & Geo-technical investigation/ hydrological reports and also co-ordination with tower erection contractor for setting of stubs/ fixing of anchor bolts (as the case may be) for River crossing locations and installation of earthing for installed pile foundations. After review of each design/ drawing by the employer, the same shall be vetted by reputed institutions like IIT/NIT etc., which shall be finally approved by Employer based on the recommendation of the institution.

1.2.1.2 The bidder shall furnish in their bid complete data regarding his previously designed & successfully installed pile foundation experience and method of installation of the pile foundations, complete list of equipment's, tools and tackles, rigs, men, materials to be deployed for the work etc. Bidder has to furnish one sample calculation for one pile foundation designed/ got designed & installed successfully along with the bid. The above data is for assessing the present design capability of the Bidder and should not be construed as review/ approval of correctness of drawings/ designs by the Employer. Subsequent to the award,

successful Bidder shall have to comply to the technical specifications irrespective of the drawings/ designs submitted at the bidding stage without any financial implication to the Employer.

1.2.1.3 The rates quoted by bidder in the BPS shall be treated as firm. In case any significant deviation from the input parameters is noticed during the actual execution at site and the Employer considers it to be fit for change of price, mutually agreed rates for the pile foundation shall be derived on the basis of rates available in the Contract.

1.2.1.4 The Bidder's offer should be based on the mobilization of at least one no. piling rig for each tower location together with all associated working gangs, tool etc. (including at least one no. of Rotary Hydraulic drilling rig capable of boring suitable diameter piles up-to designed depth below existing ground level with necessary tools/ accessories for boring). However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, the same shall be deployed without any additional cost to the Employer. The contractor has to execute the complete job as per soil strata actually encountered at the time of construction.

1.2.1.5 The Contractor shall be responsible for the soundness of the above pile foundations designed &installed/ constructed by them.

1.2.1.6 After completion of installation/ construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Employer's representative, to establish its soundness. The numbers and procedure for conducting of pile integrity test is given briefly at ***Clause 4.0*** of this Section. Cost of carrying these tests is deemed to be included in the price quoted by the bidder for pile design & installation. Bidder has to quote the price accordingly.

1.2.1.7 The setting of stub/ fixing of foundation anchor bolts (as indicated in the drawing) shall be the responsibility of the Contractor.

1.2.1.8 The Bidder shall quote against the quantity furnished in BPS. Approach road, provision of platforms/ barges etc. for construction/ installation of pile foundations is deemed to be included in the scope of works. No deviation in this respect will be acceptable and any bid quoted based on different Bill of Quantities shall be liable for rejection.

1.2.2 **Sub-Soil Data**

The detailed soil investigation for the river crossing locations where pile foundations are envisaged shall be carried out by the Employer and provided to the bidders.

1.2.3 **Design and Drawings**

The Contractor shall develop the pile foundation design and drawing based on the soil investigation report, site conditions for the particular location and design criteria as mentioned below and submit for employer's approval as per mentioned in ***Clause no. 1.2.1.1*** above.

1.2.4 **Design Criteria for Pile Foundation**

1.2.4.1 **General**

The pile design shall be done in accordance with the latest version of IS 2911 (Part-I/ Section 2).

1.2.4.2 **Spacing of piles**

The minimum center to center spacing of piles shall be as following:

a) Piles in rock / Resting on rock: 2 times diameter of pile.

b) Piles deriving the capacity mainly from end bearing i.e. good value of Ø (Ø $\geq 30^0$): 2.5 times diameter of pile.

For all other type of soils (where the load carrying capacity of the pile is mainly due to friction): 3 times diameter of pile.

1.2.4.3 **Mean Scour Depth**

a) The mean depth of scour below HFL for the design of Pile located in/ around river shall be taken as per Clause 703 of IRC 78: 2014 or Lacey formula.

b) Formula given in Clause 703 of IRC 78 shall be used for natural channel or river with defined boundary whereas Lacey formula shall be used for rivers with undefined boundaries. The maximum discharge/ maximum velocity furnished by CWC/ Local Authority/ Employer shall be used for determination of Scour depth.

c) Silt factor shall be calculated based on weighted mean diameter (in mm) of the particle size of silt furnished by soil investigating agency based on laboratory test result of samples collected from bore hole for particular location for river bed/ bank obtained upto level of anticipated deepest scour.

1.2.4.4 **Maximum Scour Depth:**

a) For Piles located in midstream/ near the river bank/ erodible strata/ location prone to erosion due to river course meandering, maximum depth of Scour shall be taken as 2 (two) times of the mean scour depth. The portion of pile upto Scour depth shall not be considered for calculating capacity of pile.

b) If piles are provided for location other than river/ bank of the river/ erodible strata, where possibility of scouring is nil/ negligible and corrected SPT value is not more than 10, the soil upto that depth shall not be considered to provide any support to pile system/ group.

1.2.4.5 **Fixity**

a) Piles shall be designed as per Annexure 'C' of IS 2911 (Part 1/Sec 2) for Lateral load. To calculate fixed head moment 'M_F' of the equivalent cantilever, Pile embedded into pile cap shall be treated as partially fixed (i.e., restrained against rotation, not restraint against position). Accordingly, equivalent length of cantilever piles shall be taken as 1.2 times of total virtual cantilever length (i.e. $E + Z_F$) of pile.

b) Then fixed end moment given in Clause 6.5.2 & C-4.3 of Annexure 'C' of IS 2911(Part I/Sec 2: 2010) shall be

$$M_F = 0.6 \times H \times (E + Z_F)$$

Where H = lateral load in kN
E = cantilever length above ground/ bed to the point of load application, in m
ZF = depth to point of fixity

1.2.4.6 **Factor of Safety (F.O.S)**

a) Factor of Safety is the ratio of ultimate load capacity of a pile to safe load on the pile.

b) The Ultimate load capacity of Pile/ pile group shall be determined as per Clause 6.3 and Annexure-B of IS 2911 (Part 1/Sec 2):2010 using Static formula.

c) Minimum F.O.S as per Clause 6.8 of IS 2911 (Part 1/Sec 2) using static formula shall be considered.

1.2.4.7 **Bearing Capacity factors**

Bearing Capacity factors shall be as per IS 2911 (Part 1/sec 2): 2010.

1.2.4.8 **Other design parameters**

Other design parameters such as Angle of wall friction (δ), Earth pressure coefficient (K), Effective over burden (P_{DI}), Embedment of pile in pile cap, Stiffness factors (T & R) and Socket length of pile in weathered / soft rock /hard rock shall be as per IS 2911 (Part 1/ Sec 2):2010.

1.2.5 **Billing Breakup**

For progressive payments, the billing break-up shall be made during execution.

1.3 **Applicable When Design of Pile foundation is not in Contractor's Scope and Employer shall provide construction drawings to the Contractor**

1.3.1 Scope

1.3.1.1 The work to be performed under this specification consists of boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of cast-in-situ RCC vertical bored piles of diameter, as specified in BPS, providing all labor, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipment's & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with IS Codes, drawings and specifications. The nature of work shall generally involve construction/installation of cast-in-situ RCC vertical bored piles of specified diameter, pile caps, pedestals, tie beam (if required) etc. as per the Employer's construction drawings and also co-ordination with tower erection contractor for setting of stubs/ fixing of anchor bolts (as the case may be) for River crossing locations

1.3.1.2 The bidder shall furnish in their bid complete data regarding method of installation of the pile foundations, complete list of equipment's, tools and tackles, rigs, men, materials to be deployed for the work etc.

1.3.1.3 The Bidder's offer should be based on the mobilization of at least one no. piling rig for each tower location together with all associated working gangs, tool etc. (including at least one no. of Rotary Hydraulic drilling rig capable of boring of specified diameter piles up-to designed depth below existing ground level with necessary tools/accessories for boring). However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, the same shall be deployed without any additional cost to the Employer. The contractor has to execute the complete job as per soil strata actually encountered at the time of construction.

1.3.1.4 The Contractor shall be responsible for the soundness of the above pile foundations designed &installed/constructed by them.

1.3.1.5 After completion of installation/ construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Employer's representative, to establish its soundness. The numbers and procedure for conducting of pile integrity test. Cost of carrying these tests is deemed to be included in the price quoted by the bidder for pile design & installation. Bidder has to quote the price accordingly.

1.3.1.6 The setting of stub/ fixing of foundation anchor bolts (as indicated in the drawing) shall be the responsibility of the Contractor.

1.3.1.7 The Bidder shall quote based on the provisional Bill of Quantities (BOQ) furnished in the Bid Proposal Sheet (B.P.S). No deviation in this respect will be acceptable and any bid quoted based on different Bill of Quantities shall be liable for rejection. However, the payment will be made as per actual quantity executed as per Employer's design & drawing based on the unit rates for items quoted.

1.3.2 **Sub-soil Data**

The detailed soil investigation for the locations where pile foundations are envisaged shall be carried out by the Contractor (if mentioned in the BPS).

1.3.3 Design and Drawings

Employer shall develop the pile foundation design based on the soil investigation report for the particular location. The construction drawings required for execution of pile foundations shall be given to the contractor as per site requirement during execution stage.

1.4 **Table of compliance**

Bidder shall use one copy of this section of Technical Specifications to indicate compliance status. Within the right-hand margin, Bidder shall indicate compliance status to each paragraph along with a cross-reference to its proposal and an index key for any explanation or comment.

In addition, The Bidder shall annotate the Table of contents of the above stated volume to provide a high-level summary of compliance status, in both cases, the following symbols, and no others, shall be used:

C- Bid complies with all requirements in the adjacent paragraph

A-Bid is not compliant with the requirements in the adjacent paragraph, but a functional alternative is proposed.

X- Bid takes exception to the requirements of the adjacent paragraph and no functional alternative is proposed.

Only one symbol shall be assigned to a paragraph and shall indicate the worst-case level of compliance for that paragraph. The annotation may be hand written.

Bidder shall underline, on the compliance copy, all requirements to which exceptions have been taken (X) or to which alternatives have been proposed (A).

Each alternative shall be clearly and explicitly described. Such descriptions shall use the same paragraph numbering as the bid document sections addressed by the alternatives. All alternative descriptions shall be in one contiguous section of the Bidder's proposal, preferably in the same volume, and titled "Alternatives". A separate section titled "Exceptions" should be provided containing any discussion or explanation Bidder chooses to provide concerning exceptions taken.

Alternatives which do not substantially comply with the intent of the bid documents will be considered exceptions.

The Employer will assess the merits of each alternative and exception and will be the sole judge as to their acceptance.

2.0 Construction of Bored Cast-In-Situ Pile Foundation

2.1 General Requirement

2.1.1 The specification covers the technical requirements for piling work, general description of work, quality and workmanship. In every case, work shall be carried out to the satisfaction of the Employer in accordance with the Technical Specifications and conform to location, lines, grades and cross sections shown on the construction drawing or as directed by the Employer. The specifications are not, however, intended to cover all the minute details and the work shall be executed according to the specified Indian Codes. In absence of the IS Codes, work shall be executed according to the best prevailing local Public Works Department practice or to the recommendations of the relevant International Standards or to the instructions of the Employer. This specification shall have precedence in case anything contrary to this is stated anywhere in this Bid Document. In case of conflict between the Specification and Codes, the former shall prevail.

2.1.2 The work shall include mobilization of all necessary equipments, providing necessary engineering supervision through qualified and technical personnel,

skilled and unskilled labour, etc. as required to carry out the complete piling work. The minimum capacities of some key equipment are listed below. However, bidder has to furnish information regarding the equipments they intend to deploy for the project as per Performa stipulated in the relevant schedules of the BPS: -

Sl. No.	Description	Capacity
1.	Tripod height	6m to 10m (clear drop)
2.	Rig (winch) capacity	3 T to 5T
3.	Weight of chisel	2T to 3T
4.	Mud pump capacity	15 HP to 25 HP
5.	Dia. of outlet pipe for bentonite	2.5 inch
6	Hydraulic rotary drilling rig along with all accessories	Minimum torque of 12T

Note: Bidder may have to provide higher capacity equipments than mentioned above, as per the actual requirement for the execution of the job, without any additional financial implication to Employer.

2.2 Layout and Levels

2.2.1 Layout and levels of structures etc. shall be made by the Contractor, at his own cost, from the general grid of the plot and the bench marks given by the Employer. The Contractor shall make his own arrangements, at his own cost, for locating the co-ordinates and position of piles as per approved drawings and for determining the Reduced Level (R.L.) of the locations with respect to the single bench mark indicated by the Employer. Two established reference lines in mutually perpendicular direction shall be indicated to the Contractor. The Contractor shall provide at site all the required survey instruments, materials and men to Employer for verification of the detailed layout and correctness of the layout and levels to the satisfaction of the Employer so that the work can be carried out accurately according to specifications and approved drawings. The contractor shall be solely responsible for the correctness of layout and levels. Approach road details also to be included in the layout.

2.3 Site Preparation

This section of the specification covers site preparation of the areas as indicated in the drawings.

