

**S.08: PILE FOUNDATIONS****8.1 General:****A. Piling plant and Methods:**

Suggested method for piling is bored cast in-situ piles with hydraulic drilling rigs using partial depth casing with Polymer slurry and oscillator arrangement.

- i. Not less than 2 weeks before any piling work is commenced, the Contractor shall submit to the Engineer for approval, full details of his proposed piling plant and detailed method statements for carrying out the Works. Details of casings and concreting methods in respect of bored cast in-situ concrete piles are to be provided.
- ii. The Contractor shall not commence any piling until the plant and methods which he proposes to use have been approved by the Engineer but such approval shall not relieve the Contractor from any of his obligations and responsibilities under the Contract. If for any reason the Contractor wishes to make any change in the plant and methods of working which have been approved by the Engineer, he shall not make any such change without having first obtained the Engineer approval thereof.
- iii. List and nos. of equipments, accessories proposed to be used for the present job shall be submitted along with the technical bid.

**B. Records:**

The Contractor shall keep complete records of all data required by the Engineer covering the boring operations, reinforcement cage lowering and concreting procedure of each pile and shall submit two signed copies of these records to the Engineer, in the format given in the specification or as approved by the Engineer, within two days of completion of concreting of the pile.

**C. Programme and Progress Report:**

- i. The Contractor shall inform the Engineer each day about the programme of piling for the following day and shall give adequate notice of his intention to work outside normal hours and at weekends, where approved.
- ii. The Contractor shall submit to the Engineer on the first day of each week, or on such other date as the Engineer may decide, a progress report showing the rate of progress to that date and progress during the previous week or period of all main items of piling works, as required by the Engineer.

**D. Setting Out:**

The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the satisfaction of the Engineer and shall set out with a suitable identifiable pin or marker, the position of each pile. The setting out of each pile shall be agreed with the Engineer at least 8 working hours prior to commencing work on a pile and adequate notice for checking shall be given by the Contractor.

Notwithstanding such checking and agreement, the Contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions and alignment of the piles.

- E. After all piles are cast and weak concrete is chipped out, the Contractor shall submit the drawing showing the exact location of piles with respect to the Pier/column centre line.

**F. Disturbances and Noise:**

- i. The Contractor shall carry out the piling work in such a manner and at such times as to minimize noise and disturbance. The pile driving operation can produce noise levels upto 100 dB(A) at a distance of 25m from the site. Using a sound absorbent could reduce the noise levels. This can reduce the noise levels to 70dB(A) at a distance of 15m from the piles. The safety and precautions as stipulated in IS:5121 (1969) "Safety Code for Piling and other Deep Foundation" need to be adopted.
- ii. The Contractor shall take precautions adequate enough to avoid damage to existing services and adjacent structures. IS: 2974 (Part 1) - 1982 may be used as a guide for studying qualitatively the effect of vibration on persons and structures. In case of deep excavation adjacent to piles, proper shoring or other suitable arrangement shall be done to guard against the lateral movement of soil stratum or releasing the confining soil stress. Any such damage shall be repaired by the contractor to the satisfaction of the Engineer.
- iii. The Contractor shall ensure that damage does not occur to completed piling works and shall submit to the Engineer for approval, his proposed sequence and timing for driving or boring piles having regard to the avoidance of damage to adjacent piles.

**G. Obstructions:**

If during the execution of the Works the Contractor encounters obstructions in the ground, he shall forthwith notify the Engineer accordingly, submit to him details of proposed methods for overcoming the obstruction and proceed according to the Engineer's instructions.

**8.2 Scope of Work:**

- a) These specifications cover the works of providing pile foundations. Work included consists of all necessary services and furnishing of all labour, material, tools, equipment and related items for the full and satisfactory performance of the contract, conforming to these specifications and as shown in the Contract Drawings or reasonably implied therein or any authorised conditions or alterations thereof.
- b) The tenderer is advised to visit the site and familiarise himself with the conditions at site. The Engineer shall not be held responsible for the accuracy of the soil data, furnished in good faith with the tender.
- c) The construction of piles shall be in accordance with the following Indian Standard Codes of Practice for Design and Construction of Pile Foundations:  
IS: 2911-2010 Part I Section 2 Bored Cast in-situ Concrete Piles Or IRC:78 Standard specifications and code of practice for road bridges Foundation And Substructure
- d) With the tender the Contractor shall submit the detailed method of construction to be used. For cast-in-situ concrete piles the Contractor shall indicate the methods he proposes to concrete the piles in order to prevent necking of piles.
- e) The items of work will generally be as follows:
  - i. Boring/drilling including provision of temporary casing/permanent casing
  - ii. Supplying, fabrication, and placement of all reinforcing bars.
  - iii. Casting of concrete piles as per specifications.
  - iv. Load testing of piles.

**8.3 Materials:****a. General:**

Unless otherwise specified in this section all materials shall conform to the requirements specified in separate sections for Concrete, Formwork and Reinforcement.

