1200

Well Foundations

1201. DESCRIPTION

This work consists of construction of well foundation, taking it down to the founding level through all kinds of sub-strata, plugging the bottom, filling the inside of the well, plugging the top and providing a well cap in accordance with the details shown on the drawing and as per these specifications, or as directed by the Engineer.

In case of well foundations of size larger than 12 m diameter, supplemental construction specifications will be necessary.

1202. GENERAL

1202.1. Wells may have a circular, rectangular, or D-shape in plan and may consist of one, two or more compartments in plan. The outer wall of the well is known as well steining which may be cellular.

The process of taking down the well to the founding level is known as well sinking. After reaching the founding level, the hollow inside the well, ("dredge hole") is plugged at the bottom by concrete ("bottom plug"). The dredge hole is then filled with approved filling upto the level indicated on the drawings and provided with a concrete plug ("top plug").

To facilitate sinking of well, steel cutting edge is fabricated and connected to a concrete well curb of required shape. On top of the well curb, adequate height of well steining is cast and the process of sinking is carried out. After a portion of the well has been sunk, another height of well steining is cast on top of the previous section and further sinking carried out. This process is continued till the bottom level of the well reaches the founding level.

At the top of the well steining, an adequately designed "well cap" is laid which transmits the loads and forces from the sub-structure (piers or abutments) to the foundations.

1202.2. At least one bore-hole must be available/carried out in accordance with these specifications at each well foundation location, prior to commencement of work. The depth of bore-holes should extend upto a depth equal to one and a half times the outer diameter/least dimension of the well below the anticipated founding level. The results of soil exploration should be presented in accordance with clause 7.4 of IRC:78. In case the well foundation is to rest on a rocky strata, it may be necessary to undertake additional borings /probings prior to commencement of work to ascertain the actual profile and the quality

of the rocky strata, at the level at which the well has to be seated, etc.

1202.3. Blasting may have to be resorted to in order to facilitate sinking through difficult strata, such as boulders and rocks etc. In case blasting is anticipated, protective/strengthening measures specified in clause 710.6 (IV) of IRC:78 shall be taken. The grade of concrete in bottom 3 metres of steining shall not be leaner than M 20 or as shown on the drawings.

1202.4. In case the bore hole data shows the presence of steeply dipping rock, chiselling may have to be resorted to so as to obtain proper seating of the foundation. For this purpose, the well may require to be dewatered completely under high air pressure inside the well. This process is known as pneumatic sinking. Pneumatic sinking may also have to be resorted to in cases where obstacles such as tree trunks, large sized boulders or hard strata etc. cannot be removed by open dredging. The necessity of adopting pneumatic sinking shall be decided by the Engineer.

The curb and steining have to be specifically designed for special loadings when pneumatic sinking is adopted.

1203. SETTING OUT AND PREPARATIONS FOR SINKING

1203.1. Necessary reference points shall be fixed, away from the zone of blow-ups or possible settlements resulting from well sinking operations. Such reference points shall be connected to the permanent theodolite stations with the base line on the banks. The centre of the individual wells shall be marked with reference to these stations. The distance, wherever practicable, shall be checked with the help of accurate tapes and precision distomat.

Reference points shall also be fixed to mark X-X axis (usually traffic direction) and Y-Y axis (normal to X-X axis) accurately.

A temporary bench mark shall also be established near the well foundation, away from the zones of blow-ups or possible settlement. The bench mark shall be checked regularly with respect to the permanent bench mark established at the bridge site.

1203.2. For wells which are to be pitched in water, an earthen or sand island shall be constructed. Sand islands are practicable for water depths of about 5 metres under stable bed soil conditions. For greater depths or in fast flowing rivers or for locations where soil is too weak to sustain sand island, floating caissons may have to be adopted.

The plan dimensions of sand islands shall be such as to have a working space of at least 2 metres all around the steining. The dimension of the sand islands shall however be not less than twice the dimension in plan of the well or caisson. Sand islands shall be maintained to perform their functions, until the well is sunk to a depth below the bed level at least equal to the depth of water.