2.3.1 The area shall be stripped to remove roots of grass, rubbish and slush, shrubs or other organic materials. Spoiled materials shall be burnt or removed to approved disposal areas on or near the job site as directed by the Employer.

2.4 Properties of Construction Materials

This clause specifies the properties of common building materials unless otherwise mentioned in the drawings or schedule of items.

All materials viz., cement, steel, aggregates, water etc. which are to be used for pile construction are detailed below. However, aggregates more than 20mm shall not be used, except for lean concrete.

2.4.1 Coarse aggregates/ Stone

2.4.1.1 All coarse aggregates shall be as per IS 383 consisting of hard, strong, compact grained and durable pieces of crushed stone having uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. Coarse aggregates should be of angular shape & rectangular surface and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles, adherent coatings, clinkers, slag, mica and any other materials liable to affect the strength, durability or appearance of concrete. The surface of a freshly broken stone shall be bright, clean, and free from any dull, chalky or earthy appearance. Coarse aggregates with round surface shall not be used. Coarse aggregates shall not absorb more than 5% of its weight of water after 24 hours immersion. Samples shall be submitted by the Contractor and approved samples shall be retained by the Employer for comparison of bulk supply.

2.4.1.2 Sieving and washing of aggregates by approved method shall be carried out wherever required**.**

2.4.1.3 Grading of coarse aggregate shall generally conform to IS 383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.

2.4.1.4 The maximum size of aggregate shall be as follows unless specified otherwise:

i) Reinforced concrete with very narrow space: 10mm
ii) Reinforced concrete & Plain Concrete : 20mm
iii) Lean Concrete 1:3:6 or 1:4:8 : 40mm

2.4.2 Cement

Cement used shall generally be ordinary Portland Cement conforming to the latest Indian Standard Code IS 8112 or IS 12269. Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS 1489 or Portland Slag Cement conforming to IS 455 can also be used. The Contractor shall submit the manufacturer's certificate, for each consignment of cement procured, to the Employer. However, Employer reserves

the right to direct the Contractor to conduct tests for each batch/ lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS 456, as per Geotechnical investigation report and as mentioned in the construction drawing. No additional payment shall be made for using Sulphate Resistant Cement.

For foundation in creek, exposed to sea water/ coastal environment, or buried aggressive soil areas, tidal zone etc., ready mix concrete/ design mix concrete using Portland Pozzolana Cement conforming to IS 1489 shall preferably be used.

2.4.3 Sand

Sand shall be hard, durable, clean and free from any adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of concrete or to cause corrosions to any metal in contact with such concrete. In no case the cumulative percentage of impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Employer all sand shall pass through IS Sieve no. 2.36 mm. Sand for concrete shall conform to IS 383.

2.4.4 Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc. Potable water is generally considered fit for use. Water to be used shall comply with the requirements of IS 456. Average 28 days compressive strength of at least three 15 cm. cubes of concrete prepared with proposed water shall not be less than 90% of average strength of three similar cubes prepared with distilled water. PH of water shall generally be not less than 6.

2.4.5 Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Reinforcement shall conform to IS 1786 for deform and cold twisted bars (Fe 500/ Fe500D). If mentioned in the approved drawing, epoxy coated reinforcement shall conform to IS 13620. Thermo Mechanically Treated (TMT) bars (equivalent grade) in place of cold twisted bars are also accepted. Hard drawn steel wire shall conform to IS

432. Hard drawn steel wire fabric shall conform to IS 1566. All steel bars including and above 6mm diameter shall be of tested for quality. Substitution of reinforcement, other than those mentioned above, shall not be permitted without the prior approval of the Employer. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of approved foundation drawings and Specifications. Spacers, chairs, stays, hangers and annealed steel wire for bending etc. as may be necessary, should be used for proper completion of foundation job. Spacers or chairs should be placed at a maximum spacing of 1 m and closer spacing shall be provided wherever necessary.

For foundation in creek, exposed to sea water /coastal environment, or buried aggressive soil areas, tidal zone etc., epoxy coated reinforcement conforming to IS 13620 shall be used.

2.5 Storage & Handling of construction Materials

All materials shall be stored by the Contractor in a manner aiding convenient access for identification and inspection at all times. The storage arrangements shall be subject to the approval of the Employer. Storage of materials shall be as described in IS 4082.

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Employer shall not be used for concrete, and shall be removed from site immediately, failing which, the Employer will get the materials removed and the cost thereof shall be recovered from contract price. The Contractor shall maintain up to date accounts of receipt, issue and balance (stock wise) of all materials.

2.5.1 Cement

The cement shall be stored in dry enclosed shed, well away from the walls and insulated from the floor to avoid contact with moisture. The cement shall be stacked in easily countable stacks to facilitate removal of first in first out basis. The cement bags shall be gently kept on the floor to avoid leakage of cement from the bags. Sub-standard or partially set cement shall be immediately removed from the site as soon as it is detected. Cement stored for period beyond 90 days shall be tested before use.

2.5.2 Coarse Aggregates and Sand

All coarse aggregates & sand shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other

injurious substance at any stage. Aggregate of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Employer, aggregates from different sources shall be stacked separately with proper care to prevent intermixing.

2.5.3 **Reinforcement**

For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colors. Steel reinforcement shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting in case of storage time exceeding one month. In store, reinforcement bar shall be stacked above ground level by at least 150mm either on brick/cement/stone platform or concrete/brick planks.

2.6 **Cement Concrete**

2.6.1 **General**

2.6.1.1 This section of the specification deals with cement concrete, plain or reinforced, and covers the requirement for concrete mix design, strength and quality, pouring at all levels, forming, protection, curing finishing, admixtures, inserts and other miscellaneous works.

2.6.1.2 The provisions of IS 456 shall be complied with, unless permitted otherwise. Any other Indian Standard Code shall form the part of the specification to the extent it has been referred to or applicable within this specification.

2.6.1.3 The Contractor shall furnish all labour, material and equipment to form, place and finish all structural concrete, concrete works and miscellaneous items complete, as described herein.

2.6.2 **Admixtures**

2.6.2.1 The admixtures in concrete for promoting workability, improving strength or for any other purpose shall be used only after the written permission from the Employer. The Admixtures shall conform to IS 9103.

2.6.2.2 Admixtures should not impair durability of concrete nor combined with the constituent to neither form harmful compounds nor increase the risk of corrosion of reinforcement.

2.6.2.3 Addition of admixtures should not reduce the specified strength of concrete in any case. The workability, compressive strength and the slump loss of concrete

with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

2.6.2.4 The chloride content of admixtures shall be independently tested for each batch before acceptance.

2.6.2.5 If two or more admixtures are used simultaneously in the same concrete mix, data shall be provided to assess their interaction and to ensure their compatibility.

2.6.2.6 In case admixtures are used in the concrete for any structure, fresh mix design shall be done considering the admixture with the specific approval from Employer. No extra payment shall be made to the Contractor on this account.

2.6.3 **Grades of Concrete**

2.6.3.1 The minimum grade of concrete to be used for piling shall be M25 with minimum cement content 400 kg/m^3 and maximum water cement ratio of 0.5. Concrete shall conform to the controlled design mix as specified in IS 456. For lean concrete of nominal mixes of 1:3:6 and/ or 1:4:8 (with aggregates of nominal size 40 mm maximum, by weight converted to equivalent volume) shall also be used as per field quality plan. The concrete in aggressive surroundings due to presence of sulphate, etc., shall confirm to IS 456. The slump of concrete shall be maintained between 150 to 180 mm.

2.6.3.2 The Contractor shall carry out concrete mix design in accordance with IS 10262 and submit mix design calculations and get them approved from the Employer well in advance of installation of pile foundations. The Contractor shall carry out adequate number of tests in accordance with IS 456 to ensure concrete of the minimum specified strength at requisite workability (i.e. slump).

2.6.3.3 For foundation in coastal areas or creek or aggressive soil areas or under marine environment, Ready Mix Concrete of grade as specified in BPS/Section-IA shall be used in RCC vertical bored piles, pile caps, pedestal/ Chimney, tie beam. However, design mix concrete of Grade, as mentioned in above, conforming to IS 456 with potable water can be used at locations where transportation of ready-mix concrete is not feasible. Minimum cement content shall be as per IS 456. However, in any case cement content shall not be less value than 330 kg/m3. The surface of the reinforcement steel shall be treated with epoxy-based coating to enhance corrosion performance of foundation. Use of epoxy coated reinforcement in foundation shall be as per IS 13620. In addition, 02 (two) numbers of coats of bituminous painting of minimum 1.6 kg/m2 per coat shall be applied on all the exposed faces of the foundation (i.e. pedestal/ chimney/ tie beam & base slab/ pile cap). Double coat 20 mm thick cement plaster shall be provided on all exposed concrete surface as well up to 300 mm below ground level to give protection to concrete surface from environmental and saline effect. Three

coats of anti-corrosive paint of minimum 30-35 microns dry film thickness each shall be applied on the stub upto 50 mm below chimney level and 350 mm above chimney level. Cost of the above shall be deemed to be included in the rates quoted.

For concreting under water, Slump of concrete shall be 100 -150 mm recorded by suitable method.

2.6.4 **Workmanship**

All workmanship shall be according to the current Industry standard and best practices.

Before starting a pour the Contractor shall obtain the approval of the Employer in a "Pour Card" maintained for this purpose. He shall obtain complete instructions about the material and proportions to be used, Slump/ workability, quantity of water per unit weight of cement, number of test cubes to be taken, type of finishing to be done, any admixture to be added, any limitation on size of pour and stopping of concrete in case of premature stopping of pours.

Mixing of Concrete

2.6.4.1 All design mix concrete shall be mixed in mechanically operated mixer of an approved size and type capable of ensuring a uniform distribution on the materials through the mass. However, contractor can also use central batching plant situated within the area allocated for the Contractor's particular use.

2.6.4.2 The proportions of sand, coarse aggregate, cement and water shall be as determined by the mix design. However, in case of nominal mix concrete (for lean concrete only) the proportions of sand, coarse aggregate, cement and water shall be fixed. The proportions, as determined for design mix concrete and shall always be approved by the Employer. The quantities of the cement, sand and coarse aggregates shall be determined by weight. The water shall be measured accurately after giving proper allowance for surface water present in the aggregate for which regular check shall be made by the Contractor.

2.6.4.3 The water shall not be added to the mix until all the cement and aggregates consisting the batch are already in the drum and dry mixed for at least one minute. Mixing of each batch shall be continued until there is a uniformity in colour and consistency but in no case shall mixing be done for less than two (2) minutes and at least forty (40) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Employer. Mixers shall not be loaded above their rated capacity as it prevents thorough mixing. If there is segregation after unloading from the mixer the concrete should be remixed.

2.6.4.4 The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Employer to allow for loss in the drum.

2.6.5 **Conveying Concrete**

2.6.5.1 Concrete shall be handled and conveyed from the place of mixing to the place of final laying as rapidly as practicable, by approved means, before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation of Concrete which may occur during transportation of concrete. In case of any such segregation during transport, the concrete shall be re-mixed. During very hot or cold weather, if directed by the Employer, concrete shall be transported in deep containers, having mortar leak proof, which will reduce the rate of water loss by evaporation and loss of heat. Conveying equipment for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete.

2.6.6 **Placing of Concrete**

a) Formwork and placement of reinforcement shall be approved in writing by the Employer before concrete is placed. The forms shall be well wetted and oil shavings, dirt and water that may have collected at the bottom shall be removed before concrete is placed. Concrete shall be deposited in its final position without segregation, re-handling or flowing. The interval between adding the water to the dry materials in the mixer and the completion of the final placing inclusive of compaction of the concrete shall be well within the initial setting time for the particular cement in use or as directed by the Employer. As far as possible, concrete shall be placed in the formwork by means approved by the Employer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1800 mm shall have to be approved by the Employer. Once the concrete is deposited in its final position, it shall not be disturbed. Care should be taken to avoid displacement of reinforcement or movement of formwork.

b) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete.

c) After the concrete has been placed it shall be spread and thoroughly compacted by approved mechanical vibration to a maximum subsidence without segregation and thoroughly worked around reinforcement or other

embedded fixtures into the correct form and shape. Vibrators shall not be used for pushing and shoveling concrete into adjoining areas. Vibrators must be operated by experienced men and over-vibration shall not be permitted. Head tamping in some case may be allowed subject to the approval of the Employer. Care must be taken to ensure that the inserts, fixtures, reinforcement and form work are not displaced or disturbed during placing of concrete. No concrete shall be placed in open while it rains. If there has been any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete. Tie beams, pile caps, footings shall be poured in one operation normally, in special circumstances with the approval of the Employer these can be poured in horizontal layers not exceeding 500 mm in depth. When poured in layers, it must be ensured that the under layer, is not already hardened. Blending of under layer if any, shall be effectively removed.

d) Wherever vibration has to be applied externally the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

2.6.7 Inserts

All anchors, anchor bolts, inserts, stubs, etc. and any other items those are required to be embedded in the concrete shall be placed in correct position before pouring. Extra care shall be taken during pouring operation to maintain their position as indicated in the drawings. These inserts shall be welded to the nearest reinforcement to keep them in position and all such welding shall be deemed to be included in the unit rate quoted and no extra payment shall be made on this account.