**b. Cement:**

The cement to be used for piling and all foundation work shall be conforming to following Indian Standard Specifications:

- i. 53 grade Ordinary Portland Cement conforming to IS:269 – 2015
- ii. IS:16714:2018 Specification of GGBS for Use in Portland cement by blending process, and for making concrete by direct addition.
- iii. IS: 455 Specification for Portland slag cement.  
Cement shall be free from lumps and caking.

**c. Concrete Mix Design:**

The concrete shall be M35 or as specified in the approved drawings. The maximum size of coarse aggregate shall not exceed 20mm. For sub aqueous concrete, the requirements specified in IS 456 shall be followed. For cast-in-situ piles, concrete with a slump of 150 to 180mm (consistent with the method of concreting) will be required. For slumps more than 150mm the workability should be tested by "determination of flow" as per IS: 9103. **Minimum cementitious content for design mix shall not be less than 400 kg/m<sup>3</sup>** of concrete in piling. For piling, quantity of cement shall be as per the design mix or the minimum cement content whichever is greater shall be used. For improving resistance against chlorides and sulphates form surrounding soils or water, mineral admixture such as GGBS is preferred to be used.

Chemical Admixture used in the Mix Design shall conform to specification mentioned in S.03 of Section-VII-F.

The contractor shall submit mix design calculations and get the same approved by the engineer well before the starting of installation of piles and carry out adequate numbers of tests to ensure the minimum specified strength as indicated in drawings.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter.

**d. Concrete cube tests:**

Concrete cubes shall be cast, tested and evaluated as specified in S.03 of Section-VII-F.

**e. Reinforcement:**

The reinforcement shall conform to the requirements specified in S.05 of Section-VII-F along with IS 2911 (Part 1/ Sec 2) and used as per the drawings, extending for the full length of the pile and shall project minimum 60 times the bar diameters above the cut off level or as specified in the drawing. Only circular concrete cover blocks threaded on to the helix shall be used for ensuring the specified cover. Minimum clear cover to the reinforcement shall be 75 mm, unless otherwise mentioned.

**f. Temporary Casings and Tremie Pipes:**

Temporary casings, as approved by the Engineer, shall be used to maintain the stability of pile bore hole. The casings and tremie pipes shall be in mild steel. The temporary casing plates shall have adequate wall thickness and strength to withstand driving stresses, stresses due to soil pressure, etc. without damage or distortion all joints shall be watertight. The internal diameter of the casing shall not be less than the nominal diameter of pile. Temporary casings and tremie pipe shall be free of distortion and shall be of uniform cross-section throughout each continuous length. During concreting, they shall be free of internal projections and encrusted concrete which may prevent proper formation of the pile. The tremie shall be water-tight throughout its length and have a hopper attached at its head by a water-tight connection.

**g. Stabilizing Material:**

The stabilizing material (Polymer slurry used & quality control) to maintain the sides of pile bores shall have the properties as per requirement given below. Polymer slurry is obtained by mixing polymer powder with water in suitable proportion (1kg powder in 1000 litres of water) and the solution is thoroughly agitated so as to ensure uniform mixing of the polymer powder and water. The capacity

of the mixing tank shall be more than 1.5 times of the volume of the bore hole for which the Polymer is to be used.

For mixing of polymer powder with water and the subsequent pumping of slurry into bore, suitable capacity mixing tank (M.S tank) equipped with agitator & pumping arrangement shall be used.

However, Use of Bentonite as stabilizing material is not permitted. Polymer slurry shall satisfy the desired properties at all times:

- a) Marsh cone viscosity 60-70 seconds/qt (900 ml-One cone volume)
- b) Specific gravity 1.05 to 1.07
- c) PH value 8 to 10
- d) Sand Content by mud balance method - 0.25 % to 2%

#### 8.4 Test Bores (150mm Dia)

- a) Bore hole shall be made as per IS 1892 for determining (which is one of the criteria of establishing) start of socketing horizon and termination level of piles. Standard Penetration Test (SPT), as per IS 2131, in a bore hole shall be conducted at 1.0 m intervals in the overburden soil and rock portion having core recovery  $\leq 30\%$ .
- b) Number of bore holes for determining termination shall vary depending on the site condition and as decided by the Engineer. Generally, one borehole shall be done at each Pier location.

#### 8.5 Cast In-Situ Bored Piles:

##### A. General:

- i) Diameters of the piles shall be the concrete shaft diameters and shall not be less than the diameters specified in the drawing.
- ii) Bore hole data provided by the Employer for construction are only indicative in this regard and it is the contractors' responsibility to make correct assessment of ground conditions before starting the piling operation. Depth of piles is likely to vary, and contractor shall have no claim whatsoever irrespective of the depth of piles provided at any and all locations.
- iii) These shall be formed by boring to the founding strata specified in the drawings or as directed at site. The sides of the boring shall be prevented from collapsing by one of the following means
  - Permanent mild steel liner (cased pile)
  - Removable/temporary mild steel casing (uncased pile).
- iv) Bored cast-in-situ piles shall conform to IS 2911 (Part 1/ Section 2) and IS 14593, where not contravening to the following provisions. Based on borehole reports and drawings, Method Statement for the piles shall be established by the Contractor before commencement of the work and the same shall be submitted to the Engineer for obtaining his approval. Installation of piles shall be carried out as per pile layout drawings, installation criteria, approved Method Statement and instructions of the Engineer. Any changes to the pile design, based on test-piles results, bore-hole data or soil conditions encountered during boring, shall be as instructed by the Engineer.
- v) During boring, the Contractor shall, where required by the Engineer, take soil, rock or ground water samples and transport them to an approved testing laboratory to carry out soil tests as directed.
- vi) The method adopted shall be chosen giving due consideration to the subsoil data, ground water conditions and to the other relevant conditions at site as well as to the presence of adjacent structures.