Sand island shall be protected against scour and the top level shall be sufficiently above the prevailing water level to be decided by the Engineer so that it is safe against wave action.

While sand islands are constructed at well location, floating caissons are generally fabricated at or near the banks on dry land or dry docks. Floating caissons are towed into position in floating condition.

Floating caissons may be of steel, reinforced concrete or a combination of the two. They should have at least 1.5 m free board above water level and increased, if considered necessary, in case there is a possibility of caissons sinking suddenly owing to reasons such as scour likely to result from the lowering of caissons, effect of waves sinking in very soft strata etc.

Stability of floating caissons shall be ensured against overturning and capsizing while being towed and during sinking for the action of water current, wave pressure, wind etc.

For floating caissons, a detailed method statement for fabrication, floating and sinking of caissons shall be prepared and furnished to the Engineer. Such statement shall include the total tonnage of steel involved, fabrication and welding specifications, list of materials and plant and a description of operations and manpower required for the work. The caisson shall be tested for leakages before being towed to site.

1203.3. Equipment

Equipment shall be deployed for construction of well foundation as required and as directed by the Engineer. Generally, the following equipments may be required for the work :

(a) Crane with grab buckets - capacity 0.5 to 2.0 cum.

(b) Submersible pumps

(c) Air compressors, air locks and other accessories where pneumatic sinking of well is anticipated.

(d) Chisels of appropriate sizes

(e) Aqua-header for cutting rocky strata

(f) Diving helmets and accessories

(g) Equipment for concrete production, transportation planing and compaction.

1204. CUTTING EDGE

1204.1. The mild steel cutting edge shall be made from structural steel sections. The cutting edge shall weigh not less than 40 kg per metre length and be properly anchored into the well curb, as shown in the drawing.

When there are two or more compartments in a well, the bottom end of the cutting edge of the inner walls of such wells shall be kept at about 300 mm above that of outer walls.

1204.2. The parts of cutting edge shall be erected on level firm ground. Temporary supports shall be provided to facilitate erection and maintaining the assembly in true shape. The fabrication may be carried out in the shop or at site. Steel sections shall not be heated and forced into shape. However, "V" cuts may be made in the horizontal portion, uniformly throughout the length, to facilitate cold bending. After bending, such "V" cuts should be closed by welding. Joints in the lengths of structural sections, unless otherwise specified shall be fillet welded using single cover plate to ensure the requisite strength of the original section.

1204.3. The cutting edge shall be laid about 300 mm above prevalent water level.

1205. WELL CURB

1205.1. The well curb may be precast or cast-in-situ. Steel formwork for well curb shall be fabricated strictly in conformity with the drawing. The outer face of the curb shall be vertical. Steel reinforcements shall be assembled as shown on the drawings. The bottom ends of vertical bond rods of steining shall be fixed securely to the cutting edge with check nuts or by welds.

The formwork on outer face of curb may be removed within 24 hours after concreting. The formwork on inner face shall be removed after 72 hours.

1205.2. All concreting in the well curb shall be done in one continuous operation.

1206. WELL STEINING

1206.1. The dimensions, shape, concrete strength and reinforcements of the well shall strictly conform to those shown on the drawings. The formwork shall preferably be of M.S. sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or M.S. sheets.

1206.2. Steining built in the first lift above the well curb shall not be more than 2 metres and in subsequent lifts it shall not exceed the diameter of the well or the depth of well sunk below the adjoining bed level at any time. For stability, the first lift of steining shall be cast only after sinking the curb at least partially for stability. Concreting of steining may be carried out in subsequent lifts of about 2 to 2.5 metres. Attempts should be made to minimise the number of construction joints. The concreting layers shall be limited to about 450 mm restricting the free fall of concrete to not more than 1.5 m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

1206.3. The steining of the well shall be built in one straight line from bottom to top such that if the well is tilted, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb bob or spirit level shall not be used for alignment. After sinking of a stage is complete, damaged portions if any, of steining at top of the previous stage shall be properly repaired before constructing the next stage.