2.6.8 Blockouts

Blockouts in concrete as indicated in the drawing or as directed by the Employer shall be provided wherever required. No extra payment shall be made to the Contractor on this account.

2.6.9 Repairs and Finishes of Concrete

All concrete surfaces shall have even and clean finish, free from honeycombs, air bubbles, fins or other blemishes. The formwork joints marks for concrete work exposed to view shall be rubbed with carborandum stone and defects patched up with a paste of 1-part sand and 1-part cement and cured. The finish shall be made to the satisfaction of the Employer.

The unit rate of pile foundation/ unit rate of concrete (as the case may be) work shall be inclusive of the cost of cleaning and finishing exposed surface as mentioned above.

2.7 Reinforcement Steel

This section of the specification shall cover providing reinforcement steel and its cleaning, bending, binding, placing with arrangements for chairs, supports and suitable covers for all reinforced concrete works, below and above ground level as per drawings and specifications.

2.7.1 General Requirements

2.7.1.1 Reinforcement steel of same type & grade shall be used for structural reinforcement work as detailed in the drawing released by the Employer. No work shall be commenced without proper verification with the bar-bending schedule provided in the drawing.

2.7.1.2 Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated on the drawings and as per specifications. The reinforcement shall be either plain or deformed steel bars or welded wire fabric conforming to relevant IS specifications.

2.7.1.3 Any adjustment in reinforcement to suit field conditions and construction joints other than shown on drawings shall be subjected to the approval of Employer.

2.7.2 Bending

2.7.2.1 Unless otherwise specified, reinforcement steel shall be bent in accordance with procedure specified in IS 2502. Bends and shapes shall comply strictly with the dimensions in the approved Bar Bending Schedule. Contractor shall be entirely responsible for its correctness. Bars correctly bend shall only be used.

2.7.2.2 No reinforcement shall be bent when in position in the work without approval of the Employer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Re-bending can be done only if approved by the Employer. Reinforcement bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved.

2.7.3 Placing in position

2.7.3.1 All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by approved means as mild steel chairs, and/or concrete spacer

blocks. Bars intended to be in contact, at crossing points, shall be securely bond together at all such points by two number No.20G annealed soft-iron wire.

Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be so spaced that the main bars do not sag perceptibly between adjacent spacers.

2.7.3.2 The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be checked by the Employer for accuracy of placement and cleanliness and necessary correction as directed by him shall be carried out. The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Employer. Care should be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar 1:2 (one-part cement: two parts sand) by volume and cured for at least (7) days. The sizes and locations of the concrete blocks shall be approved by the Employer.

2.7.3.3 Longitudinal reinforcement in pile shall be high yield strength cold twisted deformed steel bars conforming to IS 1786. Thermo-mechanically Treated (TMT) bars (equivalent grade) in place of Cold twisted deformed steel bars are also accepted. Lateral reinforcement in pile shall be of Tor Steel conforming to IS 432 (Part-I).

2.7.3.4 The longitudinal reinforcement shall project 52 times its diameter above cut-off level unless otherwise indicated in the drawing.

2.7.3.5 The minimum diameter of the links or spirals bar shall be 8mm and the spacing of the links or spiral shall not be less than 150mm and in no case more than 250 mm. The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.

2.7.3.6 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible, number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/ pile bore by providing necessary laps as per IS 456.

2.7.3.7 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100 mm for the full depth of cage, unless otherwise specified.

2.7.3.8 The laps in the reinforcement shall be such that the full strength of the bar is

effective across the joint and the reinforcement cage is of sound construction. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS 456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length.

2.7.3.9 Laps shall be staggered as far as practicable and as directed by the Employer. Not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Center to Center).

2.7.3.10 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, as required, without any additional cost to the Employer.

2.7.3.11 Minimum clear cover to the reinforcement shall be 75 mm unless otherwise mentioned.

2.7.3.12 Unless otherwise specified by the Employer, reinforcement shall be placed within the following tolerance as specified in IS 456: -

a) For effective depth 200mm or less +10mm

b) For effective depth more than 200mm +15mm

The cover shall in no case be reduced by more than one-third of specified cover or 5mm whichever is less.

2.7.3.13 Welding of reinforcement bars shall be avoided. However, welding may be done in specific case subject to prior permission from the Employer/ prior written consent of Engineer-in-charge. Welding must be staggered and shall be done in accordance with IS 2751. Couplers as per IS 16172 may be used for jointing of reinforcement bars.

2.8 Construction of Pile Cap, Pedestal, Tie Beam etc.

The Contractor shall deploy all labour, equipment, tools & tackles and materials required for complete execution of the work in accordance with the drawings and as described herein.

2.8.1 Excavation

2.8.1.1 The Contractor shall control the grading in the vicinity of all excavation so that the surface of the ground will be properly slopped or diked to prevent surface water from running into the excavated areas during construction.

2.8.1.2 Excavation shall include the removal of all materials required to execute the work

properly and shall be made with sufficient clearance to permit the placing, inspection and setting of forms and completion of all works for which the excavation was done.

2.8.1.3 Side and bottoms of excavation shall be cut sharp and true, undercutting shall not be permitted. Each side of excavation shall be used in lieu of formwork for placement of concrete unless authorized, in special cases, by the Employer, where limitation of space for larger excavation necessitate such decision.

2.8.1.4 When machines are used for excavation, the last 300mm before reaching the required level shall be excavated by hand or by such equipment that will leave the soil at the required final level, in its natural conditions.

2.8.1.5 Suitability for bearing of the bottoms of excavations shall be determined by the Employer.

2.8.1.6 The bottom of excavation shall be trimmed to the required level and when carried below such levels, by error, shall be brought to level by filling with lean concrete 1:4:8 mix, with aggregate of 40mm maximum nominal size at no additional cost to the Employer.

2.8.1.7 The Contractor shall be responsible for assumptions and conclusions regarding the nature of materials to be excavated and the difficulty of making and maintaining the required excavations and performing the work required as shown on the drawing and in accordance with these specifications. The Contractor shall be responsible for any damage to any part of the work and property caused by collapse of sides of excavations. Materials may be salvaged, if it can be done with safety for the work and structure, as approved by the Employer.

However, no extra claim shall be entertained for materials not salvaged or any other damage to Contractor's property as a result of the collapse. He shall not be entitled to any claim for redoing the excavation as a result of the same.

2.8.1.8 Excavations for foundations specified shall be carried out at least 75mm or as specified in relevant drawings below the bottom of structural concrete and then be brought to the required level by placing lean concrete of 1:4:8 mix or as specified in drawings with aggregate of 40mm maximum nominal size.

2.8.1.9 When excavation requires coffer dams, sheet piling, bracing, sheeting, shoring, draining, dewatering etc. the Contractor shall have to provide the same as required and the cost there of shall be included in the unit rate quoted for the item of excavation and contractor shall submit necessary drawings showing arrangement and details of proposed installation and shall not proceed until he has received approval from the Employer.

2.8.1.10 The Contractor shall have to constantly pump out the water collected in pits due to rain water, springs, seepage etc. and maintain dry working conditions at no extra cost to the Employer.

2.8.1.11 For the purpose of excavation in earthwork, all types of soil including kankar, morum, shingle and boulders up to 150mm size are included and no separate payment shall be made for different type of soils encountered.

2.8.2 **Form work**

2.8.2.1 **General**

2.8.2.1.1 If it is so desired by the Employer, the Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Employer. The form work shall conform to the shape, alignment and dimensions as shown in the drawings.

Form work shall be composed of steel and/or best quality shuttering wood of non-absorbent type or plywood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Plywood or equivalent shall be used where specified to obtain smooth surfaces for exposed concrete work. Struts shall generally be mild steel tubes, and strong sal ballis of 150mm in diameter or above. Bamboos, small diameter ballis, etc. shall not be used unless approved by the Employer in specified cases.

Supports or props should not be supported on an un-propped lower suspended floor or beam unless calculations are submitted to the Employer to confirm the strength of the lower floor or beam and no propping shall be taken out until the Employer approval has been given.

2.8.2.1.2 The form work shall be true and rigid and thoroughly braced both horizontally and diagonally. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as well as working load. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening off its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of Employer immediately and rectified free of charge as directed by him. To achieve the desired rigidity, the bolts, space blocks, the wires and clamps as approved by the Employer shall be used but they must in no way impair the strength of concrete or leave stains or marks on the finished surface, where there are chances of these fixtures being embedded, only mild steel or concrete of

adequate strength shall be used. Bolts passing completely through liquid retaining walls/ slabs for the purpose of securing and aligning the formwork should not be used.

2.8.2.1.3 Temporary openings for cleaning, inspection and for pouring concrete may be provided at the base of vertical forms and as may be directed by the Employer. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.

2.8.2.2 **Cleaning and Treatment of Forms**

2.8.2.2.1 All forms shall be thoroughly cleaned of old concrete wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Along with wire brushes, brooms, etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Employer.

2.8.2.2.2 Before shuttering is placed in position the form surface in contact with concrete shall be treated with approved non-standing oil or composition of other material approved by the Employer. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or existing concrete surface. They shall not be allowed to accumulate at the bottom of the shuttering.

2.8.2.2.3 If formwork for pedestal/ chimney is erected for the full height of the section, as placing of concrete proceeds, wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jarring the concrete.

2.8.2.3 **Removal of Forms**

2.8.2.3.1 The Contractor shall begin the removal of formwork only after approval of Employer. He shall place on record the date on which the concrete is placed in different parts of the work and the date of the removal of formwork there from. This record shall be checked and countersigned by the Employer. The Contractor shall be responsible for the safe removal of formwork but the Employer may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork or loading shall be entirely reconstructed without any extra cost to Employer.

2.8.2.3.2 Forms for various types of structural components shall not be removed before the minimum periods specified below which shall also be subject to the approval of the Employer.

2.8.2.3.3 No supporting forms shall be removed suddenly in such manner as to create shock

loading. Forms for sides shall not be removed before 2 days. Bottom forms shall not be removed before 28 days unless this period is reduced with specified concurrence of the Employer.

However, in any case, formwork shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected to, at the time of removal of forms.

2.8.2.4 **Re-use of Forms**

Before re-use, all forms shall be thoroughly scrapped cleaned and joints, etc. shall be examined, when necessary repaired and inside surface treated as specified. Formwork shall not be used/ re-used, if declared unfit or unserviceable by the Employer.

2.8.3 **Back Filling**

2.8.3.1 **General Requirement**

2.8.3.1.1 After completion of foundation footings, pile caps, pedestals, tie beams and other constructions below the elevation of the grades, and prior to back filling, all forms of temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials, back filling shall begin only with the approval of the Employer.

2.8.3.1.2 The soil to be used for back filling purpose shall be inorganic material and shall be free from any foreign substance which can harm or impair the strength of footing in any manner. In any case the soil to be used for back filling purpose shall have the prior approval of the Employer.

2.8.3.1.3 The soil to be used for back filling purpose shall be either from the excavated earth or from the borrow pits, as directed by the Employer. The soil may have to be brought from a distance up to 2 km. By the shortest haulage route as approved by the Employer. If directed by the Employer, the excavated earth from the adjoining areas (which is to be disposed-off up to a distance of 500 meters by manual labour) shall be used as for back filling purpose.

2.8.3.1.4 Back filling shall not be dropped directly upon or against any structure where there is danger of displacement or damage.

2.8.3.1.5 Back filling shall be placed in horizontal layers not to exceed 200mm in thickness. Each layer shall be compacted with proper moisture content and with such equipment as may be required to obtain a density equal to or greater than 95% of maximum dry density as determined by the relevant Indian Standard. The

method of compaction shall be subject to the approval of the Employer. Pushing of earth for back filling shall not be adopted under any circumstances.

2.8.3.1.6 On completion of structures, the earth surrounding them shall be accurately finished to line and grade as shown on the drawings or as per the instruction of the Employer. Finished surface shall be free of irregularities and depressions and shall be within 50mm of the specified level.

2.8.3.1.7 Any additional quantity of back filling, if required, beyond the excavation payment line shall be done by the contractor at his own expense.

2.8.4 **Construction Joints**

a) When the work is to be interrupted, the concrete shall be rebated at the joint to such shape and size as may be required by the Employer or as shown on the drawings. All vertical construction joints shall be made with stone boards, which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. If desired by the Employer, keys and/or dowel bars shall be provided at the construction joints. Construction joints shall be provided in positions as shown or described on the drawing. Where it is not described, the joints shall be in accordance with the following:

i) In a column, the joint shall be formed about 75mm below the lowest soffit of the beams framing into it.

ii) Concrete in tie beam shall be placed throughout without a joint, but if the provision or a joint is unavoidable, the joint shall be vertical and at the middle of the span.

iii) In forming a joint, concrete shall not be allowed to slope away to thin edge. The locations of construction joints shall be planned by the Contractor well in advance of pouring and have to be approved by the Employer.

b) Before fresh concrete is placed, the cement skin of the partially hardened concrete shall be thoroughly removed and surface made rough by hacking, sand blasting, water jetting, air jetting or any other method as directed by the Employer. The rough surface shall be thoroughly wetted for about two hours and shall be dried and coated with 1:1 freshly mixed cement sand slurry immediately before placing the new concrete. The new concrete shall be worked against the prepared surface before the slurry sets. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer. Old joints during pour shall be treated with 1:1 freshly made cement sand slurry only after removing all

loose materials.

c) The unit rate of pile foundation/ unit rate of concrete work (as the case may be) shall include the cost of construction joints.