- vii Before installing the initial test pile, the Contractor shall finalise the pile testing arrangement and obtain approval of the Engineer. It is envisaged that the working piles shall be installed after the successful completion of the initial pile load test.
- viii The bottom of the steel lining shall be sufficiently deep in advance of the boring tool so as to prevent settlement of outside soil and formation of cavities.
- ix Removable mild steel casings shall be used only with extreme caution. Individual casings shall be joined together by screwing or any other approved method and not by direct butting with external lug connections. The inner surface of casings shall be smooth and free of all internal projections.
- x The Contractor shall record all the information during installation of piles, including pile-bore observations before concreting each pile. The data sheet for recording pile data shall be as approved by the Engineer. On completion of each pile installation, pile record shall be submitted to the Engineer within two days of completion of concreting of the pile.
- xi The contractor shall set out piles with precision survey duly erecting permanent benchmarks and other references. He shall be responsible for correct maintenance of position and plumb thereafter and these shall be checked periodically.
- xii **Control of Position & Alignment:** Piles shall be installed as accurately as possible according to the drawings either vertically or to the specified batter. All deviations will be measured at the cut off level of the piles. The deviation from the true axis shall not be more than 1.5% for vertical piles and 4% for rake piles. Piles should not deviate in location by more than 75mm when used in groups. For single or 2 piles used under columns, deviation shall not be more than 50mm. The Contractor shall maintain a record of actual pile locations in the form of drawing and submit the information to the Engineer at suitable intervals.

#### B. Boring:

- i Boring shall be done using hydraulic drilling rigs with oscillator arrangement suiting to different kinds of strata encountered.
- ii The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm. However, the size of cutting tool shall be chosen by contractor depending on the type of substrata and equipment employed by contractor so that executable pile shall not have diameter less than nominal diameter of pile as specified in drawing.
- iii The boring centre shall be aligned with the pile centre and the boring machine shall be installed so as not to move or incline. The sides of the bore-hole shall be stable throughout.
- iv Working level shall be above the Cut-off-Level. After the initial boring of about 1.0 m, temporary guide casing of suitable length shall be lowered in the pile bore for vertical pile. The diameter of guide casing shall be such as to give the necessary finished diameter of the concrete pile. The centre line of the guide casing shall be checked before continuing further boring. Guide casing shall be minimum of 1.0 m length. Additional length of casing may be used depending on the condition of the strata, ground water level etc.
- v The temporary guide casing (if provided) shall be withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing, concrete shall not be disturbed.
- vi For providing permanent MS liner, Clause 709.1.4 of IRC: 78 shall be complied. Wherever stricter provision has been given in the drawings, the same shall be followed. The Contractor shall fabricate MS liners from MS sheets to suit to the diameter of the pile. The required length of the liners will be made up by welding each unit at site. The thickness of the liners shall not be less than 6 mm and for the bottom length of 1.2 m or such increased length as decided by the Engineer, the thickness can be increased suitably. The bottom end of the MS liners shall be stiffened by welding additional plates to withstand the impact during driving.
- vii The piles shall be founded on hard rock or other suitable strata as approved by the Engineer.