1206.4. The height of steining shall be calibrated by making at least 4 gauges (preferably in traffic direction and in a direction normal to traffic direction) distributed equally on the outer periphery of the well each in the form of a 100 mm wide strip painted on the well, with every metre mark shown in black paint. The gauges shall start with zero at the bottom of the cutting edge. Marking of the gauges shall be done carefully with a steel tape.

1206.5. After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Engineer will direct and the Contractor shall execute the remedial measures before acceptance of the well steining. In case the well cannot be accepted even with any remedial measures, then the well shall stand rejected.

1207. WELL SINKING

1207.1. General

The well shall as far as possible be sunk true and vertical through all types of strata.

Sinking or loading of the well with kentledge shall be commenced only after the steining has been cured for at least 48 hours or as specified in the drawings.

No well shall be permitted to be placed in a pre-dredged hole.

The well shall be sunk by excavating material uniformly from inside the dredge hole. Use of water jetting, explosives and divers may be adopted for sinking of wells through difficult strata with prior approval of the Engineer.

Normally dewatering of well should not be permitted as a means for sinking the well. It also shall never be resorted to if there is any danger of sand blowing under the well. Dewatering shall however be done when well is to be founded into rock. Pneumatic sinking may have to be resorted to where obstacles such as tree trunks, large size boulders, etc. are met at the bottom or when there is hard strata which cannot be removed by open dredging. The necessity for pneumatic sinking shall be decided by the Engineer.

Sinking history of well shall be maintained in the format given in *Appendix* 1200/I.

1207.2. Use of Kentledge as Sinking Load

Kentledge shall be placed in an orderly and safe manner on the loading platform and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well.

Where tilts are present or there is a danger of well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

1207.3. Use of Water Jetting

Water jetting may be employed for well sinking wherever necessary.

1207.4. Use of Explosives

Mild explosive charges may be used as an aid for sinking of the well only with prior permission of the Engineer. Blasting of any sort

shall only be done in the presence of the Engineer and not before the concrete in the steining has hardened sufficiently and is more than 7 days old. When likelihood of blasting is predicted in advance, protection of the bottom portion of the well shall be done as per these specifications. After blasting operations are completed, the well curb and steining should be examined for any cracks and remedial measures taken.

If blasting has been used after the well has reached the design foundation level, normally 24 hours shall be allowed to lapse before the bottom plug is laid.

The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances of any damage to the curb or to the steining of the well. A minimum sump of 1 metre depth should be made before resorting to blasting. Use of large charges, 0.7 kg or above, may not be allowed except under expert direction and with the permission from the Engineer. Suitable pattern of charges may be arranged with delay detonators to reduce the number of charges fired at a time. The burden of the charge may be limited to 1 metre and the spacing of holes may normally be kept as 0.5 to 0.6 metres.

All prevalent laws concerning handling, storing and using of explosives shall be strictly followed.

All safety precautions shall be taken as per IS:4081 "Safety Code for Blasting and related Drilling Operations", to the extent applicable, whenever blasting is resorted to.

There should be no equipment inside the well nor shall there be any labour in the close vicinity of the well at the time of exploding the charges.

If rock blasting is to be done for seating of the well, the damage caused by flying debris should be minimised by covering blasting holes by rubber mats before blasting.

1207.5. Use of Divers

Use of divers may be made both for sinking purpose like removal of obstructions, rock blasting and for inspection. All safety precautions shall be taken as per any acceptable safety code for sinking with divers or any statutory regulations in force.

Only persons trained for the diving operation shall be employed and shall be certified to be fit for diving by an approved doctor.

They shall work under expert supervision. The diving and other

equipments shall be of acceptable standard and certified to this effect by an approved independent agency. It shall be well maintained for safe use.