2.8.5 **Curing and Protection of Concrete**

Newly placed concrete shall be protected by approved means from rain, sun & wind. Concrete placed below ground level shall be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground or with water leaking from such ground during placing of concrete and for a period of three days or as otherwise instructed by the Employer after placing of concrete. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to prevent floatation or flooding. Steps, as approved by the Employer, shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration etc. which may impair the strength or durability of the concrete.

All fresh concrete shall be covered with a layer of Hessian or similar absorbent material and kept constantly wet for a period of seven days or more from the date of placing of concrete as per directions of the Employer. Curing can also be made by pounding. Concrete shall be cured by flooding with water of minimum 25mm depth for the period mentioned above. Step shall also be taken to protect immature concrete from damage debris by excessive loading, vibrations, abrasions, deleterious ground water, mixing with earth or foreign materials, floatation etc. that may impair the strength and durability of the concrete. Approved curing compound can be used with the permission of the Employer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

2.9 **Pile Installation**

Installation of piles shall be carried out as per pile layout drawings, installation criteria and in line with the specification.

2.9.1 **Equipment and Accessories**

2.9.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Employer.

2.9.1.2 The capacity of the rig shall be adequate so as to reach the specified founding level.

2.9.1.3 Provision shall be kept for chiseling within the pile bore, as specified in this specification. Chiseling shall be carried out only with the approval of Employer. The contractor must have the provision of equipment/ accessories which can bore in the hard rock strata if required, without any additional cost implication to the Employer.

2.9.2 **Installation Criteria**

2.9.2.1 The Contractor while boring the pile bore, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in the soil investigation report. Should there be any variation between the two soil classifications, these shall be immediately reported to the Employer.

2.9.2.2 Whenever the rock strata are encountered in the pile bore, the Contractor shall immediately report the matter to the Employer and shall take up the work of rock chiseling or any other suitable method only after the certification/ approval of the Employer. Since the piles are required to be terminated in the firm/ hard strata and as stipulated in the construction drawing the Contractor shall demonstrate such founding strata and seek approval of the Employer before terminating the piles.

2.9.2.3 The pile should be socketed and founded in good rock only. Whenever rock strata is encountered at any pile bore and the level of good rock (i.e. rock strata is not highly fractured and weathered and core recovery is not less than 80% with RQD 70%) is different than that is given in the Geotechnical Investigation report, in that case to establish the level of good rock, core drilling as per IS 6926 shall be carried out at least upto 5m depth in rock strata encountered by the contractor without any additional cost implication to Employer and no time extension will be permitted on this account.

2.9.2.4 In order to verify the terminating depth, where rock strata is met with, the rock samples obtained from the bore spoils of pile shall also be tested for point load strength index and these shall then be compared/ correlated to the values of uniaxial compression strength test shown in the soil investigation report. Accordingly, the termination of piles in the socketing zone shall be done with prior approval of the Employer.

2.9.3 **Control of position and alignment**

2.9.3.1 Piles shall be installed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS 2911 (Part I/Sec. 2), as reproduced below.

2.9.3.2 Maximum permissible deviation in alignment is 1.5%. Piles should not deviate more than 75mm or D/10 whichever is more from their positions at the working level. In case of piles deviating beyond these limits, the piles should be replaced or supplemented by one or more additional piles including the revised cap size (as the situation may be) at no additional cost to the Employer. Any extra claim whatsoever from the contractor on this account shall not be entertained.

2.9.4 **Boring**

2.9.4.1 Boring operations shall be done by rotary or percussion type drilling rigs using Direct Mud Circulation (DMC), Reverse Mud Circulation (RMC) methods or grab method. In soft clays and loose sands bailer method, if used, shall be used with caution to avoid the effect of suction. In cohesive soils, use of water for boring shall be restricted to a minimum, while boring in cohesion less deposits water level in the bore hole shall be maintained at or slightly above the standing water table.

Boring operations by any of the above methods shall be done using drilling mud. The bidder shall be required to furnish along with their bid, complete details regarding the installation of piles and the method by which they wish to install the piles.

2.9.4.2 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used, bentonite slurry shall be pumped through drill rods by means of high-pressure pumps. The cutting tools shall have suitable pores for the bentonite slurry to flow out at high pressure. If the Contractor fails to make proper bore for any reason, the Contractor has to modify the boring technique and switchover to other boring methods as approved by the Employer at no extra cost to the Employer.

2.9.4.3 Working level shall be above the pile cut off level. After the initial boring of about 1.0 to 2.0m temporary guide casing shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter to give the necessary finished diameter of the concrete pile. The center line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 2.0m length. Additional length of guide casing shall be used depending on the conditions of the strata, ground water level etc. as required by the Employer without any additional cost to the Employer.

2.9.4.4 Use of drilling mud (bentonite slurry) for stabilising the sides of the pile bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in ***Annexure-A***.

2.9.4.5 The bentonite slurry and the cuttings, which are carried to the surface by the rising

flow of the slurry shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is re-circulated back to the boring. The bentonite slurry mixing and re-circulation plant shall be suitably designed and installed.

2.9.4.6 The bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC method is used the bentonite slurry shall be under constant circulation till start of concreting.

2.9.4.7 Size of cutting tools shall be such that so as to achieve required diameter of pile as per design drawing.

2.9.5 **Chiseling**

Chiseling, if required, may be resorted to with the permission of the Employer below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desired depth.

2.9.6 **Cleaning of Pile bore**

2.9.6.1 After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/ bored material, debris of rock/boulder etc. Necessary checks shall be made as given in this Section to confirm the thorough cleaning of the pile bore.

2.9.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

2.9.6.3 Pile bore spoil along with used drilling mud shall be disposed-off from site up to 2 km or as directed by the Employer.

2.9.7 **Adjacent Structures**

When working near existing structures care shall be taken to avoid any damage to such structures.

2.9.8 **Concreting**

2.9.8.1 Concreting shall not be done until the Employer is satisfied that the bearing strata (soil/rock) met with the termination level of pile, satisfied the installation criteria/ approved founding depth.

2.9.8.2 The time between the completion of boring and placing of concrete shall not

exceed 8 hrs for piles upto 25 meter length and 12 hrs for piles above 25 meter length. In case the time of interval exceeds specified time, the pile bore shall be abandoned. However, the Employer may allow concreting, provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile bore properly. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

2.9.8.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

2.9.8.4 Proper placement of the reinforcement cage to its full length shall be ensured before concerting.

2.9.8.5 Entire concreting in pile bores shall be done by tremie method. The operation of tremie concreting shall be governed by IS 2911 (Part I, Sec. 2). Drilling mud shall be maintained sufficiently above the ground water level.

2.9.8.6 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore possess density more than 1.12T/ cum. or sand content more than 7%. The drilling mud sample shall be collected from the bottom of pile bore. This shall be checked at regular intervals, as decided by the Employer thereafter.

2.9.8.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stablised as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

2.9.8.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

2.9.8.9 The temporary guide casing shall be entirely withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.

2.9.8.10 Tests on concrete cubes shall be carried out as specified in this section of the Specifications.

2.9.9 **Cut-off-level (COL)**

2.9.9.1 Cut-off-level of piles shall be as indicated in approved construction drawings or as directed by the Engineer-in-Charge.

2.9.9.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment into pile cap.

2.9.9.3 When the pile cut off level is less than 1.0 meter below the working level, concrete shall be cast up to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to minimum of one meter above COL.

2.9.9.4 In the circumstances where COL is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Contractor with prior approval of Employer.

2.9.10 **Sequence of Piling**

2.9.10.1 Each pile shall be identified with a reference number and date wise proper record of construction shall be maintained by the Contractor.

2.9.10.2 The convenience of installation may be considered while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

2.9.11 **Building up of Piles**

If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the top level of cast pile is less than the specified level or due to any other reason, then the pile shall be built up by using, same grade of concrete, ensuring proper continuity with the existing concrete and to the satisfaction of the Employer. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

2.9.12 **Breaking off of Piles**

If any pile already cast requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, (not before seven days of casting of concrete in the piles) without affecting the quality of existing pile such as loosening, cracking etc. to the satisfaction of the Employer. No extra payment shall be made on this account.

2.9.13 **Preparation of Pile head**

2.9.13.1 The soil surrounding the piles shall be excavated up to the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

2.9.13.2 The exposed part of concrete above the COL, shall be removed/ chipped off and made square at COL not before seven days of casting of pile.

2.9.13.3 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap as shown in the drawing.

2.9.13.4 The pile top shall be embedded into the pile cap by minimum 50mm or clear cover to reinforcement, whichever is higher.

2.9.13.5 All loose material on the top of pile head after chipping to the desired level shall be removed and disposed-off up to a lead of 2 km or as directed by the Employer.

2.9.14 **Rejection and Replacement of Defective Piles**

2.9.14.1 The Employer reserve the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawings on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are judged defective shall be pulled out or left in place as decided by the Employer without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Employer at no extra cost to the Employer.

2.9.14.2 During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Employer, fresh bore holes are to be executed at a suitable new position, which may vary from 2D to 3D (where, D is diameter of pile) as decided by the Employer, which may demand for resizing of pile cap including possible increase in reinforcement quantity due to resizing of pile cap. In all such cases the abandoned bore holes are to be filled up with plain cement concrete (1:3:6) so that no cavity remains in the bore hole of the abandoned pile. Any extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile cap including increase in reinforcement quantity shall not be entertained by the Employer & the same have to be borne by the contractor.

2.9.15 **Criteria for Terminating the Piles**

2.9.15.1 The piles can be terminated at a depth based on design developed/ approved by the Employer, where loads on the piles can be transmitted to the soil in a proper manner or the depth where specified `N' value is achieved, whichever occurs later. However, in no case piles should be terminated at a higher level than that indicated in the construction drawing.

2.9.15.2 Standard penetration test (SPT) shall be carried out starting from 1.0 m above the specified pile termination depth and there after @ 1m up to the pile termination

depth.

2.9.15.3 The Standard Penetration Test (SPT) shall be carried out based on the following test procedures:

a) The test shall be conducted by driving a standard split spoon sampler in the borehole by means of a 650 N hammer having a free fall of 0.75 m. The sampler shall be driven for 450 mm using the hammer and the number of blows shall be recorded for every 150mm penetration. The number of blows for the last 300 mm drive shall be reported as N value. The test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25mm for 50 blows, whichever is earlier.

b) At the location where the test discontinued, the penetration and the number of blows shall be reported. Sufficient quantity of disturbed sample shall be collected from the split spoon sampler for identification/ classification of soil. The sample shall be visually classified and recorded at the site.

c) The specification for the equipments and other accessories, procedure for conducting the test and collection of the disturbed soil sample shall conform to IS 2131.

2.9.16 **Recording of Piling Data**

2.9.16.1 The Contractor shall record all the information during installation of piles. Typical data sheet for recording pile data as shown in Appendix D of IS 2911 (Part I, Sec. 2) shall be maintained by the contractor. The pile data shall also include all the details as in ***Annexure-B***. On completion of each pile installation, pile record in triplicate shall be submitted to Employer within two days of completion of concreting of the pile.

2.9.17 **Check for Pile bore**

2.9.17.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/ debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.

2.9.17.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the

ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

2.9.18 **Properties of drilling mud**

2.9.18.1 Properties of drilling mud shall be checked as per requirements indicated in ***Annexure-A*** prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Employer, one sample consisting of 3 specimens shall be tested.

2.9.18.2 Density and sand content of the drilling mud shall be checked in each pile.

2.10 **Erection of Steel Embedded Parts**

2.10.1 **General**

2.10.1.1 This covers the technical requirements for the supply and fabrication and/or erection of all embedded steel parts by the Contractor. The extent and type of embedded steel parts to be erected shall be as per detailed drawings.

2.10.1.2 The supply of embedded steel parts like ladders, steel pieces set in concrete inserts, dowel bars required for construction joints etc. are in the scope of the Contractor. However, supply of anchor bolts/ stubs, as the case may be, will be supplied by tower contractor.

2.10.1.3 Embedded steel parts shall include items such as foundation anchor bolts, stubs, ladders, steel pieces set in concrete inserts, dowel bars for concrete work etc. shown on the drawing or as required by the Employer. Material shall also include setting in forms for connecting in place and grouting as required. The grouting operations, if required, shall be performed as per the direction of Employer.