- viii Piling shall be done by using hydraulic rig with temporary liner. Use of liner (for the top 4 to 6 metres from ground level or more depth, to protect loose soil falling in bore hole) as directed by engineer, is essential. **No extra payment shall be made to the contractor for using temporary liner over the item of piling as in BOQ/Design and build contract.**
- ix Use of drilling mud in stabilizing sides of the pile borehole may also be necessary together with temporary or permanent casing wherever sub soil and ground water conditions are likely to cause mud flows or instability of pile bore or sand boiling. However, this will be permitted only when deemed necessary by the Engineer.
- x Consistency of the stabilizing material suspension shall be controlled throughout concreting operations in order to keep the bore stabilized, as well as to prevent concrete getting mixed up with the thicker suspension of the mud.
- xi After the installation of temporary casing, the drilling operation will continuously proceed together with the application of the Polymer slurry.
- xii Boring operation shall be carried out further by using the shaft stabilization slurry (Polymer Slurry). The drilling operation shall proceed together with the mixing of the Polymer Slurry. Once the pumping of polymer slurry into the bore is initiated, the bucket or auger is then rotated to mix the Polymer slurry along the Pile shaft.
- xiii Prior to preparation of the bore stabilising slurry, cleanliness and water tightness of storage tank shall be ensured. pH value of fresh water shall be between 7 to 9.
- xiv The site conditions and drilling diameter of bore holes may affect the usage ratio of polymer in the mixture and as well as its viscosity.
- xv During concreting activity, the flushed out Polymer fluid will be collected in storage tanks by pumping back. There is no hazardous effect of this bore stabilising fluid on environment. The Polymer slurry level shall not be kept below the bottom level of Steel Casing. The slurry shall be tested periodically and the results will be submitted to the Engineer. Prior to placing of concrete in the borehole, make sure that heavily contaminated slurry, which could impair the free flow of concrete from the tremie pipe, has not accumulated in the bottom of the borehole. For this, the borehole shall be kept untouched after reaching the desired depth for 1 to 2 hours so as to allow the suspended particles of the polymer to settle down. Then the bore hole shall be cleaned by cleaning bucket before pouring the concrete.
- xvi When borehole is stabilised by casing and drilling mud or by maintaining water head using temporary/permanent casing, the bottom of the hole shall be cleaned very carefully before concreting work is taken up. Cleaning / flushing methodology shall be submitted for the approved of the Engineer prior to commencement of piling.
- xvii Where mud flow conditions exist or the aggressive action of ground water is to be avoided, or in the case of piles built in water or in cases where significant length of piles could be exposed due to scour - the casing should be left permanently in the ground with 8 mm thick permanent liners as directed by Engineer-in-charge.
- xviii The quantum of steel required in liners up to depth of cut off level shall be measured as per drawing though the liner might have been provided right from the level of the working platform on practical considerations, since the length of the permanent liner above the cut-off level has to be necessarily removed by gas-cutting for facilitating peeling of the top portion of the pile and for interlacing its reinforcement bars into the capping slab. There is however, no objection if the surplus pieces (if cut and removed carefully and then found reusable) are joined and are re-welded to required length for reuse in the same contract on some of the other piles. No claim shall be entertained for such pieces if the cut pieces cannot be reused by the Contractor in the aforesaid manner.
- xix Pumping from bore hole shall not be permitted unless a casing has been driven into a stable stratum which prevents flow of external ground water from other strata in significant quantities.

- xx **In case of end bearing piles founded on hard rock, cutting of rock by hydraulic rig using diamond bits will be resorted to.** Scheme adopted shall be such that the noise and vibration parameters specified in tender documents /Environment manual are not violated. Drilling in rock shall be carried out by hydraulic rig using diamond bits. Hydraulics rigs of suitable capacity (in terms of rpm and torque) to be able to bore in hard rock strata shall be deployed.
- xxi In case of dry bores, inspection shall be carried out from the ground surface for bores having diameter less than 750mm. For larger diameter bores equipment shall be provided to enable the Contractor and the Engineer or their representatives to descend into the boring for the purpose of inspection with all necessary safety precautions.
- xxii Care shall be taken not to harm a recently concreted pile due to driving the casing nearby before the concrete has sufficiently set in that pile. The danger of doing harm is greater in compact soils than in loose soils.

#### **Penalty on mishandling of Polymer slurry**

Mishandling of Polymer slurry (like splashing of Polymer slurry outside specified width of barricading or non-cleaning of tyres of dumpers and transit mixers before leaving the piling site thereby making the road dirty etc.) is strictly prohibited . Noncompliance of same shall attract a penalty as follows:

- i. On first observation - Rs. one lakh
- ii. On Second observation - Rs. two lakhs
- iii. On third and each subsequent observation - Rs. three lakhs

### **8.6 Termination of Pile:**

- a) The boring depth shall be measured at two or more places to the bottom of the Hole immediately after completion of boring operations. The results shall be reported promptly.
- b) Pile shall be terminated at a design depth with a minimum socket length as mentioned in design document/drawing, or as directed by the Engineer-In-Charge.
- c) Approval of the termination depth of the pile by the Engineer shall, in no way, absolve the contractor on the integrity of the pile.
- d) For the purpose of socketing of end bearing pile in hard rock, the following criterion shall be satisfied:
  - When the crushing strength of the rock is more than characteristic strength of pile concrete, the rock encountered should be deemed as hard rock as per clause No.B7 of Annex-B, IS 2911- Part1/ Sec-2).
  - Rock will classify as hard rock if RQD > 75%.
  - Minimum Socketing depth in hard rock shall be as per approved drawing or as directed by the Engineer-In-Charge.
- e) For establishing the similarity of soil/rock strata actually met while advancing the pile-bore with the strata selected for terminating the pile, Pile Penetration Ratio (PPR) shall be used in this method as per clause No.10 of IRC-78:2014.
- f) Pile Penetration Ratio (PPR) of rock strata encountered, used for termination of pile shall be confirmed by Initial Pile Load tests, Routine pile Load tests and also co-related with the Unconfined Compressive strength of rock strata and also RQD values.
- g) As the resistance to rock cutting increases, RPM decreases, and Kelly bar pressure is required to be increased, i.e., increasing the torque. This is reflected in the torque- RPM curve.

### **8.7 Cleaning of borehole:**

- a) After completion of borehole upto the required depth, the borehole shall be cleaned as per clause 8.3 of IS : 2911 (Part 1/Section 2).