Arrangement for ample supply of low pressure clean cool air shall be ensured through an armoured flexible hose pipe. Standby compressor plant shall be provided in case of breakdown.

Separate high pressure connection for use of pneumatic tools shall be made. Electric lights where provided shall be at 50 volts (maximum). The raising of the diver from the bottom of wells shall be controlled so that decompression rate conforms to the rate as laid down in appropriate regulations.

1207.6. Use of Pneumatic Sinking

1207.6.1. General

The Engineer shall familiarise himself with particular reference to caisson diseases and working of the medical air-lock. A doctor competent to deal with cases of "Caisson Diseases" or other complications arising as a result of working under high pressure, shall be stationed at the construction site when pneumatic sinking is under progress.

The contractor shall provide complete facilities including the issuing of orders to ensure strict enforcement of the requirements outlined in these specifications.

Safety provisions as contained in IS:4138 and in these specifications shall be strictly followed.

Pneumatic sinking shall be restricted to a depth of 30.0 m.

1207.6.2. Man-Locks and Shafts

Locks, reducers, and shaft used in connection with caissons shall be of riveted construction throughout. The material used in their manufacture shall be steel plate with thickness not less than 6 mm.

Shafts shall be subjected to hydrostatic or air pressure test of at least 0.5 MPa, at which pressure they shall be tight. The pressure at which testing has been done shall be clearly and visibly displayed.

Shafts shall be provided, with a safe, proper and suitable staircase for its entire length including landing platforms which are not more than 6 metres apart. Where this is impracticable due to space constraint, suitable ladders along with landing platforms shall be installed. These

shall be kept clear and in good condition at all times and shall be constructed, inspected and maintained to the entire satisfaction of the Engineer.

A 1.0 m wide platform with 1.0 m high railing shall be provided all round the caisson air locks.

Where 15 or more men are employed, caissons shall have two locks, one of which shall be used as a man lock.

Locks shall be located so that the lowest part of the bottom door shall not be less than 1 metre above high water level.

The supply of fresh air to the working chamber shall at all times be sufficient to permit work to be done without any danger or excessive discomfort. All air supply lines shall be supplied with check valves and carried as near to the face as practicable.

A man-lock shall be used solely for the compression or de-compression of persons, and not for the passage of plant and material and shall be maintained in a reasonably clean and sufficiently warm state. However, any hand tool or hand instruments used for the purpose of the work may be carried into the man-lock.

Where it is not reasonably practicable to provide a separate man-lock for use by persons only, the lock when it is in actual use for compression or decompression of a person or persons shall not be put, simultaneously, to any other use and shall be in a reasonably clean and sufficiently warm state.

1207.6.3. Valves

Exhaust valves shall be provided, having risers extending to the upper part of the chamber. These shall be operated, whenever necessary specially after a blast. Precautions shall be taken that men are not allowed to resume work after a blast until the gas and smoke are cleared.

1207.6.4. Medical supervision and certification

Every employee absent from work for 10 or more consecutive days due to illness or any other disability shall be required to pass the regular physical examination by the doctor before being permitted to return to work.

After a person has been employed continuously in compressed air for a period of 2 months, he shall be re-examined by the doctor and

shall not be permitted to work until such re-examination has been made and the report is satisfactory.

No person known to be addicted to the excessive use of intoxicants shall be permitted to work in compressed air.

The doctor shall, at all times, keep a complete and full record of examinations made by him, which shall contain dates of examinations, a clear and full description of the person examined, his age and physical condition at the time of examination and a statement as to the period such a person has been engaged in such employment. Records shall be kept at the place where the work is in progress and shall be subject to inspection by authorised officers.

Every man lock shall always have a doctor or a responsible person in attendance. In case the person in charge is not a doctor he must have positive means of promptly communicating with and securing the services of a competent doctor in case of emergency. Such arrangements shall invariably be subject to the approval of the Engineer.

If the air pressure exceeds 0.2 MPa gauge or if 50 or more men are employed, it is obligatory for the person in charge of medical lock to be a doctor experienced in this type of work.