2.10.1.4 The Contractor shall erect all embedded steel parts in accordance with the drawings and this specification including setting materials in concrete or grouting pieces in place, furnishing all labour, materials, scaffolding, tools and services necessary for and incidental to the work to its transporting, unloading, storing, handling and erection. Contractor shall furnish welding rods and arrange for field welding as required in accordance with IS 816.

2.10.1.5 Exposed surfaces of embedded material are to be painted with one coat of approved anticorrosive and/or bituminous paint without any extra cost to the Employer. The threads of holding down bolts shall be greased and protected with water proof tape.

2.10.2 **Installation**

2.10.2.1 During erection, the Contractor shall provide necessary temporary bracing or supports to ensure proper installation of the materials. All materials shall be erected in the true locations as shown in the drawings, plumb and level. Extreme care shall be taken to ensure that the threads of holding down bolts and comparable items are protected from damage.

2.10.2.2 Groups of holding down bolts shall be set in such a manner that the tolerance of whole group is not more than 3mm from its true position in plan at the top of the bolt and not more than 3mm from the required level. The top ends of all bolt shanks shall be in one plane to the tolerance stated above.

Holding down bolt assemblies shall be set vertically to a tolerance of not more than 1:500.

2.10.3 **Protection Against Damage in Transit**

2.10.3.1 All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All protecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surface shall be suitably packed and all bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members, the Contractor shall immediately report the matter to the Employer. Distorted reinforcement bars or plates received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the Employer can be removed by acceptable methods. The cost of all such straightening shall be borne by the Contractor within his unit rates.

2.10.3.2 These distortions shall be rectified by the Contractor by cold bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the Employer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

2.11 **Foundations Bolts/ Stub**

2.11.1 The foundation bolts/ stubs, as required, for the tower structures shall be supplied by the respective tower contractor. These shall be embedded in concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate and also co-ordinate with the respective tower contractor for its correctness. The final adjustment of these bolts and their grouting are included in the scope of this contract. Grouting of block

outs and the gap between the base plate and top of concrete shall be done by the Contractor after finalisation of alignments. The unit rate of concreting/ unit rate of pile foundation (as the case may be) shall include the cost of above adjustments, grouting, and skins etc. required for this purpose.

2.11.2 The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers are in plumb.

2.11.3 Before erection of towers, by tower contractor, on the foundations the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose materials and shall be chipped with a chisel to ensure proper bond between the grout and the foundation concrete. The piling Contractor shall also be responsible for bringing down the top of concrete to the desired level by chipping. In case the foundation as cast is lower than the desired level, the Contractor shall make up the difference by providing additional pack plates without extra cost for any such work or material. No steel structures shall be erected on their foundations unless such foundations have been certified fit for erection by the Employer. Adequate number of air release holes and inspection holes shall be provided in the base plate.

2.12 **Stability of Structure**

2.12.1 The Contractor shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done for erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interface with the movement or working of other agencies working in the area. For the purpose of guying, the Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy.

2.12.2 Such temporary bracings shall neither be included in the measurement nor extra rate shall be payable. Such temporary bracings used shall be the property of the Contractor and may be removed by him at the end of the job from the site of work.

2.13 **Grouting and under Pinning**

2.13.1 **General requirement**

2.13.1.1 Furnishing of all labour materials and equipment and performance of all operations necessary to complete the work of grouting of block outs and foundation bolt holes and under pinning of base plates is in the scope of the Contractor. The cost of the above shall be included in the unit concreting rate.

2.13.1.2 Grouting shall be adopted for filling the block outs, pockets below foundation bolt holes. The block out and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operations.

2.13.1.3 Cement and aluminium powder or anti-shrinkage admixture of approved quality shall be first blended thoroughly in the required proportions as per manufacturer's specification. The mix of grouting shall contain one part of cement and two parts of coarse sand. Admixture should be according to IS 9103.

2.13.1.4 The quantity of aluminum powder shall usually be of the order of 0.005% by weight of cement. Any grout which has been mixed for a period longer than half an hour shall not be used on the work. Immediately after preparation the grout shall be poured into the block outs, pockets and foundation bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the block out is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried.

2.13.1.5 Under pinning shall be resorted to for filling the space between the underside of base plate and the top of foundation concrete. After grouting has been completed as specified above, space between the top surface of the foundation concrete and the underside of the base plate shall be filled with mortar or concrete depending upon thickness to be filled as follows: -

Less than 40mm	Dry packed cement mortar
Over 40mm	Dry packed fine concrete

2.13.1.6 Mortar, fine concrete shall be blended with aluminium powder about 0.005% by weight of cement or with anti-shrinkage admixture in a suitable proportion to the cement mortar in accordance with the recommendations of the manufacturer and subject to the approval of the Employer. Mortar shall comprise cement, sand and water in proportion of approx. 1:3:0.4 by weight. Concrete shall comprise cement, sand, 10mm max. sized aggregate and water in proportion of 1:1.25:2:0.4 by weight. In all cases minimum 28 days cube strength should not be less than $25N/mm^2$.

Shims provided for the alignment of bases shall be positioned at the edges of the base to permit subsequent removal which shall take place not less than 7 days after the underpinning has been executed. The resulting cavities shall be made good with the same grade of mortar or concrete as has been used for the underpinning of the rest of the base plate.

2.13.1.7 Cement, sand and aluminium powder or approved anti-shrinkage admixture, shall first be blended thoroughly in the required proportion. The mortar shall then be prepared by mixing with quantity of water which will produce a sufficiently workable mix to enable complete and proper compaction of the mortar.

2.13.1.8 The mortar shall then be placed below the base plate and rammed in a horizontal direction for each edge until the mortar oozes out through the grout holes provided in the base plate.

2.13.1.9 When it is clear that the center of base has been properly filled, the mortar outside the base plate shall be briefly rammed to ensure compaction below the edges. Any mortar which has been mixed for a period longer than half an hour, shall not be used in the work.

2.13.2 **Materials**

2.13.2.1 Cement shall conform to the stipulations contained in IS 8112 and shall have a fineness (specific surface of cement) not less than 225 sqm/kg when tested for fineness by Blaine's air permeability method as per IS 4031.

2.13.2.2 Sand shall conform to the stipulations contained in IS 383.

2.13.2.3 Water shall be clean and fresh and shall be of potable quality.

2.13.2.4 Aluminium powder or anti-shrinkage admixture like 'Groutex' CRS-NS grout (by Cement Research Institute of India) or its equivalent shall be of standard brand from reputed manufacturer and shall be approved by the Employer prior to its use for work.

2.13.3 **Curing**

The work shall be cured for a period of 7 days commencing 24 hours after the completion of the grouting and under pinning operations. The curing shall be done by covering the surfaces with wet gunny bags.

2.13.4 **Bar Grips**

2.13.4.1 This covers the technical requirement for furnishing and installation of bar grips complete including all labour materials, equipments, staging, etc.

2.13.4.2 The Contractor shall furnish and install the bar grips for various dia of deformed bars as indicated in drawings and as required by these specifications. The bar grip splicing system shall be of approved manufacturer and of the best quality available subject to approval of the Employer.

2.13.5 **Splicing**

2.13.5.1 a) The reinforcement bars are to be joined without any gap and the sleeve placed in position.

b) Pressure is applied by means of a hydraulic press which swages the sleeve down on the bar ends in a series of bites which are applied at high pressure.

c) The job can also be done in two stages. The 1st stage is to press the half sleeve on the loose bar at the reinforcement yard. The 2nd stage work is to be done at the actual site after the loose bar is inserted through the un-presented end of the sleeve and pressed in-situ.

2.13.5.2 The joints shall be staggered as far as possible. Necessary staging arrangements are to be made by the Contractor.

2.13.5.3 It may be necessary to fix the sleeve to the reinforcement bars at one end in the open yard for the facility of working. All these working details are to be furnished earlier subject to the approval of the Employer.

2.13.5.4 The length of the sleeve should be adequate, that it is safe under the pull-out loading conditions.

2.13.5.5 One percent representative samples of each diameter, bars shall be sent for laboratory testing at the cost of the Contractor to check the efficiency of the joints under ideal condition. These samples of sleeves will be sent in the Laboratory for pull out tests.

2.13.5.6 All bar grips installation shall be subject to inspection and approval by the Employer before concreting operation are performed. In case of any defect or joint being not up to mark, the same shall be replaced by the Contractor at no extra cost.

2.14 **MS Liner**

MS liner shall be provided wherever included in the construction drawings approved by the employer and/ or otherwise required by the employer. Detailed technical requirements of MS liner are stipulated in ***Clause 5.0*** shall apply.

3.0 Rates and Measurement

3.1 **Rates and Measurement Applicable When Design of Pile foundation is in Contractor's Scope**

The Rate quoted by bidder includes Design & Installation of 750 mm/ 1000 mm/

1200 mm/ 1500 mm diameter pile of suitable length, which inter-alia includes the design & vetting of pile foundation, excavation, boring, form work for placement of concrete, supply & placement of reinforcement steel & MS liner, concreting and PCC, back filling and conducting Standard Penetration Test & Integrity test etc. as specified in relevant clause of this section.

The details of items for completeness of pile foundation works include the following items:

3.1.1 **Design of Pile foundation**

The design of pile foundation shall be carried out as per, design criteria for pile foundation specified in clause 1.2.4 of this section, the soil parameters provided by employer, other hydrological report/ data collected from CWC/ Local authority. After completion of design works, each pile design along with design calculations & drawings shall be vetted from reputed institutions like IITs/NITs and submitted for employer's approval.

3.1.2 **Excavation**

3.1.2.1 The unit of measurement for excavation shall be in cum. The design excavation volume shall be calculated considering dimension of pile cap plus 150mm on all sides of the pile cap and depth as shown in the drawing approved by employer below the lean concrete level. The excavation covers all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job. The excavation shall be carried out in accordance with the stipulations in ***clause 2.0*** of this Specification.

3.1.2.2 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted in Price schedule shall include all lead, lift, carriage etc.

3.1.3 **Cement Concrete**

3.1.3.1 Actual volume of work as executed or as per drawing, measured in cubic meter corrected up to second place of decimal shall be considered for measurement purpose. Deductions for openings, conduits, pipes, ducts, pockets etc. shall only be made provided they are larger than 0.1 sqm. in area (for each opening).

3.1.3.2 No deduction shall be made for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

3.1.3.3 The volume for structural concrete and lean concrete shall be measured separately.

3.1.4 **Form Work**

3.1.4.1 Formworks of different types/ shapes shall be measured with reference to actual surface area in contact with the concrete. The unit of measurement will be in sqm corrected upto second place of decimal.

3.1.4.2 Opening up to 0.1 sqm of boxing left for inserts etc. shall not be considered as if non-existent for the purpose of formwork measurement of surface in which the opening occurs. If the cross-sectional area of any openings exceeds 0.1 sqm., area of such openings shall be measured and deducted from the area payable for the total form work**.**

3.1.4.3 The total formwork should be water proof and includes the supports, scaffolding, centering, approaches, and fillets for rounding of chamfering junctions, corners etc.

3.1.5 **Back filling**

3.1.5.1 The actual volume of backfilling shall be measured in cubic meter rounded off up to 2nd place of decimal shall include all the necessary operations required to complete the work as per drawing & ***Clause 2.0*** of this section. The rate quoted by bidder includes the backfilling works also.

3.1.6 **Reinforcement Steel**

3.1.6.1 The bidder shall supply and place reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to complete the RCC work in pile, pile cap, pedestal/ chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. Contractor shall also place of reinforcement cage in pile shaft/bore and all other cost for tools, plants, materials, labour, transportation to site are to be borne by the bidder. Wastage, overlaps, spacer bars, chairs, stays, hangers, annealed steel wire shall not be measured and cost of these items shall be deemed to be included in the quoted price of pile foundation.

3.1.6.2 Standard hooks, cranks, bends, authorized laps, etc. shall be measured.

3.1.6.3 Separator pieces between two or more layers of steel shall not be measured.

3.1.6.4 For supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300mm, shall be prepared by the Contractor and got it approved from Employer.

3.1.6.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

3.1.6.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.

3.1.7 **Piling work**

3.1.7.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the corresponding sections in the Technical Specifications, including amendments, and additions, if any. The rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

3.1.7.2 The rate shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

3.1.7.3 rate shall also include for all safety measures as required by Codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant, equipment, scaffolding, materials, skilled and unskilled labour, de-mobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.

3.1.7.4 The rate quoted by bidder-shall be inclusive of cost of boring by approved method, bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/ debris etc. and disposing same along with the drilling mud up to a distance of 2 km, flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results including necessary materials, equipment and manpower.

3.1.7.5 The rate quoted shall include shifting of plant and equipment from one pile location to another location**,** providing temporary casing as required and removal of the same after completing concreting. The quoted rate shall also include the boring/ installation of pile and is inclusive of the empty boring and extra concreting required above the pile cut off level.

3.1.7.6 The rate quoted shall also include chiseling through rock, if required, in the pile up to the specified level bailing out the pile bore debris/ spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/ mud up to 2 km, flushing the pile bore by fresh betonies before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.