- b) When the boring is done by rotary drilling rigs, cleaning-bucket attached to the Kelly shall be used for cleaning the bore. Wherever stabilizing material is used, after using the cleaning-bucket, the bore shall be flushed with fresh slurry.
- c) Pile bore shall be cleaned by fresh stabilizing material through tremie pipe or as specified in the Method Statement, before (in case delay in concreting after the completion of bore) and after placing the reinforcement cage and just before the start of concreting. Pile boring shall be inspected and approved by the Engineer, in accordance with approved Method Statement, before concreting.
- d) The Contractor shall measure the final depth after this cleaning, when there is a delay in concreting after completion of the bore, for knowing the casting pile length, and confirm its effect by comparing with the depth at the end of boring.

### 8.8 Reinforcement Steel:

- a) The reinforcement shall be assembled before placing in the moulds and all hoops and links shall be of uniform length firmly wired into position. Ends of helical reinforcement, if used, shall be firmly secured. Diagonal fork spacers shall be of a pattern that has been approved by the Engineer.
- b) Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided in staggered manner at agreed locations, designed to develop the full strength of the bar across the joint, provided with adequate extra links or stirrups and staggered in position from those of adjacent longitudinal bars, all to the approval of the Engineer.
- c) All joints/laps in the longitudinal bars will be held in position by means of binding wire and tack welding. Nothing extra shall be paid for the welding of lap joints. The last one circle of helical stirrups at each end shall be welded to main longitudinal bars.
- d) **Lowering of the reinforcement cage:**  
The reinforcement cage shall be properly aligned with the pile core and kept vertical without collapsing the hole wall. In lowering of the reinforcement cage, it shall avoid deformations, damages, etc. by using reinforcing material as necessary. In the lap joint part of the reinforcement cage, the upper and lower cages shall be in a straight line, with the joints tightly bound.

Proper cover to reinforcement and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers. cast specifically for the purpose, as directed by the Engineer. **The longitudinal reinforcement shall project, minimum 60 times the dia. of reinforcement bar or as indicated in the drawing, above Cut-off-Level.**

After lowering of the reinforcement cage, the height of the top end of the reinforcement shall be measured and reported. The axes of the reinforcement cage and the pile core shall be matched, checked and reported.

### 8.9 Concreting:

- i Concreting shall not be done until the Engineer is satisfied that the termination level of pile, is as per the installation criteria and the Method Statement that has been approved by the Engineer.
- ii Prolonged delays in the commencement of concreting after the completion of the boring shall not be permitted. The time interval between the completion of boring and placing of concrete shall not exceed 6 hour.
- iii Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS 2911 (Part 1/ Sec 2).
- iv The concrete shall have a minimum slump of 150mm in case of concreting in a water free bore. Suitable precautions shall be taken for prevention of segregation. Internal vibrators shall not be used



unless the Contractor is satisfied that segregation will not result because of vibration and unless the method of use has been approved by the Engineer. It is essential that the water level within the pile bore be in equilibrium before commencement of concreting.

- v The concrete for piles underwater or in drilling mud shall be placed with a tremie pipe. The tremie pipe shall not be less than 200mm diameter for 20mm aggregate. The joint between the hopper and tremie pipe as well as the joints in the tremie pipe shall be watertight and the tremie pipes shall be thoroughly cleaned after each use.
- vi Concreting by tremie shall continue to allow the initial pours of concrete, mixed with stabilizing fluid, sludge and cut spoils from the bore to overflow and the consistency and quality of the overflowing concrete is comparable to that of design mix. The length of overflow shall be decided by the Engineer.
- vii The contractor shall also ensure that there is no reduction in poured concrete quantities. These calculations shall be based on consumption of concrete poured in bore (as recorded in bore log) and actual concrete required in bore on theoretical basis i.e. based on nominal diameter of pile and actual bore hole length (based on actual sounding of founding level). Above 5% reduction in consumption of poured concrete quantities in pile may be rejected.
- viii While concreting the tremie shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal.
- ix The Contractor shall ensure that heavily contaminated drilling mud has not accumulated at the base of boring since this could impair free flow of concrete from the tremie pipe.
- x If the specific gravity of the drilling mud at the base of the bore exceeds 1.20 the placing of concrete shall not proceed.
- xi The first charge of concrete shall be placed in the hopper over a sliding plate of the bottom of the hopper. The charge should be adequate in volume to ensure flushing action to prevent mixing of water or drilling mud and concrete. Alternatively, floating plugs of approved specification may be used before the first charge of concrete.
- xii The tremie pipe shall at all times penetrate the previously placed concrete with adequate margin against accidental withdrawal. The tremie pipe shall not be withdrawn until the completion of concreting. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the seepage water.
- xiii Spot measurements shall be taken at suitable intervals to check that the tremie pipe has an adequate penetration into previous concrete.
- xiv Concreting of the pile shall be in one single and continuous operation. In case of long piles of large diameter, large size mixers or more mixers shall be used so that the entire concreting operation is completed in not more than two hours.
- xv Temporary casings, when used, shall be extracted carefully to the satisfaction of the Engineer, whilst the concrete is sufficiently workable to ensure it is not disturbed or lifted, and the reinforcement cage does not get disturbed. During extraction, a sufficient quantity of concrete shall be maintained inside the casing to overcome the pressure from external water, soil or stabilizing material and to ensure that no reduction in section by way of necking or shearing of concrete and contamination of the pile takes place.
- xvi When a casing is being extracted a sufficient quantity of concrete shall be maintained within the bore to ensure the pressure from external ground water and soil is adequately exceeded by the pressure of concrete. Otherwise necking of the pile may result. A minimum embedment of 1.5 to 1.8 m is required.
- xvii Grouting at base of pile shall be done wherever the results of proof coring (in case of rock), sonic logging and/or loading test etc. confirm that there is a void/sludge at the pile base. The grouting shall be done with cement slurry under suitable pressure after concrete in the pile attains the desired