All cases of compressed-air illness shall be reported and copies of all such reports shall be kept on file at the place of work.

1207.6.5. Lighting

All lighting in compressed air chambers shall be operated only by electricity. Two independent electric lighting systems with independent sources of supply shall be used. These shall be so arranged that the emergency source shall become automatically operative in case of failure of the regularly used source.

The minimum intensity of light on any walkway ladder, stairway, or lower working level shall be one-quarter (1/4) candlepower. In all work places, the lighting shall always be such as to enable workmen to see their way about clearly. All external parts of lighting fixtures and electrical equipment lying within 2.5 metres above the floor shall be constructed of non-combustible, non-absorbing insulating materials. If metal is used it must be effectively earthed. Portable lamp shall have non-combustible, non-absorbing insulating sockets, approved handles, basket guards and approved cables. The use of worn or defective portable and pendant conductors, shall be prohibited.

1207.6.6. Safety against fire hazard

No oil, gasoline, or other combustible material shall be stored within 30 metres of any shaft, caisson, or tunnel opening. However, oil may be stored in suitable tanks in isolated fireproof buildings, provided such buildings are not less than 15 metres from any shaft, caisson, or tunnel opening or any building directly connected thereto.

Positive means shall be taken to prevent leaking flammable liquids from flowing into areas specifically mentioned in the preceding paragraph.

Where feasible, a fire hose connected to a suitable source of water shall be provided at the top of every caisson. Where fire mains are not accessible, a supply of water shall be stored in tanks near the top of every caisson, provided fire pails or suitable pumps are kept available. Approved fire extinguishers shall also be provided.

1207.6.7. Sanitation

Properly heated, lighted and ventilated dressing rooms shall be provided for all employees engaged in compressed air work. Such rooms shall contain lockers and benches and be open and accessible to men during intermission between shifts. Adequate toilet accomodation of one for every twenty five employees shall be provided.

Care shall be taken to keep all parts of the caissons and other working compartments, including locker rooms, dry rooms, rest rooms, and other equipment in a good sanitary condition and free from refuse, decaying, or other objectionable matter.

No nuisance shall be tolerated in the air chamber. Smoking shall be strictly prohibited and all matches and smoking materials shall be left out of the locker rooms.

A separate dry-room shall be provided where working clothes may be dried within reasonable time.

1207.6.8. Protection against gases

In all cases where gas is expected including alluvium impregnated with decayed vegetable matter the use of Davy Safety Lamp shall be compulsory.

1207.6.9. Additional safety provisions

a) The weight of the pneumatic platform and that of steining and kentledge, if any, shall be sufficient to resist the uplift from air inside, skin friction being neglected in this case. If, at any section the total weight acting downwards is

less than the uplift pressure of air inside, additional kentledge shall be placed on the well.

If it is not possible to make the well heavy enough during excavation, "blowing down" may be used. The men should be withdrawn and air pressure reduced. The well should then begin to move with small reduction in air pressure. "Blowing down" should only be used when the ground is such that it will not heave up inside the chamber when the pressure is reduced. When the well does not move with the reduction in air pressure, kentledge should be added. "Blowing down" should be in short stages and the drop should not exceed, 0.5 metre at any stage. To control sinking during blowing down, use of packings are recommended.

b) The pneumatic sinking plant and other allied machinery shall not only be of proper design and make, but also shall be worked by competent and well trained personnel. Every part of the machinery and its fixtures shall be minutely examined before installation and use. Availability of appropriate spares, standbys, safety of personnel as recommended in IS:4138 for working in compressed air must be ensured at site. Codes for safety and for working in compressed air and other labour laws and practices prevalent in the country, as specified to provide safe, efficient and expeditious sinking shall be followed.

c) Inflammable materials shall not be taken into air locks and smoking shall be prohibited. Wherever gases are suspected to be issuing out of dredge hole, the same shall be analysed by trained personnel and necessary precautions adopted to avoid hazard to life and equipment.

d) Where blasting is resorted to, it shall be carefully controlled and all precautions regarding blasting shall be observed. Workers shall be allowed inside after blasting only when a competent and qualified person has examined the chamber and steining thoroughly and found the same to be safe.

1207.7. Precautions During Sinking

a) When the wells have to be sunk close to each other and clear distance between them is not greater than the diameter of wells, sinking shall be taken up on all wells and they shall be sunk alternately so that sinking of wells proceeds uniformly. Simultaneous and even dredging shall be carried out in the wells in such a manner that the difference in the levels of the sump and cutting edge in the adjacent wells does not exceed half the clear gap between them. Plugging of all the wells shall be done together.

b) During sinking of dumb-bell or double D-shaped wells, the excavation in both the dredge holes should be carried out simultaneously and equally.

c) Bore chart shall be referred to constantly during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

d) Before seasonal floods all wells on which sinking is in progress shall be sunk to sufficient depths below the designed scour level. Further, they shall be temporarily filled and plugged so that they do not suffer any tilt or shift during the floods.

e) All necessary precautions shall be taken against any possible damage to the

foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

f) The dredged material shall not be allowed to accumulate over the well. It shall be dumped and spread, as far away as possible, and then continuously and simultaneously removed, as directed by the Engineer. In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank but on the side on which the river current flows.

g) Very deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to one-sixth of the outer diameter/least lateral dimension of the well in plan. Normally, the depth of sump shall not exceed 3.0 metres below the level of the cutting edge unless otherwise specifically permitted by the Engineer.

h) In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction of the Engineer to see that no damage has occurred to it.

i) In pneumatic sinking, the well shall not, at any time, be dropped to a depth greater than 500 mm by the method of "blowing down".

j) Dewatering shall be avoided if sand blows are expected. Any equipment and men working inside the well shall be brought out of the well as soon as there are any indications of a sand-blow.

k) Sand blowing in wells can often be minimised by keeping the level of water inside the well higher than the water table and also by adding heavy kentledge.

l) In soft strata prone to settlement/creep, the construction of the abutment wells shall be taken up only after the approach embankment for a sufficient distance near the abutment has been completed.

1207.8. Tilts and Shifts

The inclination of the well from the vertical is known as tilt and the horizontal displacement of the centre of the well at the founding level from its theoretical position is known as shift.

Unless otherwise specified, the tilt of any well shall not exceed 1 (horizontal) in 80 (vertical), and the shift at the well base shall not be more than 150 mm in any resultant direction.

Tilts and shifts shall be carefully checked and recorded in the format vide *Appendix 1200/II* regularly during sinking operations. For the purpose of measuring the tilts along the two axes of the bridge, reduced level of the marks painted on the surface of the steining of the well shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axes, with reference to fixed reference points.

Whenever any tilt is noticed, adequate preventive measures like placing eccentric kentledge, pulling, strutting, anchoring or dredging

unevenly and depositing dredge material unequally, putting obstacles below cutting edge. Water jetting etc., shall be adopted before any further sinking. After correction, the dredged material shall be spread out uniformly.

A pair of wells close to each other have a tendency to come closer while sinking. Timber struts may be introduced in between the steining of these wells to prevent tilting.

Tilts occurring in a well during sinking in dipping rocky strata can be safeguarded by suitably supporting the curb.

In the event of a well developing tilt or shift beyond the specified permissible values, the Contractor shall have to carry out, at his own cost, suitable remedial measures to the satisfaction of the Engineer, to bring the tilt and shift within permissible values, as far as practicable.

If the resultant tilt and / or shift of any well exceeds the specified permissible values, generally it should not exceed 1 in 50 and 300 mm respectively. The well so sunk shall be regarded as not conforming to specifications and a sub-standard work. The Engineer in his sole discretion, may consider accepting such a well, provided :

(i) Calculations for foundation pressures and steining stresses, accounting for the actual tilt and shift furnished by the Contractor show that the well is safe. Any remedial measures required to bring the stresses within permissible values (such as increase in the dimension of the well cap, provision of dummy weights on the well cap etc), shall be carried out by the Contractor without claiming for any extra cost.

(ii) The Contractor shall agree to reduction in rates in accordance with Clause 1215(g).

In case the Engineer, in his discretion, rejects the well, the Contractor shall dismantle the rejected well to the extent directed by the Engineer and remove the debris. Further, the Contractor shall, at his own risk and expense complete the bridge with modified span arrangement acceptable to the Engineer.

1207.9. Seating of Wells

The well shall be uniformly seated at the founding strata. It shall be ensured by test borings that the properties of the soil encountered at the founding strata and upto a depth of one and a half times the well diameter is identical to that adopted in the design. The procedure for test borings shall satisfy the provisions of these specifications. In case the soil encountered is inferior to that adopted in design,

the well shall be re-designed by the Engineer adopting the soil properties actually encountered and the founding level intimated to the Contractor, who shall carry out the work.

In case of seating of wells in hard rocky strata, where the rock profile is steeply sloping, pneumatic methods of sinking may be adopted to seat the well evenly as directed by the Engineer. The decision of adopting pneumatic sinking shall be taken by the Engineer. The cutting edge may also be embedded for a suitable depth in the rocky strata, as decided by the Engineer keeping in view the quality of rock. As an additional measure of safety, the well shall be anchored to the rocky strata by anchor bars provided in the steining of the well, as shown on the drawing irrespective of the fact that tension develops or not at the base of the well under design loads. After the well has been evenly seated on good hard rock, arrangements shall be made to facilitate proper inspection in dry and visible conditions before the bottom plug is laid.

1208. BOTTOM PLUG

For bottom plug, the concrete mix shall be designed (in dry condition) to attain the concrete strength as mentioned on the drawing and shall contain 10 per cent more cement than that required for the same mix placed dry, to cater for underwater concreting. However, the total cement content shall not be less than 363 kg/cu.m. of concrete with a slump in the range of 150 mm to 200 mm. Admixtures may be added to the concrete to impart the required characteristics indicated herein.

Concrete for the bottom plug shall be laid by tremie pipe method. Tremie concrete when started shall be continued without interruption for full concreting in the bottom plug. The concrete production equipment and placement equipment should be sufficient to enable under water concreting within stipulated time. Necessary standby equipment should be available for emergency situation.

Before commencing plugging, all loose material from the bottom of the well shall be removed.

Concreting shall be done in one continuous operation till the dredge hole is filled upto the required height and thereafter sounding shall be taken upto ensure that the concrete has been laid to the required height.

Least disturbance shall be caused to the water inside the well while laying concrete in the bottom plug.

Concrete shall not be disturbed in any way for at least 14 days.

In order to check any rise in the level of the bottom plug soundings should be taken at the close of concreting and once every day for the subsequent 3 days.

The soundness of the bottom plug may be tested by dewatering the well by 5 metres below the surrounding water level and checking the rise of water. The rate of rise shall preferably be less than 10 cms per hour. In case the rate is higher, suitable remedial measures as directed by the Engineer, shall be taken by the Contractor at his own cost.

1209. SAND FILLING

Sand filling shall commence after a period of 3 days of laying of bottom plug. Also, the height of the bottom plug shall be verified before starting sand filling.

Sand shall be clean and free from earth, clay clods, roots, boulders, shingles, etc. and shall be compacted as directed. Sand filling shall be carried out upto the level shown on the drawing, or as directed by the Engineer.

1210. TOP PLUG

After filling sand upto the required level a plug of concrete shall be provided over it as shown on the drawing, or as directed by the Engineer.

1211. WELL CAP

A reinforced cement concrete well cap will be provided over the top of the steining in accordance with the drawing. Formwork will be prepared conforming to the shape of well cap. Concreting shall be carried out in dry condition. A properly designed false steining may be provided where possible to ensure that the well cap is laid in dry conditions.

The bottom of the well cap shall be laid preferably as low as possible, taking account the water level prevalent at the time of casting

Bond rods of steining shall be anchored into the well cap.

1212. TOLERANCES

The permissible tilt and shift shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150 mm in any resultant direction.

For the well steining and well cap the permissible tolerances shall be as follows :

a) Variation in dimension : +50 mm - 10 mm

b) Misplacement from specified position in plan : 15 mm

c) Surface irregularities measured with 3 m straight edge : 5 mm

d) Variation of levels at the top : ±25 mm

1213. TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1214. MEASUREMENTS FOR PAYMENT

All quantities shall be measured from the drawing, or as ordered by the Engineer, excepting those required to be provided by the Contractor at his cost.

a) The cutting edge shall be measured in tonnes based on the net weight of metal used in it, as per Section 1900.

b) The concrete in curb, well steining and well cap shall be measured in cubic metres in each of the items as per Section 1700. The reinforcements shall be measured in tonnes separately in each of the items, as per Section 1600.

c) The measurement for well sinking shall be made in running metres for different depths and in different types of strata (for example, predominantly sand/ clay soil, soft rock, hard rock, etc) as specified in the Contract. The depth of sinking shall be measured from the level specified in the Contract. If no level has been specified in the Contract, sinking shall be measured from the low water level or from the level at which the cutting edge was laid, whichever is higher.

d) The quantity of concrete in bottom and top plug shall be measured in cubic metres as per Section 1700.

e) The quantity of sand filling shall be measured in cubic metres.

f) Pneumatic sinking, where required shall be paid as a separate item and shall be measured in cubic metres of material to be excavated.

1215. RATE

a) The Contract unit rates of cutting edge shall cover all costs of labour, material, tools, plant and equipment, including placing in position, sampling and testing,

and, supervision, all as per respective Section of Structural Steel Work and as described in this section.

b) The Contract unit rates for concrete in curb, steining, bottom plug, top plug and well cap, shall cover all costs of labour, material, tools, plant and equipment, formwork and staging including placing in position, sampling and testing, and, supervision, all as per respective Section of Structural Concrete and as described in this section.

c) The Contract unit rates for reinforcement in curb, steining, and well cap, shall cover all costs of labour, material, tools, plant and equipment, including bending to shape, placing in position, sampling, testing and supervision, all as per respective Section of Steel Reinforcement and as described in this section.

d) The Contract unit rates for sand filling shall cover all costs of labour, material, tools, plant and equipment, including placing in position, sampling, testing and supervision, all as described in this section.

e) The Concrete unit rates for sinking shall cover the costs of labour, tools, and equipment and plant and for all operations and other incidentals for sinking of well including seating excepting provisions of pneumatic sinking as described in this Section. The unit rates shall specify the strata such as types of soil, rock, etc. The rate shall cover all testing and supervision required for the work.

f) The Contract unit rate of material to be excavated by pneumatic sinking shall cover all costs of labour, material, tools, plant and other equipment and other incidentals and safety provisions and supervision required for pneumatic sinking as per this Section.

g) Reduction in contract unit rates for sinking as a penalty, in pursuance of clause 1207.8.

If any well with tilt and/or shift exceeding beyond permissible values is accepted by the Engineer, the Contractor shall give a reduction in the rates as follows :

S.No.	Amount of tilt and/or shift	Per cent deduction on the rate(s) for sinking of whole well
1.	Tilt exceeding the specified permissible value but equal to or within 1 in 60	5 per cent
2.	Tilt exceeding 1 in 60 but equal to or within 1 in 50	10 per cent
3.	Tilt exceeding 1 in 50	20 per cent
4.	Shift exceeding the specified permissible value but equal to or within 200 mm	2 per cent
5.	Shift exceeding 200 mm but equal to or within 300 mm	5 per cent
6.	Shift exceeding 300 mm	10 per cent

Penalties for excessive tilt and shift shall be deducted separately.