3.1.7.7 The rate shall also include concreting in piles by tremie method only, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to cut off level (COL), up to a distance of 2 km.

3.1.7.8 The rate shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.

3.1.7.9 The rate quoted shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.

3.1.7.10 Measurement for the item of boring as per BPS through soil including all kind of rocks shall be done by linear measurement for the length bored from the bottom of pile cap or ground level whichever is lower through soil all kind of rocks up to termination/ founding level as per drawing or actual length achieved of the pile in meters, up to second place of decimal.

3.1.7.11 In case bottom of pile cap is placed above existing ground level and boring is not done for the part of pile above existing ground level, the unit rate for boring as per BPS shall not be applicable for pile above ground level and the payment for concreting work shall be done from unit rate of concrete quoted for pile caps, pedestal/chimney etc. as per BPS. The grade of concrete for the portion of pile above ground level shall be same as that of grade of concrete in bore below ground level. No additional payment shall be admissible on account for shuttering of pile (if required), necessary arrangements required for concreting in pile and/or pile cap above ground level**.**

3.1.7.12 To establish the quality of rock as hard rock, core drilling as per IS 6926 shall be carried out in rock strata encountered by the contractor without any additional cost implication to Employer. Rock shall be considered as Hard rock if the core recovery is more than 80% with minimum RQD as 70%.

3.1.8 **Standard Penetration Test (SPT)**

The actual quantity of SPT done shall be calculated in nos. and the rate quoted shall include all the necessary equipment, labour, materials, operations etc. required to complete the work as per ***Clause 2.0*** of this section.

3.1.9 **MS Liner**

3.1.9.1 The measurement shall be made in Metric Ton (MT) corrected upto third place of decimal based on the calculated weight of the MS liner as per construction

drawing and with reference to the sectional weights of respective thickness of MS plate as per Indian Standards or MS liner actually provided, whichever is less. The rate quoted shall be inclusive of all wastage.

3.1.9.2 The rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

3.1.10 **Pile Integrity Test**

The actual quantity of pile integrity test done shall be calculated in numbers and the rate quoted by the bidder shall include all necessary equipments, manpower, labour, materials, operations etc. required to complete the work as ***per Clause 4.0*** of this section. The work shall be deemed to be complete only after submission of complete report of pile integrity test on all piles. Minimum one integrity test per pile installed/casted has to be carried out by the bidder.

3.2 **Rates and Measurement Applicable When Design of Pile foundation is not in Contractor's Scope and Employer shall provide construction drawings to the Contractor**

3.2.1 **Excavation**

3.2.1.1 The unit rate for excavation shall be quoted by the Bidder in the respective schedule of BPS. The unit rate quoted shall hold good for excavation (other than boring) for all depth and size in all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job. The excavation shall be carried out in accordance with stipulations in Clause 2.0 of this section.

3.2.1.2 The unit of measurement shall be in cum. The design excavation volume shall be calculated considering dimension of pile cap plus 150mm on all sides of the pile cap and depth as shown in the drawing below the lean concrete level. The payment shall be made based on unit rate quoted, for excavation actually carried out or as per the design excavation volume as calculated above, whichever is less. No extra payment shall be admissible for excavations if required to be carried out in slope to maintain stability of pit.

3.2.1.3 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted for excavation in Price schedule shall include all lead, lift, carriage etc.

3.2.2 **Cement Concrete**

3.2.2.1 Actual volume of work as executed or as per drawing issued, whichever is less, measured in cubic meter corrected up to second place of decimal shall be considered for payment as per unit rate quoted in BPS. Deductions for openings, conduits, pipes, ducts, pockets etc. shall only be made provided they are larger than 0.1 sq. in area (for each opening).

3.2.2.2 No deduction shall be made for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

3.2.2.3 The volume for structural concrete and lean concrete shall be measured separately.

3.2.3 **Form Work**

3.2.3.1 Formworks of different types/ shapes shall be measured with reference to actual surface area in contact with the concrete and paid on area basis. The unit of measurement will be in sqm corrected up-to second place of decimal.

3.2.3.2 No payments for formwork for construction joints shall be made.

3.2.3.3 Opening up to 0.1 sqm. of boxing left for inserts etc. shall not be considered as if non-existent for the purpose of formwork measurement of surface in which the opening occurs. If the cross-sectional area of any openings exceeds 0.1 sqm, area of such openings shall be measured and deducted from the area payable for the form work**.**

3.2.3.4 No payment shall be made for making the formwork water proof or for supports, scaffolding, centering, approaches, etc.

3.2.3.5 No separate payment shall be made for using fillets for rounding of chamfering junctions, corners, etc.

3.2.4 **Back filling**

The actual volume of backfilling shall be measured in cubic meter rounded off up to 2nd place of decimal and the unit rate shall include all the necessary operations required to complete the work as per drawing & ***clause no. 2*** of this section.

3.2.5 **Reinforcement Steel**

3.2.5.1 The unit rate for reinforcement steel shall include supply and placement of reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to

complete the RCC work in pile, pile cap, pedestal/ chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. The unit rate shall also include placement of reinforcement cage in pile shaft/ bore and all other cost for tools, plants, materials, labour, and transportation to site by appropriate means as required. The measurement for payments shall be made in Metric Ton (MT) corrected up to third place of decimal based on the calculated weight of reinforcement steel as per construction drawing and with reference to the sectional weights of respective size of reinforcement bars as per Indian Standards or reinforcement bars actually provided, whichever is less. The unit rate quoted shall be inclusive of all wastage.

3.2.5.2 Standard hooks, cranks, bends, authorised laps, etc. shall be measured.

3.2.5.3 Separator pieces between two or more layers of steel shall not be measured.

3.2.5.4 No payment shall be made for supports, spacers, chairs, hangers, etc. of height/ length of 300 mm and less, required for keeping the steel in position. For supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300 mm, shall be prepared by the Contractor and got it approved from Employer. Payment shall be made for these supports as approved by the Employer, or as actually provided, whichever is less, as per the unit rate quoted for reinforcement.

3.2.5.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

3.2.5.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.

3.2.6 **Piling work**

3.2.6.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the corresponding clause in this section including amendments, and additions, if any. The unit rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

3.2.6.2 The unit rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

3.2.6.3 Unit rates shall also include for all safety measures as required by Codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant,

equipment, scaffolding, materials, skilled and unskilled labour, de-mobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.

3.2.6.4 Unit rate on per meter length basis for a particular diameter of pile shall remain unchanged irrespective of the actual length/depth of individual piles executed at any location

3.2.6.5 Unit rate shall be inclusive of cost of boring by approved method, bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/ debris etc. and disposing same along with the drilling mud up to a distance of 2 km, flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results including necessary materials, equipment and manpower.

3.2.6.6 Unit rate quoted shall include shifting of plant and equipment from one pile location to another location**,** providing temporary casing as required and removal of the same after completing concreting. The quoted rate shall also include the boring/ installation of pile and is inclusive of the empty boring and extra concreting required above the pile cut off level

3.2.6.7 Unit rate quoted shall also include chiseling through rock, if required, in the pile up to the specified level, bailing out the pile bore debris/ spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/ mud up to 2 km, flushing the pile bore by fresh betonies before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.

3.2.6.8 Unit rate of pile boring shall include concreting in piles by tremie method only, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to COL, up to a distance of 2 km.

3.2.6.9 Unit rates shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.

3.2.6.10 The rate quoted for boring and installation shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.

3.2.6.11 Measurement for the item of boring through soil including all kind of rocks shall be done by linear measurement for the length bored from the pile cut off level or ground level whichever is lower through soil/ all kind of rocks up to termination/

founding level as per drawing or actual length achieved of the pile in meters, up to second place of decimal.

3.2.6.12 To establish the quality of rock as hard rock, core drilling as per IS 6926 shall be carried out in rock strata encountered by the contractor without any additional cost implication to Employer. Rock shall be considered as Hard rock if the core recovery is more than 80% with minimum RQD as 70%.

3.2.6.13 The payment for boring in hard rock upto depth of 10 meter in each bore (either cumulative or in single layer) shall be considered as per BPS. In case boring in hard rock is more than 10 meters in each bore, the payment shall be based on mutually agreed rates, to be derived on the basis of rates available in the Contract.

3.2.7 **Standard Penetration Test (SPT)**

The actual quantity of SPT done shall be calculated in nos. and the unit rate quoted shall include all the necessary equipments, labour, materials, operations etc. required to complete the work as per ***clause 2.0*** of this section.

3.2.8 **MS Liner**

3.2.8.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the clause 5.0 of this section. The unit rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

3.2.8.2 The unit rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

3.2.8.3 The measurement for payments shall be made in Metric Ton (MT) corrected upto third place of decimal based on the calculated weight of the M.S. liner as per construction drawing and with reference to the sectional weights of respective thickness of MS plate as per Indian Standards or MS liner actually provided, whichever is less. The unit rate quoted shall be inclusive of all wastage.

3.2.9 **Pile Integrity Test**

The actual quantity of pile integrity test done shall be calculated in nos. and the unit rate quoted shall be include all necessary equipments, manpower, labour, materials, operations etc. required to complete the work as per ***clause 4.0*** of this section. The payment shall only be made after successful completion of the job and submission of complete report of pile integrity test on all piles.

4.0 Testing and Acceptance Criteria

4.1 Construction Materials

4.1.1 Any material considered to be sub-standard or not meeting the requirement of ***clause 2.0*** of this section and as declared/ certified accordingly by the Employer shall not be used by the Contractor and shall be removed from the site immediately at no extra cost to the Employer.

4.2 Cement Concrete

4.2.1 Testing

4.2.1.1 The Contractor shall carry all sampling and testing in accordance with the ***Standard Field Quality Plan (SFQP) which is available on the POWERGRID Website 7 (seven) days prior to the actual date of bid opening***, relevant Indian Standards and this Specification at his own cost in field and in a laboratory approved by the Employer. For the tests carried in the laboratory, Contractor shall submit the test results to the Employer in triplicate within 7 (seven**)** days after completion of the test.

4.2.1.2 Facilities required for sampling and testing materials, concrete, etc. in field and in laboratory shall be provided by the Contractor. Where no specific testing procedure is mentioned the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Employer. In field Tests shall be done in the presence of the Employer or his authorized representative. For the tests to be performed in the laboratory other than field, shall be done in the independent certified lab approved by Employer. In case the Employer requires additional test, the Contractor shall arrange to get these tests done and submit to the Employer the test results in triplicate within three days after completion of any test.

4.2.1.3 The Contractor shall maintain records of all inspection and testing, which shall be made available to the Employer, whenever required.

4.2.1.4 The testing apparatus/ equipment installed in the field laboratory shall be calibrated/ corrected by the qualified person as frequently as possible to give accurate testing results.

4.2.1.5 Frequency of sampling and testing, etc. and Acceptance Criteria should be as per SFQP. However, Employer shall have the full authority to call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the Specifications. The materials shall be tested to meet all the specified requirements before acceptance at manufacturers' premises or at independent government approved laboratory. Tests indicated in the tables of

Standard Field Quality Plan are for cross checking at site to ascertain the conformity of the materials to the Specifications.

4.2.1.6 One sample consisting of six test cubes shall be made from the concrete used in each pile, three to be tested after 7 days and three after 28 days.

4.2.1.7 In preparation of test cubes/ specimens, vibrators shall not be used.

4.2.1.8 Concrete shall be tested for slump at every 1-hour interval.

4.2.2 **Acceptance Criteria for Concrete**

a) The acceptance criteria of concrete shall be in accordance with Standard Field Quality Plan (SFQP) and as per ***clause 2.0*** of this Specification**.**

b) Concrete work found unsuitable for acceptances shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant form work and reinforcement, embedded fixtures, etc. wasted in the dismantling shall be made to the Contractor. If any damage is done to the embedded items of adjacent structures, the same shall be made good free of charge by the Contractor, to the satisfaction of Employer.

c) The dimensions of concrete as cast, when compared with the drawing, shall be within the tolerances given below. Steps in surface alignment shall not exceed 2mm. No reduction will be permitted in the cover to reinforcement because of a specified negative tolerance in a concrete section.

Structural Element Detail	**Permissible Deviation in mm**	
Faces of concrete in foundations and structural members against which backfill is placed	+25	-5
Exposed concrete foundations	+10	-5
Top surfaces of Pedestal/chimney and for concrete to receive grouted plant or structural steel work	+5	-5
Alignment of tie beams, Pedestal/chimney**,** pile cap	+5	0
Cross sectional dimensions of tie beams, Pedestal/chimney, cap	+5	-5
Level and alignment of holding down bolts	+5	-5
Level of holding down bolt assemblies	+10	-5
Alignment of holding down bolt	+5	-5

assemblies		
Centers of pockets or holes with greatest lateral dimensions not exceeding 150mm	+5	-5
Centers of pockets or holes with greatest lateral dimension exceeding 150mm	+10	-5

4.2.3 **Acceptance criteria of Finished Concrete**

4.2.3.1 Finished concrete shall be true to shape, lines, levels plumb and dimensions as shown on drawings.

4.2.3.2 All embedded fixtures shall be of correct type and in correct position as shown in drawings.

4.2.3.3 Finished concrete surface shall be free from blemishes like honey-combs, air bubbles, fins, etc.

4.2.3.4 Exposed concrete surface shall be free from rust stains, grease and mould oil stains etc. and shall have uniform pleasing appearance to the satisfaction of the Employer.