strength. For this purpose, conduit pipes with easily removable plugs at the bottom end shall be placed in the bore along with reinforcement cage before concreting.

- xviii No concreting shall be placed in the bore once the bottom of the casing has been lifted above the top of concrete.
- xix The top of concrete in a pile shall be brought above the cut-off level since the top concrete is loose and is weak because of contamination with water/drilling mud. This ensures good concrete at the cut-off level.
- xx After each pile has been cast, any empty bore shall be protected and carefully backfilled as soon as possible with approved materials.
- xxi Complete boring and concreting records shall be submitted to the Engineer for each pile. The records shall include the duration of concreting, tremie lengths (individual and cumulative), tremie pipe lengths removed, theoretical sounding, actual sounding, actual lengths of pile concreted and the volume of concrete placed, cut off level, founding levels etc. For piles with temporary casings records of sequence of casing withdrawal and levels of concrete before and after withdrawal shall also be included in the reports.

### 8.10 Cut-off-level ( COL)

- a) Cut off level of piles shall be as indicated in working drawings or as directed by Engineer.
- b) The top of concrete in pile cast shall be above the Cut-off-Level by 1.0 m (minimum) and as per the Method Statement, to remove all laitance and weak concrete and to ensure good concrete at Cut-off-Level, for the proper embedment into the pile cap. Any exceptions, due to contingent situation, will be subject to the approval of the Engineer.
- c) **Preparation of pile head:** The area surrounding the piles shall be excavated up to the bottom of the pile caps. After seven days of concreting of pile, the exposed part of concrete above the COL shall be removed or chipped off and made rough at COL. In case a part of extra-pile concrete before curing is handled, the Contractor shall obtain prior approval from the Engineer. The projected reinforcement above COL shall be properly cleaned and bent carefully, only where required, to the required shape and level to be anchored into the pile cap as per the drawing. While finishing the pile head, care shall be taken to ensure no harmful damage, such as cracks, occurs in the concrete. The pile top shall be embedded into the pile cap by 150 mm or clear cover to reinforcement, as per the drawing and as agreed by the Engineer. All loose material on the top of pile head after chipping to the desired level shall be removed and disposed as per contractual procedure and as directed by the Engineer.
- d) In case of concrete being placed by tremie method and pile cut off level less than 1.0 meter below the ground level, concrete shall be cast 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 a minimum of one meter above COL. Before concreting, contractor shall obtain the approval of the Engineer of the height above COL up to which the concrete is to cast.
- e) Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete.

### 8.11 Pile Cap:

Pile caps shall be of reinforced concrete. A minimum offset of 150 mm shall be provided beyond the outer faces of the outer most piles in the group. If the pile cap is in contact with earth at the bottom, a levelling course of minimum 75 mm thickness of PCC of grade M15 shall be provided or as shown in the drawings. The ground shall be excavated, levelled, prepared and then layers of coarse aggregate and blinding concrete shall be constructed below pile cap, conforming to Clause 2.0 of this Specifications and as per the drawings. The pile cap shall then be cast as per the drawings and conforming to specifications

mentioned in S.03 & S.05 of Section-VII-F of this Technical Specifications, subject to tolerances mentioned therein.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. The top of pile after stripping shall project at least 150mm or clear cover to reinforcement or as per given in the drawing, into the pile cap. Concreting of the pile cap shall be carried out in dry conditions. All the operations and tools required for making the pile in dry condition is included in the item.

#### 8.12 Testing of Piles:

- i The Contractor shall conduct Load tests/Integrity Tests on Pile as described below in accordance with these specification and approved method statement. **Cost of the same is deemed to be included in the contract price and nothing extra shall be payable to the contractor on this account.**
- ii When preparing for conducting a pile test, the Contractor shall follow the requirements of the various acts, orders, regulations and other statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.
- iii Full details of the equipment proposed to be used, the test setup and pile testing scheme along with detailed design, drawings shall be submitted to the Engineer, before making arrangements to carry out the tests, for obtaining his approval. Approval of the Engineer shall also be obtained after the test setup is complete, prior to commencement of loading.
- iv The work shall include mobilization of all necessary equipment, anchor piles and rock anchors and anchor piles and rock anchors, providing necessary engineering supervision and technical personnel, skilled and unskilled labour as required, to carry out the complete pile testing and submission of test reports.
- v It is essential that all the equipment and instruments are properly calibrated both at the commencement and immediately after the completion of tests, so that they represent true values. If the Engineer desires, the Contractor at his own cost shall arrange for calibration of the instruments in presence of the Engineer, at a laboratory having Engineer's approval, and the test report and calibration certificate shall be submitted to the Engineer.
- vi The load tests shall be in accordance with the Indian Standard Code of Practice for Design and Construction of Pile Foundations IS 2911 (Part IV) Load Tests on Piles. For initial load test, test load will be 2.5 times the theoretical designed capacity of pile. For initial load, test arrangement to be designed shall also cater for additional 25% above test load and nothing extra will be paid on this account. Permissible stresses in test arrangement (steel truss or plate girder) to cater for test load plus additional 25% load shall be within permissible stresses as per IS: 800 (as for permanent structure). For test frame, steel of Grade -B conforming to IS: 2062 shall be used.
- vii Engineer will decide the locations of initial and routine (both lateral and vertical load tests). The Frequency or number of the Initial/Routine pile load test shall be as per IS: 2911 (Part IV). Notwithstanding to the above, the number of Routine Load test shall be 2 percent of the total number of piles required. **Nothing Extra shall be payable to the contractor on this regard.** The contractor shall undertake test piles required for initial pile load test (both lateral and vertical) in the initial stages of work using the same methodology and equipments which will be subsequently used for working piles. These tests shall be undertaken well in advance of taking up working piles. No working pile would be allowed to be undertaken till satisfactory initial pile load tests have been completed. Non-granting of permission for pile/ pile cap by Engineer in such respect will not be considered as reason for delay or any claim thereof. The test arrangement to be employed shall be of nature which is quick to install and remove and easily transferable. However, for stations initial load tests for all pile types have to be performed. Routine pile testing has to be as per IS 2911-Part 4

- viii The Contractor shall give the Engineer at least 48 hours' notice of the commencement of construction of these piles which are to be subjected to Initial Tests.
- ix The load tests shall not normally be conducted unless the concrete is at least 28 days old. However in special circumstances, permission can be given by Engineer for prior testing.
- x All testing shall be done under the direction of experienced personnel conversant with the equipment and the testing procedure.
- xi Before the commencement of the tests all the particulars regarding the test pile including boring data and concrete cube strengths shall be made available at site and shall form a part of the test report.
- xii On completion of each load test the Contractor shall submit a report of the load test which shall include the following information.
  - a. Description of soil conditions, ground water table, actual boring and installation records, concrete cube test results.
  - b. Method of load application
  - c. Load settlement readings during loading and unloading
  - d. Time load-settlement curve
  - e. All other observation relevant to the test being conducted.

### 8.13 Integrity test

Two types of pile integrity tests will be performed:

a. **Dynamic Integrity Test:**

The Dynamic Integrity test using pile driving analyser or approved equivalent for pile integrity shall be performed on all the piles as specified below. The top of the pile shall be made accessible, chipped off up to hard concrete, levelled by trimming it back as far as practicable. The reinforcing bars of the piles tested shall be bent sideways. The test shall be performed after removal of bad/ weak concrete at top so that the wave propagation is steady through hard concrete. The test shall be carried out at minimum 3 locations on each pile in such a way that the entire cross section of the pile is evenly covered. The test shall be conducted with a minimum age of concrete of 15 days. A specialist approved agency shall be employed for the test and the tests shall generally be as per recommendations of the agency unless directed by the Engineer. A complete report indicating the graphical display of wave propagation under each hammer blow shall be submitted along with interpretation of results showing discontinuities, cross-sectional changes or material changes if any are to be co-related with Site data. **75% of total working piles shall be tested by dynamic integrity test.**

b. **Cross hole Ultra-Sonic Integrity Test**

The bored piles shall be tested to determine integrity of the pile by the above method.

The tests shall be carried out with consented method and consented specialist firm. **25% of total working piles shall be tested for integrity by Cross hole ultra-sonic method**

c. **General**

- i. The integrity of each pile shall be examined prior to acceptance of the pile into the Permanent Works.
- ii. At least 30 days prior to the commencement of integrity test, the Contractor shall submit the testing method, equipment, and testing company (specialised firm) to the Employer's Representative for his consent.
- iii. The Contractor shall demonstrate how the results obtained from the tests are to be interpreted in order that irregularities can be identified.
- iv. The equipment of tests shall be certified with recent calibration/set up of the instrument and with curriculum vitae of those using the instrument and interpreting the result.