4.2.3.5 The finished concrete shall be of a standard quality and equal to the accepted sample.

4.3 **Reinforcement Steel**

Reinforcement shall be checked for cleanliness, proper bending, binding, placing and securing in position with provision for proper cover. The reinforcement should conform to the requirement of under ***clause 2.0*** of this section.

4.4 **Testing for position and alignment**

4.4.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

4.4.2 Permissible limits for deviation shall be as specified under ***clause 2.0*** of this section.

4.5 **Properties of drilling mud**

4.5.1 Properties of drilling mud shall be checked as per requirements indicated in ***Annexure A***. Prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Employer, one sample consisting of

3 specimens shall be tested.

4.5.2 Density and sand content of the drilling mud shall be checked in each pile.

4.6 **Check for Pile bore**

4.6.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/ debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.

4.6.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

4.7 **Pile Integrity Test**

4.7.1 Pile Integrity test is used to assess the as-installed pile characteristics as well quality achieved during the construction of pile. The parameters to be evaluated through the Pile Integrity Test (also known as low-strain dynamic test/ sonic echo test/ low-strain integrity test) should generally cover pile continuity, defects such as cracks, necking, soil incursions, changes in cross section and approximate pile lengths changes in cross-section if any etc.

4.7.2 The equipment consists of an electronic control unit, a hand-held instrumented hammer and an accelerometer and computer. The test shall be conducted as per IS 14893:2001.

4.7.3 The results to be stored in a compact control unit and transferred to computer and detail analysis to be carried out.

4.7.4 The contractor is to submit a detailed report for the data specified in ***clause 4.7.1*** above and as required by the Employer.

5.0 Structural steel MS liner for RCC Vertical bored piles

5.1 **General Requirements**

This specification covers general requirements for supply, fabrication, shop

painting (if required), and delivery at site mild steel liners of specified diameters and lengths for piles.

MS liner shall be provided to piles at locations, as directed by the Employer and design guidelines mentioned in the Design & Drawings clause of this section. The extent up to which the MS liners for piles required to be provided shall be as shown in the approved drawings and as per direction and written approval of the Employer.

5.2 Drawings

5.2.1 Contractor shall submit calculations and fabrication details for connection/ splice/ joint for fabrication of liners and get these approved by the Employer before starting any fabrication works. The approval of fabrication drawings prepared by the Contractor shall not relieve the Contractor of the responsibility for the liners in place.

Fabrication drawing (drawn to large enough scale) to convey all information clearly shall include the following:

i) Reference of the design drawings based on which fabrication had been prepared. The reference should include and indicate the latest revision of design drawing.

ii) layout, elevations and sections with erection marking of all members.

iii) Quality of Structural Steel, Welding electrodes, and standards to which these conform to.

iv) Detailing of structural joints and shop/field splices.

v) Details of shop and field joints/connections.

vi) Bill of material indicating size and weight of members/ component.

vii) Erection assemblies and sub-assemblies identifying all transportable parts.

viii) Method of erection, special erection instructions, and special precautions to be taken during erection, as required.

5.2.2 Employer reserves the right to make changes in the fabrication drawings. Revisions to drawings may be made to reflect more updated requirements. Revisions to drawings and any new drawings made to include additional work by Contractor shall be considered as a part of this specification and the Employer shall entertain no extra claim on this account. All revisions in the drawings should be highlighted in the drawing distinctly.

5.2.3 Unless otherwise specified, the drawings and specifications are intended to

include everything obviously requisite and necessary for the proper and entire completion of the work and the job shall be carried out accordingly for the completeness as required.

5.2.4 In the case of variations in drawings and specifications, the decision of the Employer shall be final. In case Contractor in the execution of his work, find discrepancies in the information furnished by Employer, he shall refer such discrepancies to the Employer before proceeding with such work.

5.3 Fabrication

5.3.1 General

The fabrication work shall be carried out generally in accordance with IS 800 as well as the stipulation contained in these specifications. All materials shall be completely shop fabricated and finished with proper connection materials for ready assembly in the field. All the workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All edges shall be free of burrs, shearing and chipping shall be neatly and accurately done. Material at the shop shall be kept clean and protected from weather, Checklist format, inspection certificate for fabrication and protocol for handing over of structural steel shall be submitted by the Contractor in the form as agreed to by the Employer.

5.3.2 Straightening

All material shall be straight and free from bends or twists. If necessary, before being worked, the materials shall be straightened, unless otherwise required/ specified. In case plates are distorted or twisted, straightening or flattening shall be done by methods that will not injure the plates. Long plates shall be straightened by passing through mangle of leveling rolls. Heating or forging shall not be resorted to without the prior approval of Employer in writing.

5.3.3 Welding

5.3.3.1 Welding shall be in accordance with IS 816, IS 819, IS 1024, IS 1261, IS 1323, IS 4353 and IS 9595, as appropriate.

5.3.3.2 For welding of any particular type of joint, Contractor shall give evidence acceptable to the Employer of having satisfactorily completed appropriate tests as described in any of the Indian Standards IS 817, IS 1393, IS 7307 (Part J), as relevant and as per the checklists given in the ***Annexure*** to this section of the specification.

5.3.3.3 The works shall be done as per approved fabrication drawings which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld. Symbols for welding on shop drawings shall be according to IS 813. Efforts shall be made to reduce site welding so as to avoid improper welding due to constructional difficulties.

5.3.3.4 Welding of Structural Steel shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be applied shall be subject to the approval of the Employer and shall conform generally to relevant acceptable standards viz. IS 816, IS 9595, IS 814, and Indian Standard Hand Book for metal arc welding, and other standard codes of practice internationally accepted.

5.3.3.5 "Open-Arc-Welding" process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.

5.3.3.6 Wherever welding is done for assembling the components of liner, the job shall be so positioned that down hand welding is possible. In cases where such positioning of job is not possible other manual welding positions could be resorted to.

5.3.3.7 Any structural joints shall be welded only by those welders who are qualified for all welding procedures and positions required in such joint that is welded. The entire weld of any liner joint shall be made by one welder.

5.3.3.8 All welds shall be free from defects like blow holes, slag inclusions, lack of penetration, undercutting, cracks and show uniform Sections, smoothness of Weld metal, feather edge without overlap and freedom from porosity.

5.3.3.9 Proper edge preparation shall be made for jointing of materials before welding. Suitable edge preparation shall be done for all processes of welding except for square butt welds. Type of edge preparation shall depend on the thickness of parent materials that are to be joined. The edge forms shall be chosen to suit the design, technology and production conditions and shall be subject to the approval of the Employer. The edge form of weld elements shall be prepared either by machines or by automatic gas cutting with surface rougher of the welding area not exceeding 50 sq.mm. All edge cut by flame shall be ground before they are welded.

5.3.3.10 Electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired e.g. normal penetration welds or deep penetration welds.

5.3.3.11 Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux wire combination for submerged arc welding

shall conform to the requirements of F-60 class of AWSA-5-17-69 and IS 3613 (Latest). The electrodes shall be sorted properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.

5.3.3.12 Specific approval of the Employer shall be taken by the Contractor for the various electrodes proposed to be used on the work before any welding is started.

5.3.3.13 Electrodes larger than 5mm diameter shall not be used for root-runs in butt-welds.

5.3.3.14 Welding plant and accessories shall have capacity adequate for the welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequate means of measuring the current shall be provided.

5.3.3.15 Voltage and current (and polarity if direct current is used) shall be set according to the recommendations of the manufacturer of the electrode being used and suitability to thickness of material, joint form etc.

5.3.3.16 Pre-qualified welding procedures recommended by appropriate welding standards and known to provide satisfactory welds shall be followed. For non-standard procedures, qualification tests as prescribed in IS 9595 (latest) shall be made to verify the adequacy of the procedures. A welding procedure shall be prepared by Contractor and submitted to the Employer for approval before start of welding. This shall include all details of welding procedures with references to provisions of IS 9595 and IS 4353. Approval of the welding procedure by Employer shall not relieve Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

5.3.3.17 No welding shall be done, when the surface of the members is wet, during periods of high wind, unless the welding operator and the work are properly protected.

5.3.3.18 In joints connected by fillet welds, the minimum sizes of single run fillet welds for first run and minimum full sizes of fillet welds shall conform to requirements of IS 816.

5.3.3.19 **Sequence of Welding**

i) The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect of by counter distortion. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.

ii) Each case shall be carefully studied before finally following a particular sequence of welding.

5.3.3.20 Approval of welding sequence and procedure shall not relieve the Contractor of the responsibility for the correct welding and for minimising the distortion in the finished structure which in no case shall exceed that laid down in Indian Standards.

5.3.3.21 All welds shall be finished full and made with correct number of runs, the welds being kept free from slag and other inclusions, all adhering slag being removed from exposed faces immediately after such run.

5.3.3.22 Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid so as to leave the edges un-melted.

5.3.3.23 Pudding shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

5.3.3.24 Non-uniform heating and cooling should be avoided to ensure the excessive stresses are not locked up resulting ultimately in cracks.

5.3.3.25 The fusion faces shall be carefully aligned. Angle shrinkage shall be controlled by presenting. Correct gap and alignment shall be maintained during the welding operation.

5.3.3.26 All main butt welds shall have complete penetration and except where it is impracticable they shall be welded from both sides, back surface of the weld being gouged out clean before first run of the weld is given from the back.

5.3.3.27 Intermittent welds shall not be permitted without the approval of the Employer. These shall be permitted only when specifically approved in the fabrication drawings.

5.3.3.28 Inspection of Welds: All Welds shall be inspected for flaws by any of the methods described under Clause “Inspection”. The choice of the method adopted shall be determined by Employer.

5.3.3.29 The Contractor shall carry out tests which establish soundness of welds. In case the tests uncover defective work, the Contractor shall correct such defects at his own cost and prove the soundness of rectified work at his own cost.

5.3.3.30 The correction of defective welds shall be carried out as directed by Employer without damaging the parent metal. When a crack in the weld is removed,

magnetic particles inspection or any other equally positive means as prescribed by Employer shall be used to ensure that the hole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such test and operations incidental to correction shall be to Contractor's account.

5.3.3.31 **Inspection and Rectification**

5.3.3.31.1 **Visual Inspection**

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The length and size of weld shall be as per approved fabrication drawing. It may be slightly over sized but should not be under sized. The profile of weld is affected by the position of the joint but it should be uniform. In case of butt and corner welds the profile shall be convey and in case of submerged are fillet weld, it shall be slightly concave. The welds should have regular height and width of beads. The height and spacing or ripples shall be uniform. The joints in the weld run where welding has been recommended shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from the unfilled craters on the surface under cuts slag on the surface visible cracks. Such inspection shall be done after clearing the welds surface with steel wire brushes and chisel to remove the sputter metal, scales, slag, etc. If external defects mentioned above are noticed the work shall be dismantled and redone duly replacing the defective materials including the base members.

5.3.3.31.2 **Rectification of Defective Welding Work**

Wherever defects like improper penetration, extensive presence of blow holes, undercuts cracking, slag inclusion etc. are noticed by visual inspection/other tests, the welds at such locations shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary and re-welded. The gouging as far as possible be done using gouging electrodes. Flame gouging shall be resorted to only in special cases with specific permission of the Employer.

5.3.3.31.3 **Acceptance of the Welded Structures**

The acceptance of the welded work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the examination and testing of the joints and the test specimens as per IS soundness of the welds and upon general workmanship being good.

Random die penetration tests shall be conducted after welding of MS liner plates.

5.4 Erection Marks

5.4.1 Before any steel work leaves the Contractor's fabrication shop, it shall be suitably marked in accordance with the approved fabrication drawing and according to an approved marking plan. Copies of all drawing showing such erection marks on the various steel works to be furnished to the Employer well in advance of the erection.

5.4.2 The erection marks assigned to various components of the structural steel work shall also contain an erection sequence number indicating the sequence in which the various components are to be erected.

5.4.3 Erection marks shall be clearly painted on the work, each piece being marked in at least two places. Each piece shall also have its weight marked thereon. In order to help identification, each piece shall bear the erection marks and erection sequence number. Erection marks shall be painted on the structures, during the process of fabrication to facilitate their identification during inspection. Where a number of components are identical and bear the same erection marks, these components shall be further identified by assigning numerals in addition to the common erection mark.

5.5 Errors

Any error in shop work which prevents proper assembling and fitting of parts in the field, moderate use of drift pins or moderate amount of reaming will be classified by Employer as defective workmanship. All charges incurred by Employer either directly or indirectly because of workmanship will be deducted from the amount due to Contractor, before payment is made. The amount of such deduction will consist of the sum total of the costs of labour direct or indirect, material, plants, transportation, equipment, rental and overhead expense. In case Employer chooses to reject the material because of poor workmanship the cost of all handling and returning the material to Contractor, if he so desires, shall entirely be to Contractor's account and in such cases, the cost of handling, transport and delivery to site shall be borne by Contractor.