d. **Criteria for acceptance**

- i. Criteria for acceptance or non-acceptance of the piles shall be established before starting the test in agreement between the Employer's Representative and the Contractor, based on specifications and experience records from the equipment supplier and the specialized company performing the testing, and other available information.
- ii. In cases where there is doubt if the pile can be accepted based on the test results, an impartial expert appointed by the Employer's Representative shall decide.
- e. **Installation of pipes for integrity testing Cross hole Ultra-sonic method**
  - i. 4 nos. of 50 mm (OD) Mild Steel pipes shall be fastened to the inner side of the reinforcement cage of all piles with diameter 1200mm or below. Installation of these pipes shall be carried out for the entire length of the pile. All the joints (if any) in the pipes shall be properly sealed by suitable means so as to make them water tight. The bottom and top of these pipes shall be plugged to prevent entry of mud, slush, polymer slurry, concrete etc.. Spacing of these pipes shall be at 90° in piles with diameter of 1200mm or below. For 1500 mm and 2000 mm diameter piles, 6 nos. of 50 mm (OD) pipes spaced at 60° shall be used.
  - ii. The mild steel pipes shall be supported and braced securely so that they maintain their position during cage lowering and subsequent concreting operations.
- f. **Testing**
  - i. The Contractor shall carry out the tests by a specialized experienced agency consented by the Employer's Representative for all bored piles or as directed by the Employer's Representative.
  - ii. Unless otherwise directed or consented by the Employer's representative, integrity tests shall not be carried out until 7 days or more have elapsed since pile casting. Testing shall be undertaken on pile heads before steel reinforcement for pile caps is placed.
  - iii. Once the testing is completed, the pipes shall be filled with standard cement non-shrink mortar/grout before taking up the pile cap works.
  - iv. The testing shall be carried out in the presence of the Employer's Representative.
- g. **Reporting**
  - i. The Contractor shall submit to the Employer's Representative the test results, associated interpretive report and certificate for each tested pile within 10 days of the completion of each test.
  - ii. The interpretation of test results shall be carried out by competent specialist engineers.
- h. **Anomalies**
  - i. If any anomalies, which indicate unacceptable weaknesses in the concrete, are reported as a result of integrity testing, the Contractor shall perform core drilling for sampling and laboratory testing to prove whether the quality and bearing capacity of the concrete are adequate. The program for necessary core drilling and testing shall be consented by the Employer's Representative.
  - ii. If such anomalies are shown to be detrimental to the performance of the pile, remedial measures shall be consented by the Employer's Representative and undertaken by the Contractor to rectify this.

- iii. No covering over of the piles shall occur until the Employer's Representative is satisfied with the results of the testing and any remedial works.

The contractor shall conduct trial probes and trial pits down to depths decided by the Engineer with the objective of locating underground utilities well in advance of the piling. The locations shall be decided by the Engineer after consultation with the contractor.

#### **8.14 Defective Piles:**

- i. The Engineer reserves the right to reject any pile which in his opinion has not been constructed in accordance with the specifications.
- ii. The Contractor will not be paid for rejected piles. The increase in cost of the pile caps, tie beams and other measures adopted for strengthening as a result of rejection of defective piles shall be borne by the Contractor.

#### **8.15 As-Built Drawings:**

On completion of the work, the Contractor will submit a plan showing the exact location and length of each pile as constructed at site, as well as dates of concreting, cube test results etc. The original tracing of this drawing shall be submitted to the Engineer.

#### **8.16 Pile Data:**

The contractor shall submit data in the following proforma for each pile indicating all technical details along with date and time of various operations in adequate permanent forms/copies for record.

##### **Proforma:**

- i) Reference No. Location (Co-ordinates) \_\_ area.
- ii) Sequence of installation of piles in group
- iii) Pile diameter & type
- iv) Working level (Platform level)
- v) Cut off level (COL)
- vi) Actual length below COL
- vii) Pile termination level
  - (a) Start of socket (Level)
  - (b) Termination of pile (Level):
- viii) Top of finished concrete level
- ix) Date and time of start and completion of boring
- x) Depth of ground water table in the vicinity.
- xi) Type of rock at pile tip
- xii) Method of boring operation
- xiii) Details of stabilizing material as used:
- xiv) (a) Unconfined Compression Strength (UCS) Value in rock (from the nearest bore hole): Core recovery (from the nearest bore hole):
- (b) Rate of drilling in mm / hr:
  - (1) At start of socketing horizon
  - (2) At termination level
- xv) Date and time of start and completion of concreting.
- xvi) Concrete quantity
- Actual:
- Theoretical:
- xvii) Grade and slump of concrete
- xviii) Results of test cubes

#### **8.17 Measurement for Payment (Not applicable for Schedule B):**

The Contractor shall be paid for the length of each pile as measured from the theoretical founding level (as per drawing) or as per actual whichever is less to the point of the vertical cut-off level. The Contractor's rate shall include all items of work including all temporary/permanent arrangements for boring including usage of polymer slurry, concreting, handling, form-work, including chipping of top weak concrete, cutting off the MS liner / casing as necessary, removal of excavated earth, chipped concrete, casing / liners and polymer slurry away from site including its treatment & final disposal, and all other items of work for the satisfactory completion of the pile foundations. Reinforcement shall be measured and paid separately.

The quantity of permanent steel liners required for the job shall be measured in Metric tonnes and paid for separately as per the relevant item of BOQ.

The boring/drilling and socketing through hard rock strata shall be measured extra over and paid for separately as per the relevant item of BOQ.