5.6 Protection against Damage in Transit

All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever to prevent damage or distortion during transit. Should there be any distortion of fabricated members the Contractor shall immediately report the matter to the Employer. Distorted steel shall not be used in fabrication unless the distortion is minor which in the opinion of the Employer can be removed by acceptable methods. These distortions shall be rectified by the Contractor by cold-bending. If heating is necessary to rectify the defects the details of the procedure shall be intimated to the Employer whose approval shall

be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

5.7 Anti-Corrosive Treatment for Mild Steel Liners

5.7.1 After inspection and issue of test and acceptance certificate, all steel surfaces shall be coated with a coat of direct to rust primer i.e. Densotrol or equivalent and thereafter these shall be provided with a final coat of minimum 250 microns of high built epoxy coal tar, as specified below. The fabricated mild steel liners to be used for the piling work shall be cleaned from grease or any other contaminant, by mechanical/ manual cleaning. The primer shall be applied with a brush or spray to develop a dry film thickness or minimum 25 microns. The primer surface shall be left for curing for at least 24 hours before it is coated with the final coat. The final coat shall consist of high built epoxy coal tar with a thickness of minimum 250 microns. The physical properties of primer and top coat shall be as given below.

5.7.2 Technical data of priming material

1	Binder content	45%
2	Total Solids	45%
3	Solvent	55%
4	Viscosity	16 (Ford Cup No.4)
5	Density	0.88
6	Flash point	$+40^0$ C
7	Anti-porosity	80/99 in one and two layers, respectively
8	Heat-resistance	170/220 continuously & short period strain
9	Contact angle	5^0 (Lorentzon & Westtress)
10	Covering Capacity	12-20 sqm. /litre
11	Layer thickness	12/25 on glossy/coarse surface
12	Homogeneity	No sediment
13	Thinning	Normally, no thinner shall be used
14	Drying time	Dust-free in 2 hours, Solid in 4/5 hours. Between layers from wet-in-wet 2 hours for continuous penetration between layers
15	Lustre	Semi-glossy
16	Colour	Lightly yellowish
17	YSAM group	2
18	Injurious to health	No
19	Physiological condition	No dangerous gas generation

		when welding
20	Application	Airless spray equipment or conventional painting with roll/brush
21	Cleaning of equipment	White spirit

5.7.3 **Technical particulars of final coat**

1	System	Two Components Component A: Base Part Component B: Accelerator Part
2	Colour	Black
3	Mixing Ratio	1:1 by Weight
4	% Solid by Weight	More than 95%
5	Pot Lift (Temp.27°C, Relative humidity 65%)	2 hours
6	Setting Time (At 22°C, Relative humidity 65%)	4-5 hours
7	Fully cured	7 days
8	Density of cured mass	1.35
9	Flash Pt. of blended product	40°C (104°F)
10	Hardness	75 Shore D
11	Finish	Semi glossy
12	Water absorption after 6 months	Negligible
13	Covering Capacity	1.5 sqm/kg (400 Microns thickness)
14	Storage Life	1 year in sealed condition

5.8 **Shop Connections**

5.8.1 Surfaces to be permanently in contact shall receive a priming coat immediately at the works except where jointed by welding.

6.0 List of Indian Standards

The construction work of pile foundation shall conform to the following Indian Standards, which shall mean latest revisions, amendments/ changes adopted and published, unless otherwise specified hereinbefore. Some of the important relevant applicable codes for this section are as follows:

1	IS 432	Specification for mild steel and high tensile steel bars and hard drawn steel wire for concrete reinforcement

2	IS 456	Code of practice for plain and reinforcement concrete
3	IS 516	Methods of test for strength of concrete
4	IS 800	Code of Practice for General Construction in Steel
5	IS 813	Scheme of symbols for Welding
6	IS 814	Specification for Covered Electrodes for Metal Arc Welding of Structural Steels
7	IS 816	Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel
8	IS 817	Code of Practice for Liquid Penetrant Flaw Detection
9	IS 1199	Methods of sampling and analysis of concrete
10	IS 1200 (Part-I)	Method of measurement of Building and civil Engineering work-earthwork
11	IS 1200 (Part-23)	Method of measurement of Building and civil Engineering Work-Piling
12	IS 1786	Cold worked steel high strength deformed bars for concrete reinforcement
13	IS 1838	Performed fillers for expansion joints in concrete non-extruding and resilient type (bitumen impregnated filler).
14	IS 2062	Weld able structural steel
15	IS 2074	Ready Mixed Paint, air drying, Red Oxide Zinc Chrome, Priming
16	IS 2386 (Part-III)	Specific gravity, density, voids absorption and bulking
17	IS 2502	Code of Practice for bending and fixing of bars for concrete reinforcement
16	IS 2505	General requirements for concrete vibrators immersion type
19	IS 2506	Screed board concrete vibrators
20	IS 2514	Concrete vibrating tables
21	IS 2911 (Part 1/ Section 2)	Code of practice for design and construction of pile foundation-Bored cast-in-situ concrete piles
22	IS 3025	Methods of sampling and test (Physical and chemical) for water used in Industry
23	IS 3350	Methods of tests for routine control for water used in

		Industry
24	IS 3370	Code of Practice for concrete structure for the storage of liquids
25	IS 3613	Acceptance Tests for Wire Flux Combinations for submerged Arc welding of structural steels
26	IS 3658	Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates
27	IS 3764	Safety codes for Excavation work
28	IS 4353	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steels
29	IS 4656	Form vibrators for concrete
30	IS 4701	Code of practice for earth work on canals
31	IS 8500	Specification for weldable structural steel (medium and high strength qualities)
32	IS 9103	Admixtures for concrete
33	IS 10262	Recommended guidelines for concrete mix design

Annexure-A

Specification of Drilling Mud (Bentonite Slurry)

1.0 Bentonite suspension used for piling work shall satisfy the following requirements:

a) Liquid limit of bentonite when tested in accordance with IS 2720 (Part V) shall be more than 300 percent and less than 450 percent.

b) Sand content of the bentonite powder shall not be greater than 7 percent.

c) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.024 and 1.10 gm/ml depending upon the pile dimensions and type of soil in which the pile is to be met. However, the density of bentonite suspension after mixing with deleterious materials in the pile bore may be up to a maximum of 1.25 gm/ml.

d) The Marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

e) The differential free swell shall be more than 540 percent.

f) The pH value of the bentonite suspension shall be between 9 and 11.5.

Annexure-B

Pile Data Sheet

1	Reference No. Location (Co-ordinates)	
2	Sequence of Piling	
3	Pile diameter & Type	
4	Working level (Platform level)	
5	Cut off level (COL)	
6	Actual length below COL	
7	Pile termination level	
8	Top of finished concrete level	
9	Date and time of start and completion of boring	
10	Depth of Ground water table in the vicinity	
11	Type of strata at pile tip	
12	Method of boring operation	
13	Details of drilling mud as used:	
i)	Freshly supplied mud:	
a)	liquid limit	
b)	sand content	
c)	density	
d)	marsh viscosity	
e)	Swelling index	
f)	pH value	
ii)	Contaminated mud:	
a)	Density	
b)	sand content	
14(a)	SPT, N values in soil (from the nearest bore hole) / UCS value in rock (from the nearest bore hole)	
15	Chiseling if any,	from....m to.....m
16(a)	Date and time of start of concreting	
16(b)	Date and time of completion of concreting	
17	Method of placing concrete	
18	Concrete quantity:	
a)	Actual	
b)	Theoretical	
19	Ref. Number of test cubes	
20	Grade and slump of concrete	

21	Results of test cubes	
22	Reinforcement details:	
i)	Main Reinforcement	
a)	Type	
b)	No.	
c)	Dia	
d)	Depth	
ii)	Stirrups:	
a)	Type	
b)	No.	
c)	Dia	
d)	spacing	
23	Any other information regarding constructions, delay and other interruption to the sequence of work.	

Note: The above details are required to be furnished by the Contractor before starting the installation work.

Annexure-C

Inspection & Testing for Structural Steel Works

1.0 General

Contractor shall carry out a comprehensive inspections and testing programme during fabrication and erection. An indicative programme of inspection/testing envisaged by Employer is given below. This is however not intended to form a comprehensive programme as it is the Contractor's responsibility to draw up and carry out such a programme duly approved by the Employer. Such approval shall not relieve the Contractor of the responsibility about the correctness and adequacy of workmanship, materials etc.

1.1 Raw Materials Inspection

1.1.1 Steel

i) Specifications

Check the specification of steel and availability of the relevant Test Certificates.

ii) Physical Conditions

a) Steel shall not be pitted and should be free from scales and rust.
b) If the plates are bent or distorted, bent to distortion shall normally be removed by the cold treatment etc.
c) Straightening under hot stage shall be resorted to only under specific permission from the Employer.
d) If any rolling defect viz, laminations, cracks etc. are found in the steel during processing it shall be rejected.

iii) Storage

a) Steel plates of different specifications shall be stacked separately.
b) Steel of IS 2062 quality shall be given a distinctive identification mark.
c) Steel sections shall be stacked over spacers supported on posts of about 50 cm height above round. Passage and space between the stacks shall be sufficient for rigging operations.

1.1.2 **Electrodes**

i) Electrodes for manual metal arc welding shall be procured envisaged in the welding procedure sheet predetermined before actual welding operation starts.
ii) Electrodes shall be properly stored dry as required by the IS Code or by the manufacturer.
iii) Electrodes shall bear the I.S.I or equivalent Certification mark.
iv) The approval for all the consumables for welding shall be specifically obtained beforehand.

1.1.3 **Paints/ Primers**

i) The relevant IS or equivalent mark on sealed tins shall be checked.

ii) A few tins shall be opened at random to check the condition of the paints. Paint from old stock and showing signs of solidification shall not be accepted.

1.2 Welding Procedure Qualification

As per ASME section (ix) or equivalent Indian Standards, Welding procedures, Specification shall be submitted by the Contractor for review and approval of Employer.

1.3 Welders Qualification Test

As per ASME section (ix) or equivalent Indian Standard.

1.4 Inspection for Tack Assembly set up for:
i) Level
ii) Gap
iii) Offsetting
iv) Shrinkage allowance
v) Fitment sequence
vi) Principal overall size.

1.5 **Inspection of Main welds**

a) Fillet welds for

i) Size
ii) Dye Check
iii) Visual examination
iv) Dye penetration test/MPI shall be carried out.

b) Butt welds for

i) Dye check for root after back gauging shall be carried out.
ii) Mechanical testing of welds (Destructive Tests) Minimum on joint per liner length/piece.
iii) Non-destructive-as per FCL:SS:4-100% visual examination.

B. **FABRICATION CHECK LIST (STANDARD)**

Title: **Welding Tests on welds and Weld Defects**

Mechanical testing of welds (Destructive test) Butt welds having one or more of the following defects are not acceptable.

i) Bend test: No crack on root/ face on being bent through 180 deg. with mandrel of 4t where t is the thickness of plate.

ii) Tensile test: Weld strength not to be less than part metal's strength.

VISUAL EXAMINATION

Following defects are not allowed:

1) Unsatisfactory appearance
2) Incomplete weld
3) Molten metal flow
4) Pits
5) Surface crack, lack of penetration
6) Insufficient length
7) Surface defects exceeding 5% of weld seam area

DYE PENETRATION TEST

All surfaces to be examined shall be free from:

a) Relevant linear indications
b) Four or more rounded defects in a line separated by 1/16" or less (edge to edge) except where the specification for the material establishes requirements for acceptance so far as defects are concerned.

C. **TYPICAL WELDING PROCEDURE DATA SHEET**

Contractor.....Address.....
..

Quality of weld metal.....Specification.....
Inspection and Test Schedule .....Specification.....
Material Specification.....Thickness.....Batch/Cast No.....
Joint Preparation (Fig.).....Gap.....
Location of Specimens.....
Weather Conditions.....Time of day.....Wind brake used.....
Electrode Group No..... Make.....Specimen.....
Pre and Post Heating.....
Welding position.....
Size of Reinforcement.....Whether removed.....
Welding Sequence.....
Backing Strip use.....Type.....
Welding Process.....
Current Conditions-Polarity.....
Size of Electrode.....
Amperage and Voltage.....
Number of Electrodes used per run.....
Cleaning method.....
Remarks.....

Signature

Engineer-in-Charge
Employer
(Inspecting Authority)

For and on behalf of Contractor
Date:

D. **FABRICATION CHECK LIST: ACCEPTANCE PROFORMA**

No.: _____

Dt.: _____

Project: _____

Work: _____

Sub-Assy

_____

Sl. No.	Characteristic	As per DRG/FCL	Actual	Accept/ reject	Remarks

Signature

Engineer-in-Charge
Employer
(Inspecting Authority)

For and on behalf of Contractor
Date: