

**SPECIFICATION NO. : C0**

**FOR**

**GENERAL - CIVIL & STRUCTURAL**

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**C O N T E N T S**

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**ATTACHMENT**

ANNEXURE-A	DESCRIPTION OF BUILDINGS/ STRUCTURES
ANNEXURE-6 (under Vol-II of spec. G0)	GEOTECHNICAL REPORT (Borehole Data)

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**1.00.00 GENERAL**

This specification is intended to cover general as well as technical specification required for design, supply, execution & erection of complete civil & structural & miscellaneous works required for completion of complete combined cycle power plant to the satisfaction of the Owner.

1.01.00 The work shall include design, construction and erection activities of both underground and above ground civil and structural works and shall include all working drawing, labor, materials, plants, equipment, transportation and all incidental items not shown or specified explicitly but reasonably implied and necessary for proper completion of the project, all in strict compliance with this specification, including the revision and amendments thereto as may be required during the execution of the work.

1.02.00 The work shall be carried out according to the design/drawing to be developed by the Contractor and approved by the Owner. For all building, structure, foundations, roads, drainage, necessary details and layout shall be prepared by the Contractor keeping in view the functional requirement of the plant and the facilities and providing enough space and access for operation use and maintenance. The drawings and specifications attached herewith do not provide complete description of each and every system but state the minimum acceptable standards for the plant as a whole or certain individual components.

1.03.00 All the quality of works and standards pertaining to field and laboratory testing, excavation, concreting, fabrication, erection, welding and other technical requirements covered under this specification shall strictly conform to the respective technical specifications annexed hereto. The specifications are intended for the general description of the work, quality and workmanship. The specification are not, however, intended to cover the minutest details and the work shall be executed according to the spirit of the specification and in the absence thereof according to the relevant latest Indian Standard Codes. In absence of the later, the work shall be executed according to the local public work department practice or to the recommendation of relevant American & British Standards or to the instruction of the Owner. The IS Codes to be followed are mentioned in the relevant Technical specification for different items of works. The bidder is expected to get clarified any doubts about the specification etc., before bidding through discussion with the Owner recorded in writing in respect of interpretation of any portion of this documents. The Owner reserves the right to alter/amend any part/criteria of this specification in the interest of the project without creating any financial implication whatsoever on the part of Owner.

1.04.00 Before bidding the contractor shall visit the site to get them fully acquainted with site condition, approaches, transport facilities, off-site facilities, availability of materials, storage space, fabrication and bar bending yard, accommodation of workmen, site office, testing laboratory and other assorted facilities. The bidder or its consultants, if any, shall have well-equipped design office with

modern drafting, computing and transmission facilities to comply with high rate of drawing/document production pertaining to civil & structural system to meet the stipulated time frame laid down in the specification. No extra claim shall be entertained for any unforeseen reason.

## 2.00.00 **SITE DESCRIPTION**

For the basic preliminary site information data as required for civil & structural design, namely:

- a) Terrain condition
- b) Topography of adjacent area,
- c) Plant access condition
- e) Maximum rainfall intensity
- f) Seismic zone classification
- g) Basic wind speed
- h) Availability of plant water
- i) Annual variation of temperature & humidity

The section G0 shall be referred to. Any additional information, if bidder may require, can obtain at his own interest by visiting the site, and collecting information from appropriate local/state authority.

## 3.00.00 **DESCRIPTION OF WORKS**

The bidder shall be responsible for complete design, construction and testing of following broad spectrum of works associated with aforesaid power plant with all its supporting facilities. The list is not exhaustive but indicative only.

### 3.01.00 **Site Survey**

Ungraded virgin land will be given to the contractor by the Owner in, as it is condition. The elevation of land varies from RL125.5 to RL126.0 (approx) in main power block area and from RL127.0 to RL127.5 (approx) in area designated for switchyard. The Contractor shall visit the site immediately after award of the contract and shall undertake all necessary survey including existing underground facilities and leveling works necessary for layout and level of all structure etc., at his own cost from the general grid of the plant and bench marks given by the Owner. The Contractor shall give all help in providing instruments, materials and personnel to the Owner's engineer for checking the detailed layout and correctness of the layout and levels. However, the contractor shall be solely responsible for the correctness of layout & levels.

3.02.00      **Site Preparation & Area Grading**

All sites clearing and grubbing within all areas where excavation filling or other construction is planned shall be done by the Contractor. The bidder shall be responsible for furnishing all supervision, labor, tools, materials and equipment, performing all operations in connection with excavation of all materials, regardless of nature of materials, obtaining fill and backfill materials, installing and compacting of fill and back fill materials; and producing final grade line, keeping in view the surface drainage, their disposal and adjacent topography.

3.02.01      All necessary arrangements for stripping of surface vegetation, sods, debris, removing organic topsoil and providing suitable topsoil from borrow pits with necessary compaction and stabilization shall be the responsibility of the Contractor. All combustible and other waste materials shall be removed from the construction areas and disposed of by and at the expense of the contractor. The bidder shall comply with technical specification of Area grading annexed hereto for details required for this item of work.

3.03.00      **Geotechnical Investigation**

A preliminary soil investigation was carried out by the owner at the proposed site and the field boring and limited laboratory test results are appended as Annexure-6 under Vol.-II of specification GO solely for the purpose of guidance. However, the owner does not take any responsibility of interpreting the result of this investigation or making any recommendation regarding sub-soil conditions and sub-structure system to be adopted by the contractor.

Any variation of the said data shall not constitute a valid reason in effecting the terms and conditions of this bid. The bidder shall fully satisfy himself about the nature of the soil expected to be encountered including the type of foundation, bearing capacity, sub-soil water level etc., prior to the submission of his bid.

3.03.01      The contractor shall carry out his own geotechnical investigation in all works before he commences detailed design and working drawings for finding out the allowable bearing pressures, expected settlements, type of foundations, etc. The contractor shall get the approval for the field and laboratory testing scheme proposed by him from the owner before undertaking geotechnical investigation work. Geotechnical work shall be carried out strictly in accordance with the relevant technical specification annexed hereto. The soil investigation shall be submitted to the owner for approval and the approved report shall become the basis for design of sub-structure. Approval of the owner shall in no way relieve the contractor of his sole responsibility in regard to stability and safety of his design.

Soil investigation by the contractor shall be done along with laboratory testing, in sufficient depth and numbers as necessary, for complete determination of sub-soil condition as approved by the owner before the execution of work. Based on the geotechnical investigation, the contractor shall establish a sound geotechnical design criteria, along with a comprehensive report including the recommendations as stipulated in relevant clause of technical specification.

3.03.02 In addition to the recommendations stipulated, as per technical specifications, following information shall also be furnished by the contractor in his report.

- i) Identification of corrective measures required for the improvement of sub-surface conditions such as removal of poor material, insitu densification etc.
- ii) Submit information covering the seismicity of the project site with possibility of liquefaction and remedial measures.

All major buildings and foundations will be on pile foundation. However the bidder can provide shallow foundation (Isolated footing / raft) foundation for Pump houses, Auxiliary buildings and lightly loaded structures depending upon the results of geotechnical investigation to be carried out by him. Suitable measures to counter act the aggressive chemicals present in soil & ground water and to counter act the swelling characteristic of the soil, if any, will be taken care of by the bidder.

3.03.03 If pile foundation is adopted, the same shall be cast in situ/driven/bored or pre-cast as per relevant I.S. Code. Only R.C.C piles shall be provided.

3.03.04 The piling work shall be carried out in accordance with the detailed technical specification for piles enclosed as part of this specification. Testing of piles and interpretation of test result shall be done as per IS-2911 Part IV.

3.03.05 Keeping in view the above requirements, and specialist nature of work, which requires expert handling and recommendations, the geotechnical investigation shall get to be executed by reputed Geotechnical Consultants, subject to the approval of their credentials by the Owner.

3.03.06 Additional requirement or involving opinion of experts in the field shall be communicated by the Owner and such additional requirements to be taken care of prior to submission of interim report and the same to be discussed and got approved by the Owner.

3.04.00 **General Buildings & Structures**

The bidder shall be responsible for complete layout, analysis, design, preparation of working & detail engineering drawings, construction and supervision including all labors and supply of the following major building and structures required for the completion of power plant with all its supporting facilities as envisaged at the time for preparation of this bid document. The items are not exhaustive but indicative only. All buildings in general shall comply with the following criteria:

- a) All buildings and facilities shall meet its functional requirements.
- b) Create an acceptable, controllable working environment for all building users.
- c) Be sufficiently flexible to allow necessary changes and expansion with minimal disruption to plant operation.

- d) Be readily replaceable if damaged during the design life.
- e) Be of an acceptable consistent appearance.
- f) Be capable of resisting any operational environmental or chemical effects produced by the plant or external environment.
- g) Allow penetrations in the building enclosure to be formed and sealed easily.
- h) Provide a completely watertight envelope around all plant, equipment and personnel.
- i) Be sufficiently robust or be adequately stiff to undergo minimum displacement/yield/tilt/vibration, not to cause any occupant discomfort or equipment/machinery malfunctioning or anything of the sort to render the structure ineffective for its intended purpose.

#### 3.04.01 **Gas Turbine Building**

The Gas Turbine Building will be an enclosed structure housing the gas turbine generators (GTG) and related equipments.. This building will also house related mechanical/electrical equipments. The gas turbine generator foundations will be placed on separate foundation system with isolation joint all round. The building size, floors and heights will be as per Equipment GA drawings. An E.O.T Crane will run all along the building over Gas Turbine hall. This building will have two bays. The Main bay is the Crane bay and the other bay will have lean to roof supporting Inlet air filter. Access Stairs will be provided as per GA drawings.

Super structure will be a steel structure of either (1) Simple frames with vertical diagonal bracings at column lines in both directions and horizontal bracing at the roof and major floor levels or (2) Moment resisting frame in transverse direction with braced frames in longitudinal direction. The columns will be independently seated on reinforced concrete pedestals supported by spread footings resting on pile. The column base plate level will be below ground floor to avoid obstructions arising from these base plates and stiffeners and will be encased in concrete.

The ground floor slab will be of 150 mm thick reinforced concrete laid over 50 mm thick blinding concrete underlain by 250 mm thick crushed aggregate soling.

Turbine Hall roof shall be flat RCC roof with water proofing treatment supported on steel truss beams. Adequate slope in roof shall be provided for roof drainage purpose. This roof will be made of cast-in-situ RCC slab cast on metal deck formwork.

2.10 M high masonry block external wall will be provided for the steel framed building. External cladding (above 2.10 M high block wall) for the building will be colour coated profiled sheet as per Architectural specification. This cladding wall will be supported by structural steel girts at suitable intervals.

#### 3.04.02 **Steam Turbine Building**

This shall be an enclosed structure, with a flat roof, housing the steam turbine generator and structural components of the turbine generator, with all its accessories. The central portion of the building shall be blocked out for turbine generator pedestals. The bidder shall detail a complete layout elevation of the building showing all equipment, supports, laydown area, office, stairs, elevators etc., before final design can be taken up. The floors within the building shall consist of a R.C.C. slab. The minimum floor height shall be 4.5m. Access stair shall be provided. Through out the length of the building there shall be steel runway crane girder to support heavy duty bridge of EOT. Crane to handle turbine generator and its components. The operating floor will have a large erection opening in the unloading bay for handling equipment with the EOT crane.

The building shall have access to truck unloading facilities. During normal operation, the truck entrance shall be closed by an overhead electrically over head door.

Major equipment movement in and out of the building shall be through the unloading bay and through equipment erection opening of the floors above unloading bay.

The framing of the building shall be of braced/and or rigid jointed steel structure with column supported on RCC pedestals supported by spread footings resting on pile.

Turbine Hall roof shall be flat RCC roof with water proofing treatment supported on steel truss beams. Adequate slope in roof shall be provided for roof drainage purpose. This roof will be made of cast-in-situ RCC slab cast on metal deck formwork.

Operating floor shall be of RCC and Mezzanine floor shall be of steel /RCC. Grating floors will be provided at places shown in equipment layout drawing. Ground floor slab will be 150th reinforced concrete of grade M25 laid over 75 mm thick lean concrete (1:3:6) underlain by 230 mm thick rubble soling.

The turbine building shall be designed for all applicable dead, live, wind, earthquake, equipment & construction loads.

Exterior cladding shall be of colour coated profiled sheet as per Architectural specification. Brick masonry wall will be provided for a low height on ground floor.

### 3.05.00 **Electrical and Control Building**

This shall be a multi-storied steel frame building annexed to Turbine building with common column. The minimum height of the floors shall be 4.5m. The building shall house all electrical switchgear, MCC and Control panels. Battery and battery charger shall also be located in this building.



The building shall be provided with monorail for handling equipment. The ground floor shall be a slab on grade. Intermediate floors including roof shall be of RCC. External cladding shall be either plastered brick masonry or precast metal cladding as per architectural drawing.

Roof shall be reinforced concrete slab with water proofing treatment supported on steel beams which span between main framing members made of steel girder.

The design of structural framework, foundations and ground floor slab shall be as described for steam turbine building.

#### 3.06.00 **Compressor Room**

This shall be a single story steel frame building annexed to turbine building with common column to accommodate the plant air and instrument air compressor. The building shall be provided with a monorail for handling equipment. The roof will be RCC slab resting on steel beams/girders and Ground floor slab shall be a slab on grade. External cladding shall be as described in preceding clause. Compressor foundation shall be designed as a block foundation.

Separate RCC framed building may also be provided as per plant layout.

#### 3.07.00 **Steam Turbine and Gas Turbine Generator Foundation**

3.07.01 The Steam Turbine Generator shall be rigid RCC frame structure supported on pile foundations. The concrete outline and embedments/inserts/pockets detail shall be supplied by machine manufacture.

Detailed static and dynamic analysis shall be performed both for normal operating condition & abnormal condition such as short-circuit, accidental loss of blades & earthquake. At any event of time any two transient loading (short circuit, seismic) need not be assumed to act in the same direction simultaneously. Seismic analysis shall be done by response spectrum method. Minimum five no. modes shall be included in the design.

The dynamic analysis shall consist of free-vibration and forced vibration analysis. Frequency separation criteria and amplitude criteria as laid down in IS-2974 and or VDI 2056 and/or as required by machine manufacture whichever is more stringent shall be satisfied.

RCC design shall be done by working stress method. A fatigue factor of 2.0 shall be considered for dynamic analysis. Elaborate mathematical model including soil structure interaction shall be considered, if recommended by the Owner. In case of pile foundation, due regard shall be given to pile stiffness in lateral and vertical direction and pile-soil interaction.

Stress for thermal load, shrinkage and creep shall be properly accounted for. Minimum reinforcement shall be governed by IS-2974 as well as IS-456.

For appropriate load combinations or any other information, stipulations of IS-2974 shall be satisfied.

3.07.02 The Gas Turbine Generator shall be RCC block type foundation supported on piles. The concrete outline and embedments/ inserts/pockets detail shall be supplied by machine manufacture.

3.07.03 **Boiler Feed Pump and Deaerator Building and Boiler Feed Pump Foundation**

The building will be steel framed building housing Deaerator, piping and other equipment as per Equipment layout plan.

Boiler feed pump will be a RCC block foundation resting on pile. It shall be isolated from the building to reduce the transmission of vibration. Concrete outline and details of pipe sleeves/pockets/embedments shall conform to the data provided by machine manufacturer. The mass of the RCC block shall not be less than three times the mass of the machine. All block foundations resting on soil or piles shall be designed using elastic half space theory.

Dynamic analysis shall be carried out to calculate natural frequencies in all possible modes. Frequency and amplitude criteria shall be as per relevant IS codes/or VDI and/or as per requirements of machine manufacturer.

3.08.00 **Waste Heat Recovery Boiler Structure & Foundation**

Boiler structure with all its accessories shall be supported by steel structure and shall be founded on isolated or strip footings or mat resting on piles. The structure shall be either braced and/or rigid jointed Frame to resist, dead load, live load, erection load, wind load, seismic load and thermal load. The top of the boiler shall be provided with canopy with rainwater down comers. The ground level of the boiler shall have RCC slabs on grade with provision for storm water and equipment water drainage. WHRB structure shall be provided with steel stairways, platforms, walkways for easy maintenance and access to plant components. All platforms and walkways shall have a minimum clear width of 1000m.

3.08.01 Stair for WHRB shall not be less than 1000mm width. In addition to main WHRB structure, the flue gas duct structure from GT to bypass stack through WHRB, and from WHRB to boiler stack shall be stiffened suitably and shall be designed along with its supporting frames, and foundations for dead load, live load, erection load, wind load, seismic load and thermal load. Adequate precaution to be adopted so that high-speed flue gas exhaust induced vibration shall not be transmitted to stack or duct supporting structure.

3.09.00 **Bypass Stack & WHRB Stack**

The bypass and WHRB stacks shall be capable of serving, satisfactorily, under all the respective normal and emergency operating conditions to which they may be subjected during the life of the plant. The chimney and the lining materials shall therefore be selected to serve the worst operating condition. External and internal corrosion allowances, for metallic liners and their components shall be suitably selected in line with the relevant standards for the designated operating conditions and the service life of the plant.

3.09.01 The stacks shall be provided with access ladders, with closely spaced circular

- safety hoops. Atleast two continuous external platforms (one near top and one at the mid-height) shall be provided on each stack.
- 3.09.02 Gas sampling test ports accessible from the top platform shall be provided on each stack. Thermal insulation may have to be used to restrict the surface temperatures of the stacks.
- 3.09.03 The other components of the chimney include doors, hatches, drainage system, screened ventilation openings external platform lighting, lighting protection and grounding system and aviation obstruction lighting. Adequate measures should be taken to ensure that the rainwater does not enter into the stacks when gas turbine is in operation.
- 3.09.04 Helical strakes shall be provided if found necessary to reduce cross wind and ovalling vibration and forces.
- 3.09.05 All metal surfaces shall be painted for a maintenance free life of at least 10 years. The top ten meters of the stack shall be painted, using heat and acid chemical resistant paint, in alternate bands of colours of deep red and bright white. The paint shall be of epoxy based polyurethane enamel type of approved make.
- 3.09.06 Both bypass stack and WHRB stacks shall be of structural steel construction.
- 3.09.07 The stack shall be designed for the following: -
- i) Vertical self-loading with live load/equipment.
  - ii) Along Wind load
  - iii) Cross-wind load
  - iv) Seismic load
  - v) Circumferencial wind load (ovalling)
  - vi) Thermal stresses for flue gas
  - vii) Fatigue stress
  - viii) Effect of solar radiation
  - ix) Local buckling
  - x) Corrosion allowance
- 3.09.08 In addition to above, rotation to chimney base and moments of the second order, or any other forces not specifically mentioned but pertinent for the safe design of the structure shall be considered. The stack shall be designed to resist the most significant forces resulting from all the possible combinations of the various loading.
- 3.09.09 For the dynamic response of the chimney under seismic and wind loading, at least the first five modes of vibrations shall be used.
- 3.09.10 Elaborate dynamic model shall be made taking into consideration of soil-structure interaction, including effect of piles (if any) for all response calculations.

- 3.09.11 While estimating the loading resulting from either along wind or cross wind effects, the proximity of the other chimneys shall be considered. Amplification factors on account of this aerodynamic interference shall be suitably estimated and included in the analysis.
- 3.09.12 In the event the bidder fails to establish any sound design criteria for wind loading or fails to ascertain a reliable estimate of wind loading effect by calculation, the bidder shall be required to arrange for an aerodynamic model study simulating the plant environment including other stacks and buildings. The cost of study shall be entirely borne by the bidder.
- 3.10.00 **Induced Drought Cooling Tower**
- Induced draft cooling tower of Reinforced concrete shall be constructed to dissipate evaporative cooling in cooling tower. The design, construction and supply consists of underground cold water basin with intake channel, pre-cast RCC louvers, hot water distribution basin, draft tower shell etc., complete with all platforms, walkways, ladders, monorails, cable trenches, embedments. The super structure shall be designed against dead load, equipment load, live load, and seismic load & wind load. In addition, dynamic load due to I.D. fan and motor shall be considered to check resonant condition.
- 3.10.01 The basin underneath the cooling tower for collection of cold water will be made of RCC of grade M-25. The insides of wall of cold water basin will be applied with two coats of bituminous paint confirming to IS:9862. The floor of the basin will be sloped to minimum 1V:120H towards drain sump which will be connected through CI pipe to sludge sump. One outlet channel will be constructed from the outlet face of the basin and connected to the CW Pump structure. The stoplog will be provided for isolating the basin from the approach channel.
- 3.10.02 The basin underneath the cooling tower for collection of cold water will be made of RCC of grade M-25. The insides of wall of cold water basin will be applied with two coats of bituminous paint confirming to IS:9862. The Floor of the basin will be sloped to minimum 1V:120H towards drain sump which will be connected through CI pipe to sludge sump. One outlet channel will be constructed from the outlet face of the basin and connected to the CW Pump structure. The stoplog will be provided for isolating the basin from the approach channel.
- Cooling tower support structure like columns, beams, and slabs etc. will be of reinforced cement concrete of grade M-25 as per IS:456.
- Expansion joints in cooling tower structure will be located at not greater than 45m in spacing.
- The fan deck slab will be properly sloped (1V:120H) so that rain water does not accumulate over the deck slab. The slope may be provided with screed concrete (1:2:4) also. Deck slab and other over ground platforms will be provided with 32mm dia. GI hand rails & posts and with toe guard all-round.

Cooling tower cells will consist of RCC columns and beams. Hot water distribution channel will also be made of RCC. The RCC fan stack will be minimum 125mm thick.

The minimum grade of concrete will be M-25 for all the above structures.

Two (2) nos. stairs, one each at gable end, will be provided. Stairs will be made of RCC of grade M-25 with galvanised MS hand railing.

Steel door of size 2100mm high & 1200mm wide clear (minimum) will be provided in each fan stack at fan deck level. Steel doors will be heavy duty hot dipped galvanised.

### 3.10.03 Design considerations

- i) All structural members of cooling tower consist of combination of slab system, wall, column and beam etc.
- ii) The basis for all RCC structures will be as per working stress method of design as outlined in IS:456.

Design consideration for loads (including wind load, earthquake & loading on fan supporting structure) & load combinations will be as mentioned in the section. 4.0.

In addition to above load combinations, the cooling tower structure will be analysed & design for load conditions mentioned under fan supporting structure in Specification No. M7.

Design of all member of cooling tower, which are not in contact with water/water spray/moist air, will be carried out as per IS:456 code of practice for plain & reinforced concrete for general building construction.

Design of all other members in contact with water/water spray/ moist air will be designed as per working stress design method based on IS:456 code of practice for concrete but the stresses in reinforcement steel will be limited to the values as given in IS:3370.

- iii) CW Basin (including outer face i.e. face in contact with earth), sump, outer channel, duct, sludge pit, HW distribution basin/HW channel shall be designed as uncracked section as per IS:3370 (Part-I to IV).
- iv) CW Basin, ducts, sludge pit etc. shall be designed for following conditions :
  - Water filled inside upto the designed level & no earth outside.
  - Earth pressure plus 2000 Kg/sq.m surcharge outside and no water inside and ground water table at grade level.
  - Uplift due to ground water table or due to water logging when no water inside.

- v) The minimum thickness of the base slab shall be 150mm. The minimum reinforcement steel (HYSD) to be provided in each direction of basin slab shall be 0.24% of the gross cross sectional area.
- vi) The minimum clear cover to reinforcement in all RCC structures shall be as per IS:3370 (Part-II), except as mentioned for following :

Stair case	-	15mm for slab
Foundation for all elements	-	50mm
Columns (below & above ground level)	-	50mm
Fan Stack	-	30mm
- vii) RCC stair cases will be minimum 1000mm wide clear and riser will be 180mm maximum and treads 250mm minimum.
- viii) All mild steel parts in structural steel works used in cooling tower will be hot dip galvanised as per IS:4759 with 750 gm/sq.m coating.

All inserts, embedments, bolts, nuts etc. will also be hot dip-galvanised as per IS:4759, 4826 & 5358.
- ix) For design of all underground structures, sub-soil water will be considered at final formation level (finished grade level).
- x) Earth pressure for all underground structure will be calculated using coefficients of earth pressure at rest.
- xi) A minimum 100 mm thick lean concrete (1:3:6) will be provided below all underground structures, foundations, trenches etc.
- xii) The interior surface of the cooling Tower structure and the interior face of the basin shall be painted with two (2) coats asphaltene of British Paints Limited, or equivalent cold applied bituminous paint.
- xiii) External surface of cooling tower shall be painted with three (3) coats of water proof cement paint of approved colour over a coat of primer.

### 3.11.00

#### **C.W. Pump House with Forebay**

Cooling water pump house shall have RCC underground sump with pump floor above. The super structure shall be of steel framework with sloped roof truss. Roof and side cladding will be made of metal sheeting as per architectural specification. The pump operating floors shall be of cast in situ reinforced concrete. One EOT crane shall be provided for handling of pumps. An electrical room and laydown area with monorail shall be provided to the pump house. MS gate with rubber seal shall be provided to isolate each compartment of the sump.

In addition to dead load, equipment load, live load, dynamic load from pump & motor shall be considered for the design of operating floor. The vibration level shall be within tolerable limit.

3.12.00      **Clariflocculator, Clarified Water Pump House and Reservoir**

An underground RCC circular water-retaining structure with abstraction of clarified water channels, working platforms, stilling chamber, sludge pits etc., with other accessories complete, shall be designed and constructed by the bidder as per plant requirement.

3.12.01      Clarified water pump house shall be provided with a RCC clarified water underground or semi underground reservoir with a pump operating floor and an electrical control room. The super structure shall be of a RCC/ Steel frame structure with a closed envelope and provision for handling equipment.

3.13.00      **Chemical House**

This shall be a single/double storied RCC/Steel frame building with various chemical dosing facilities. The building shall have RCC cast in situ floor and roof slab with provision for adequate ventilation. The floors shall be of chemical resistant materials. The structural design load shall be same as for other buildings.

3.14.00      The aforementioned buildings and facilities are major civil structural items. Besides, following supporting facilities shall be designed and constructed by the bidder. The facilities shall have a safe, stable and consistent structural form and shall be disposed suitably in the plant to meet the basic functional requirement of the plant in an optimum way:

- |     |  |   |  |
|-----|--|---|--|
| 1.  | Transformer foundations                      | - | as per plant requirement   |
| 2.  | DM Plant                                     | - | as per plant requirement   |
| 3.  | Sludge pits                                  | - | as per plant requirement   |
| 4.  | DM Water tanks                               | - | as per plant requirement   |
| 5.  | Acid/Alkali storage area, neutralisation pit | - | as per plant requirement   |
| 6.  | Oil water separator pits                     | - | as per plant requirement   |
| 7.  | Pipe & cable rack, Trestle, trench           | - | as per plant requirement   |
| 8.  | B.F.P. Sheds                                 | - | as per plant requirement   |
| 9.  | Chlorination room                            | - | as per plant requirement   |
| 10. | Effluent treatment, Septic tanks & Soakpit   | - | as per plant requirement   |
| 11. | Temp. construction shed/office etc.          | - | As per bidder's requirement, shall be easily removable, when required. |

3.15.00      **Switchyard structures**

All works for switchyard structural, gantries, towers and foundation shall be covered under the scope of this contract.

Entire switchyard area will be paved with RCC pavement to avoid growth of grass and weeds inside fenced area. Suitable drainage arrangement to be provided to keep the paved area clean and dry.

3.16.00      **Design Considerations for Switchyard Structures**

3.16.01      General

Selection of optimum and economical configuration of various structures, analysis and design shall be carried out for all towers, gantries, lightning towers/masts, equipment supporting structures etc. for the switchyard complex.

Tower foundations will be on pile depending on magnitude of load at base.

3.16.02      Load

All above structures shall be designed to withstand the worst combination of following loads as applicable:

- a)      Dead loads including weights of various equipment, conductor, insulators etc. supported on the structure.
- b)      Loads due to tension in each conductor per phase and earthwire of 1000 kg. and 500 kg. respectively, unless specified otherwise.
- c)      Wind loads on towers, gantries etc., and conductors and earthwires evaluated as per IS-802 (Latest) Design wind speed will be considered as 50.0 Meters/Sec.
- d)      Seismic forces according to IS: 1893-2002 for Zone-V.
- e)      Live Load of 150 kg. at worst location due to weight of line man and his tool box.
- f)      Any other special load during service period of structure e.g., load due to unbalanced tension in conductor, torsion load due to unbalanced vertical and horizontal forces, erection loads. short circuit forces including "snatch" in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40.0 kA. IEC-865 may be followed for evaluation of short circuit forces.
- g)      Switchyard girders structure shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.
- h)      Terminal/line take off girders shall be designed for a minimum



conductor tension of 2000Kg per phase for 220 kV. The distance between terminal girders and dead end tower shall be taken as 200 metres. The design of these terminal girders shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other girders the structural layout requirements shall be adopted in design.

- i) The girders shall be connected with lattice columns by bolted joints.

All support structures used for supporting equipment shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces. short circuit forces.

Short circuit forces shall be calculated considering a fault level of 40.0 kA. IEC-865 may be followed for evaluation of short circuit forces.

- j) Minimum grade of concrete shall be M25 for all foundations and other structures.

#### 3.16.03 Factor of Safety

The factor of safety in design of structural members shall be 2.0 under normal and broken wire conditions and 1.5 under combined short circuit broken wire condition.

Foundation shall be designed for a factor of safety of 2.2 for normal and broken wire conditions and 1.65 for combined short circuit and broken wire condition.

#### 3.16.04 Method of Design & Permissible Stresses

Structures shall be designed as per IS-802 (latest) considering factors of safety for different load combinations as specified above. The unbalance pull due to broken conductor or ground wire shall be equal to the maximum working tension in the longitudinal direction along with its component in the transverse direction. Design of RCC foundation shall conform to IS: 456.

#### 3.16.05 General Requirements

- a) Thickness of Gravel Pitching on unpaved area shall be 150 mm above FGL.
- b) Top of RCC pedestals will be at 300 mm above FGL. Bottom of Base Plates for all structural steel columns, ports equipment supports, towers etc. will be 350 mm above FGL. The Gap (50 mm) between base plate and concrete pedestal will be filled-up by ready mix cement concrete grout (minimum compress strength =  $50 \text{ N/mm}^2$  at 28 days) by structural erector after final alignment and leveling.

- c) The fence around switchyard area shall comprise of 12 gauge G.I. PVC coated chain link fencing of mesh size 75 mm to a height of 2.4 m above the toe wall with a 600 mm high galvanised concertina at the top such that total fence height of 3.0 m above toe wall level is achieved. Toe wall shall be minimum 200 mm above finished grade level.

The chain link will be stretched and attached by 'C' clips at 0.5 m intervals to 3 strands of high tensile spring steel wire (HTSSW) of 12 gauge interwoven in chain link wire mesh and kept under tension which in turn are attached to the fence post with security nuts and bolts. On every fourth post a clamping strip will be threaded through the links of chain link and bolted to the fence post with the help of security nuts and bolts.

Above the chain link a 600 mm high Tensile Serrated Wire (HTSW) galvanised concertina will be stretched to 6 m and attached to 2 strands HTSS wire by means of 'C' clips at 1 m intervals. The 2 HTSS wire strands will be attached to angle iron posts with ½" security fasteners.

All fence posts shall be 65 x 65 x 6 MS angles spaced at 2.5 m C/C distance. All straining posts i.e., end posts shall be 65 x 65 x 6 MS angles. All corner posts will have two stay posts and every tenth post will have a transverse stay post. Suitable concrete foundations for the angle iron posts and stays shall be provided based on the prevailing soil conditions. Toe walls either of brick masonry with bricks of minimum 50 kg/cm<sup>2</sup> compressive strength shall be provided between the fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200 mm above the switchyard grade formation level with PCC coping (1:2:4). All gates shall be of hot dip galvanised structural steel as per specification.

All structural steel work for the fencing shall be painted with synthetic enamel paint over a suitable primer.

d) **Galvanising**

All structural steel works including members for towers, gantries, equipment supporting structures and gates shall be hot dip galvanised after fabrication in accordance with relevant Indian Standard Codes.

Zinc required for galvanising will have to be arranged for by the Bidder. Purity of zinc to be used for galvanising shall be 99.5% as per IS:209.

The weight of the zinc coating shall be at least 0.610 kg/m<sup>2</sup> unless noted otherwise. Stub members, anchor bolts shall be having heavier zinc coating not less than 0.80 kg/m<sup>2</sup>.

Fasteners, bolts, washers etc. shall have zinc coating as per relevant IS Code unless specified otherwise.

- 3.16.06 All structures shall be designed for the worst combination of dead loads, erection load, wind load/seismic forces, short circuit forces and operating forces acting on the equipment.

- 3.16.07 The layouts shall show RCC Cable trenches and pipe trenches with suitable drainage arrangements for trenches, roads within the switch yard and storm water drainage.
- 3.16.08 The maximum limit of slenderness ratio (1/r) of the structural members shall be as per IS 802.
- 3.16.09 Broken wire conditions shall be considered for dead end towers with any one power conductor broken (or) one ground wire broken whichever is more stringent for a particular member.
- 3.16.10 Since the line towers are exposed to open atmosphere conditions, tower structures should be checked against temperature variations also as per IS 800.
- 3.16.11 Edge Preparation for welding: Proper edge preparation shall be made for jointing of materials before welding. Suitable edge preparation shall be done for all processes of welding except for square butt welds.
- Type of edge preparation shall depend on the thickness of parent materials that are to be joined. The edge forms shall be chosen to suit the approval of Engineer in charge.
- The edge form of weldments shall be prepared either by machines or by automatic gas cutting. All edges cut by flame shall be ground smooth before they are welded.
- 3.16.12 Cutting list shall be prepared and got approved by the engineer before cutting any material for fabrication.
- 3.16.13 All the welders to be employed for the job shall have to qualify the appropriate test laid down in IS 1181 and IS 817. If the welder fails in these tests, two further set of tests shall be undertaken and the welder must pass both these sets of tests to be qualified. Routine testing of all welders shall be done every six months. All expense incurred for the testing of the welders shall be borne by the Bidder.
- 3.16.14 Only approved make of electrodes shall be used. For members of thickness larger than 20 mm, low hydrogen electrodes shall be used.
- 3.16.15 Supply of foundation bolts, stairs hand railing, ladders, gratings etc., also be included in the scope.
- 3.16.16 In addition to the Bidder's normal supervision and testing procedures, radiographic/ultrasonic or other non-destructive examination shall be carried out as and when required by the Engineers in charge on butt or fillet welded joints/and/or on test specimens Radiographic/Ultrasonic testing shall be done as follows:
- 2% Radiographic testing at random for all butt joints.
- 100% Ultrasonic tests of butt welds of flanges of main framing beams and columns.

### 3.17.00 Plant Area Roads & Paving

The bidder shall be responsible for layout, design, and construction of new roads required for this extension project and maintenance of all in-plant road works as per relevant technical specification.

3.17.01 All road within plant boundary shall be double lane roads with 7.0m wide black topping and 2.5m wide shoulders on either side of the road except patrol road along boundary wall and roads within the DM Plant area which shall be single lane road with 4.0m wide black topping and 1.0m wide shoulders on either side.

3.17.02 Finished top (crest) of roads shall be 250mm above the surrounding grade level. The Construction detail of road shall be as follows:

#### Layer Details

1. Seal Coat - Bitumen and Sand Mix as per I.R.C. Standard.
2. Open Graded Premix Carpet of 25 mm Compacted thickness.
3. Tack Coat over Water bound Macadam Base Course.
4. Water Bound Macadam base course of minimum 150 mm Compacted thickness with Grading-2 (Aggregate Size: 63-40 mm). This course is to be laid in two layers of 75 mm each as per I.R.C. Specification.
5. Granular Sub-base of minimum 250 mm Compacted thickness with Grading-1 (Aggregate size 90 mm to 40 mm). This course is to be laid in two layers of 125 mm each as per I.R.C. Specification.
6. Minimum 500 mm thick Sub-grade. Sub-grade shall be compacted to 95% of max. Dry Density for the entire depth in case of cohesive sub-grade.
7. 150 mm thick (Compacted) moorum shoulder. Soil under shoulder area shall be compacted to min. 95% of max. proctor density for the entire depth and width.

3.17.03 California Bearing Ration (CBR) method shall be followed for the design of roads as per IS2720 (Part XVI). All the culverts shall be designed for IRC Class `AA' loading and shall be checked for class `A' loading. Compacted moorum shoulders of minimum 150mm thickness shall be provided on either side of the roads.

3.17.04 All building shall be provided by access road, which shall either, by single or double lane road depending upon the functional requirement. Access roads shall also be provided to areas such as transformer areas, boiler area and other equipment area, where access is necessary for inspection, operation and maintenance.

3.17.05 Concrete paving of grade M20 with underbed as specified below shall be provided in the following areas: -

- a) Entire area of WHRB, stacks, BFP and deaerator building, STG & Gas Turbine Building and DM Plant Area.
- b) Minimum 3 m wide strip around the gas turbine and steam turbine building, compressor room, electrical control room, BFP and deaerator sheds and stacks.
- c) Minimum 1.2 m wide strip around all other plant building except noted otherwise.

Beside above areas, RCC paving shall be given in other areas, where easy and quick movement is necessary. The detail of RCC paving will be 150 mm thick M20 grade concrete having 8 mm dia. HYSD bars with spacing 150 mm centre to centre bothways in top and bottom layers. The paving slab will be laid on 75 thick lean concrete (1:3:6) underlain by 230 mm thick rubble soling. A 50 mm thick floor finish with metallic hardener will be laid over RCC paving.

3.17.06 The bidder shall furnish a detailed layout drawing including existing plant road, building access road and paving areas along with its offer indicating all salient buildings, equipment layout etc., for the approval of Owner.

#### 3.18.00 **Plant Area Drainage & Sewage System**

The storm area drainage for the area and buildings under the scope of extension project shall take into account the topography of the plant area, existing drainage, intensity of rainfall. All storm water drains shall be designed for the maximum hourly rainfall intensity as specified in Section G0 and to be connected to existing outfall/drainage outlet.

All drains shall be of RCC construction with minimum wall thickness 150mm shall have reinforcement in both faces.

3.18.01 The maximum velocity for pipe drains and open drains shall be limited to 2.5m/sec. and 1.5m/sec respectively. However, minimum velocity for self-cleansing of 0.6 m/sec. shall be ensured.

3.18.02 Sanitary sewers shall be designed for a maximum self-cleansing velocity of 0.75m/sec. and the maximum velocity shall not exceed 2.5 m/sec.

3.18.03 The bidder shall furnish a comprehensive layout of drainage system, taking consideration of different construction phase for the approval of Owner.

3.18.04 Drainage shall be provided for all roads, pavements, sidewalks, buildings, structures and wet areas including cable/pipe trenches, tunnels, basement of buildings and pits. Where gravity flow is not possible, pumps shall be installed for lifting and/or diverting pressurized water to location of discharge. Pump sumps and pumps shall be provided at all necessary locations.

3.18.05 Plant equipment drainage shall be connected to storm drainage system after treatment wherever necessary.

- 3.18.06 Proper drainage of floors, basements, cable / pipe trenches, tunnels and pits shall be provided for firewater, operation and leakage water.
- 3.18.07 The outdoor common storm and plant water shall be drained through concrete lined open drains ultimately connecting to nearest existing drainage network or drainage channel of the area outside the plant boundary. All equipment drainage, building roof and floor drainage, drainage of cable/pipe trenches, tunnels, pits, basements etc., shall be provided with suitable buried piping system (gravity flow) for discharging ultimately into the common outdoor drainage system. The sanitary sewage shall be drained through suitable gravity flow buried piping system.
- 3.18.08 The sanitary sewer system shall be independent of plant and storm drainage system. The treatment of sanitary sewage shall be through septic tanks and soakpits/leaching fields or treatment plant as per environmental rules and regulation. The number of septic tank shall be kept minimum and their location shall be away from plants, buildings and facilities. The size of septic tanks shall be designed based on fixture units and for a minimum storage of 5 years but not less than 2.0 cum.
- 3.18.09 Chemically soiled waste water shall be led to the neutralization pit and the neutralized water shall be directed to the drainage system.
- 3.18.10 Industrial oily waste water shall be passed through oil water separator system before connecting to the drainage system.
- 3.18.11 The drainage of oily waste water from transformers shall be provided with dual system. The oily water during normal operation shall be passed through oil water separator system and then connected to drainage system. The oily water during emergency operation shall be led through another system of pipes connecting to central blind sump. The blind sump shall have sufficient capacity to store transformer oil and fire fighting water for half-hour duration.
- 3.18.12 Very hot (over 60°C) water shall be first cooled down to less than 60°C in collecting basin by mixing with cold water before connecting to storm drainage system.
- 3.18.13 The maximum temperature, quality, quantity and location of drain water of individual equipment shall be tabulated and furnished to the Engineer.
- 3.18.14 All underground piping below concrete slab shall be cast iron of minimum 100mm dia and for outdoors it shall be reinforced concrete pipe of minimum 200mm diameter. In outdoor buried piping system manholes shall be placed at every change in direction and at every 30M (max) interval in straight run.
- 3.18.15 Following minimum drainage slope shall be provided:
- |                                   |   |                                |
|-----------------------------------|---|--------------------------------|
| Open drains                       | : | 1 (vertical): 400 (horizontal) |
| Pipes of diameter less than 200mm | : | 1 (vertical): 150 (horizontal) |
| Pipes of diameter                 | : | 1 (vertical): 200 (horizontal) |

### 3.19.00 **Raw Water Reservoir and Pump House**

Reservoir for storage of raw water required by the plant shall be either in open underground pond surrounded by embankment or a semi underground type in complete open pond system the base and sides shall be lined with cement concrete to control seepage and growth of vegetation.

In case of semi underground type, the RCC retaining walls around the pond, with its foundation, shall be designed for pressure due to water, soil and surcharge. In case semi-underground type, stability of the structure of above ground shall be checked for seismic load. The RCC walls above ground level shall be designed as a water retaining structure as per IS Code.

The inside face of the RCC wall shall be treated with water proofing compound to ensure water tightness.

The raw water pump house shall have an underground RCC sump with pump floor above. The pump house shall be of RCC/Steel portal frame with RCC roof complete with drainage, insulation, parapet etc. The pump operating floors shall be of RCC. One EOT crane shall be provided for handling of pumps. M.S. gates with rubber sealing shall be provided to isolate each compartment of underground sump.

Underground RCC sump shall be designed as a water retaining structure. All other criteria shall be same as described for C.W. pump house.

External cladding shall be of plastered masonry brick work or metal cladding as per Architectural specification.

### 4.00.00 **LOADING**

All structures will be designed for most critical combinations of dead loads, imposed loads, equipment loads, crane loads, wind loads, seismic loads and temperature loads. In addition, loads and forces developed due to differential settlement will also be considered, wherever required, as per Indian Code provisions.

#### 4.01.00 **Design Loading**

##### 4.01.01 **Dead Loads**

Dead loads will consist of the self weight of the structure complete with finishes, fixtures, walls, partitions etc. Dead loads will be determined using the unit weights from IS : 875 Part-I. While calculating dead load of the structure, total thickness of floor finish will be considered as 50mm.

##### 4.01.02 **Equipment Loads**

Equipment loads are self weight of permanent or semi-permanent equipment acting on the structure. Such loads will be supplied by the equipment manufacturer. Only major equipment loads will be considered separately. The minor equipment loads will be included in live loads.

#### 4.01.03 Imposed Loads

For consideration of loads on structures, IS:875-"Code of practice for structural safety of buildings" will be followed. The uniform live loads will not be applied to floor areas which will be permanently covered with equipment.

For the design of all structure, minimum live loads shall be higher of following loads or loads as mentioned in approved GA drawings.

- |    |   |  |
|----|---|--|
| a) | Roof  | 150 kg/sq.m for accessible roofs and 75 kg/sq.m for non-accessible roofs. (for control building roof 150 kg/sq.m).               |
| b) | GT/ STG Hall  |  |
|    | i) Ground floor   | 1,500 kg/sq.m  |
|    | ii) Operating floor   | 1,500 kg/sq.m (25% of the total area will have loading of 2,500 kg/sq.m for lay-down of STG components)                          |
|    | iii) Mezzanine floor  | 1,000 kg/sq.m  |
|    | iv) In addition to the above, a load of 500 Kg/sq.m is to be considered for piping/cabling loads for operating and mezzanine floor in STG Hall. |  |
| c) | Electrical/Control Building (except toilet, stair & walkway)  | 1,000 kg/sq.m or as required by the equipment supplier, whichever is higher.   |
|    |   | In addition a uniform load of 250 Kg/sq.m will be considered for cabling, ducting, false ceiling etc.                            |
| d) | BFP & Deaerator Structural Building/Shed  |  |
|    | Ground floor  | 1,500 Kg/sq.m  |
|    | Intermediate floor (if any)   | 1,000 Kg/sq.m  |
|    |   | In addition, a uniform load of 250 Kg/sq.m will be considered for cabling, ducting, false ceiling etc. below intermediate floor. |
| e) | Other building floors   | 500 kg/sq.m  |



f)	Stairs, landings and balconies	500 kg/sq.m
g)	Toilet Rooms	200 kg/sq.m
h)	Grating/Chequered plate floor	400 kg/sq.m excepting stairs, landings and balconies
i)	Operating floor slab of pump houses	A minimum live load of 1,500 kg/m <sup>2</sup> or as required by the equipment supplier, whichever is higher.
j)	Walkways	300 kg/sq.m
k)	Culverts & its allied structure including RCC pipes	Shall be designed for class 'A' loading as per IRC standard for two lane roads and class "70R" per IRC standard for single lane road.
l)	Channels, tanks, cable and pipe trenches and other underground hollow structures	In addition to earth pressure and ground water pressure etc. the surcharge of 2,000 kg/sq.m should be considered.
m)	RCC Covers for trenches and channels. Where covers are likely to be exposed to vehicular traffic the requirements of Code of Practice for road bridges and culverts shall be resorted to	These shall be designed for a live load of adjoining areas or 2,000 kg/sq.m whichever is higher.
n)	Cooling Tower	
	i) Roof/fan deck	500 Kg/sq.m
	ii) Cover for HW channels/ HW distribution basin	300 Kg/sq.m
	iii) Grating floors	400 Kg/sq.m
o)	Underground	Besides effects of overburden, buried pipes ground water table and internal pressure or suction, a surcharge load of 2,000 kg/sq.m shall also be considered.

#### 4.01.04 Crane Load/Monorail Hoist Load

For crane loads an impact factor of 25 % and lateral crane surge of 10% of (lifted weight + trolley weight) will be considered in the analysis of frame according to provisions of IS:875. The horizontal surge will be 5% of the static wheel load. For frame analysis, the lateral crane surge will be applied on one side of the frame at a time and in either direction. Impact factor for hoists, elevators etc. will be according to provisions of IS:875.

#### 4.01.05 Wind Load

All power plant structures, including plant auxiliary structures of the project will be designed for wind forces in accordance with IS:875 (Part-3) - 1987 "Code of practice for design loads for buildings and structures".

The basic wind velocity ( $V_b$ ) for the region is 50 m/sec at 10 m above the mean ground level. This basic wind speed is based on the peak gust velocity averaged over a short time interval of about 3 seconds and corresponds to open (category-2) terrains and for a return period of 50 years. Category-2 terrains, as defined in IS:875 are generally open terrains with obstructions having heights generally between 1.5 to 10 meters. This power plant site lies in Category-1, i.e. exposed open terrain.

Design wind pressure will be calculated as follows :

Design wind speed ( $V_z$ )                      =               $V_b \times K_1 \times K_2 \times K_3$  (ref. IS:875 part 3)  
in m/sec.

( $K_1 = 1.08$ ,  $K_2 = 1.15$ ,  $K_3 = 1.0$ )

Design wind pressure in N/sq.m ( $P_z$ ) =  $0.6 \times V_z^2 = 235 \text{ kg/m}^2$

#### 4.01.06 Earthquake Load

All power plant structures, including plant auxiliary structures of the project will be designed for seismic forces in accordance with IS:1893 "Criteria for Earthquake Resistant Design of Structures" Part-1 (2002): "General provisions and buildings" and Part-4 (2005): "Industrial structures including stack like structures".

In the calculation of seismic load, the dead load, equipment load and 50 percent of floor live load will be considered. Roof LL also need not be considered.

Detailed dynamic analysis using response spectrum method shall be done to determine the seismic forces. At least five modes shall be considered in the analysis and the modal combination shall be as per IS:1893.

The acceleration spectra given in code for appropriate damping ratio (2% for steel structures and 5% for concrete structures) may be used in the analysis.

Since the structure is in Zone-V, a high seismic zone, ductile detailing as per IS:13920 and IS:4326 shall be followed for all buildings and structures.

#### 4.01.07      **Temperature Loading**

The total temperature variation will be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose will be taken as the difference between the mean of the daily minimum temperature during the coldest month of the year and mean of daily maximum temperature during the hottest month of the year. The structure will be designed to withstanding stresses due to 50 % of the total temperature variation.

#### 4.02.00      **Load Combinations**

Buildings and structures, will be designed to resist the load stated in the previous section acting in the following combinations.

#### 4.02.01      **Basic Load Cases**

- |     |              |   |
|-----|--------------|---|
| 1.  | DLS          | [Only self weight]  |
| 2.  | DLE          | [Self weight of equipment]  |
| 3.  | LLR          | [Roof live load]  |
| 4.  | LLF          | [Floor live load]   |
| 5.  | CL-L+CLHx(+) | [Maxm. crane load on left col. plus horizontal surge in (+) X-direction]  |
| 6.  | CL-L+CLHx(-) | [Maxm. crane load on left col. plus horizontal surge in (-) X-direction]  |
| 7.  | CL-R+CLHx(+) | [Maxm. crane load on right col. plus horizontal surge in (+) X-direction] |
| 8.  | CL-R+CLHx(-) | [Maxm. crane load on right col. plus horizontal surge in (-) X-direction] |
| 9.  | WLx(+)       | [Wind load in (+) X-direction]  |
| 10. | WLx(-)       | [Wind load in (-) X-direction]  |
| 11. | SL x         | [Seismic load in (+) X-direction]   |
| 12. | CL           | [Crane self weight]   |
| 13. | TL           | Temperature load  |

(X-direction is towards the cross direction of the building from left to right)

#### 4.02.02 Load Combination for Steel & RCC Structure

Comb. 1 = 1	
2 = 0.9(1) + 5 + 9	
3 = 0.9(1) + 5 + 10	
4 = 0.9(1) + 6 + 9	
5 = 0.9(1) + 6 + 10	
6 = 0.9(1) + 7 + 9	> For anchor bolt and pile uplift
7 = 0.9(1) + 7 + 10	
8 = 0.9(1) + 8 + 9	
9 = 0.9(1) + 8 + 10	
10 = 0.9(1) + 11	
11 = 0.9(1) - 11	
12 = [(1+2)+(3+4)+5+ 9]0.75	
13 = [(1+2)+(3+4)+5+10]0.75	
14 = [(1+2)+(3+4)+6+ 9]0.75	> For steel structure& pile design
15 = [(1+2)+(3+4)+6+10]0.75	
16 = [(1+2)+(3+4)+7+ 9]0.75	
17 = [(1+2)+(3+4)+7+10]0.75	
18 = [(1+2)+(3+4)+8+ 9]0.75	
19 = [(1+2)+(3+4)+8+10]0.75	
20 = (1+2) + (3+4)+5	
21 = (1+2) + (3+4)+6	> For steel structure& pile design
22 = (1+2) + (3+4)+7	
23 = (1+2) + (3+4)+8	
24 = [(1+2)+ 0.5(4)+12+11]0.75	
25 = [(1+2)+ 0.5(4)+12-11]0.75	
26 = [(1+2)+(3+4)+5+9]1.2	
27 = [(1+2)+(3+4)+5+10]1.2	
28 = [(1+2)+(3+4)+6+ 9]1.2	
29 = [(1+2)+(3+4)+6+10]1.2	
30 = [(1+2)+(3+4)+7+ 9]1.2	
31 = [(1+2)+(3+4)+7+10]1.2	
32 = [(1+2)+(3+4)+8+ 9]1.2	> For design of fdn. & RCC structure
33 = [(1+2)+(3+4)+8+10]1.2	
34 = [(1+2)+(3+4)+5]1.5	
35 = [(1+2)+(3+4)+6]1.5	
36 = [(1+2)+(3+4)+7]1.5	
37 = [(1+2)+(3+4)+8]1.5	
38 = [(1+2)+ 0.5(4)+12+11]1.2	
39 = [(1+2)+ 0.5(4)+12-11]1.2	

- Note :**
1. Load combinations for individual building will be taken suitably from above load combinations.
  2. For structure with no crane but monorail hoist, the loading from monorail hoist will be included in live load case.
  3. In addition to above load combinations, the cooling tower structure will be analysed & design for load conditions mentioned under fan supporting structure in the specification no. M7.

4. In addition, loads and forces developed due to differential settlement shall also be considered, wherever required, as per codal provisions.

#### 5.00.00 **DESIGN CRITERIA**

In addition to the general requirements & civil design criteria stipulated for individual building and structure, following clauses are applicable and shall be strictly complied with for any structure as a whole or in part for safety and serviceability.

- 5.01.00 All structures as a whole or any part/component of it shall be designed for a life of 30 years.
- 5.01.01 Structure shall be designed for the most critical combination (as per relevant codes) of dead loads, super imposed loads, equipment loads, crane loads, wind loads, seismic loads, thermal loads & loads due to differential settlements. The structures shall be safe and stable at each stage of construction considering appropriate erection loads. The bidder shall specify the probable erection load from equipment suppliers at the stage of detail design.
- 5.01.02 Seismic analysis of all building structure may be carried out by response spectrum method as specified in section 4.0.
- 5.01.03 All reservoir and retaining structure of liquid shall be checked for its safety and stability as per IS-1893 under Seismic loading.
- 5.01.04 All structures shall be designed for wind forces in accordance with the latest edition of the IS-875 (Part 3) and as specified in section 4.0.
- 5.01.05 Earth pressure for all underground structure shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of sub-structure of pump house or underground trenches, earth pressure at rest shall be considered. The co-efficient of earth pressure shall be taken as 0.5 or as recommended in the geotechnical report, whichever is more.
- 5.01.06 In addition to earth pressure and ground water pressure, a surcharge of  $2T/m^2$  shall also be considered for the design of all underground structure including sub-structure of pump house for the vehicular traffic in the vicinity of the structure.
- 5.01.07 Following conditions shall be considered for the design of sub-structure of pump house, channels, sumps, tanks, trenches and other underground structure:
  - i) Only water pressure from inside and no earth pressure and ground water pressure & surcharge from outside (applicable only to structures which are liable to be filled up with water or any other liquid).
  - ii) Earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
  - iii) Design shall be checked for buoyancy due to the ground water during

construction and maintenance stage. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring super imposed loading.

- iv) Base slab of CW pump house fore bay shall also be designed for the fore-bay empty condition during construction and maintenance stages with maximum ground water table. Base slab of the pump house shall also be designed for the condition of different combination of pump sumps being empty during maintenance stage with maximum ground water table.
- v) Intermediate dividing walls of pump sumps shall be designed considering water in one pump sump only and the other sump being empty for maintenance.

5.01.08 All RCC design shall be either limit state method or working stress method following the recommendation of IS-456 (latest).

5.01.09 All structural steel work shall be designed either by allowable stress method following the recommendations by IS-800.

5.01.10 All foundations shall be founded at a level at least 1.0m below virgin soil. No foundation shall be placed on filled-up soil.

5.01.11 All underground walls & slabs shall have two layers of reinforcement for section having thickness 150 mm and above. Clear cover shall be minimum 40mm.

5.01.12 All super structure walls and slab shall have two layers of reinforcement for section having thickness 150 mm & above.

5.01.13 All water retaining structure shall be designed as uncracked section in accordance with IS-3370 (Part I to IV).

However, water channels and sub-structure of pump house shall be designed as cracked section with limited steel stress as per IS-3370 (Part I to IV) by working stress method. Minimum grade of concrete for the above structure shall be M20.

5.01.14 For grating floors on steel beams, it shall be suitably braced to ensure the integrity of the floor for horizontal diaphragm action.

5.01.15 The ground floor slab of any building will be of 150 mm thick reinforced concrete of Grade M15 laid over 75 mm thick lean concrete underlain by 230 mm thick rubble soling.

5.01.16 For all the foundations supporting minor equipment weighing less than one tones or if the mass of the rotating parts is less than one hundredth of the mass of the foundations, no dynamic analysis is necessary. However, if such minor equipment are to be supported on building structures, floors etc., suitable vibration isolation system shall be provided by means of springs, neoprene pads etc., and such vibration isolation systems shall be designed suitably.

5.01.17 For design of RCC pipes for drains & culverts IS- 456, and IS-783 & SP-13 shall be used.

- 5.01.18 For pre-stressed concrete design, the recommendation in the IS-3434 shall be followed. Minimum grade of concrete shall be M30.
- 5.01.19 Foundation systems shall be designed suitably, so that maximum settlement shall not exceed as stipulated in IS-1904 (latest).
- 5.01.20 For wind sensitive structure, no allowance for stress reduction shall be permitted.
- 5.01.21 The stack foundation shall be checked for overturning with a factor of safety of minimum 1.5. Any part of the foundation base shall not be allowed to up-lift under maximum lateral load & minimum vertical load.
- 5.01.22 The worst effect for the following sub-soil water level shall be considered in the design:
- a) Maximum sub-soil water level as per geotechnical report.
  - b) Maximum sub-soil water as 0.50 m below finished grade level.
  - c) Minimum sub-soil water level to be below the foundation level.
- 5.02.00 **Codes and Standards**
- 5.02.01 **Applicable Codes and Standards**
- a) **Specification for Materials**

Properties, storage and handling of common construction materials namely coarse aggregates, cement, lime water, sand, structural steel and reinforcement steel etc. will follow all relevant Indian Standards, specifications, codes of practice including all official amendments and revisions.
  - b) **Design of Reinforced Cement Concrete**

IS:456 Design and construction of RCC member

IS:11384	Design and construction of steel & concrete composite beam
IS:5526 & SP34	Details of reinforcement
IS:3370	Design and construction of RCC water retaining structures
IS:2911	Code of practice for design and construction of pile foundations (Part-1 to Part-4)
IS:2974	Code of practice for design and construction of machine foundations (Part-1 to Part-5)

c) **Design of Structural Steel**

To follow IS:2062, IS:8500, IS:800

5.02.02 **Reference Codes and Standards**

a) **American Concrete Institute (ACI)**

ACI 318-02 Building Code Requirement for reinforced Concrete

b) **American Institute of Steel Construction (AISC)**

AISC Manual of Steel Construction Allowable Stress Design

c) **International Conference of Building Officials (UBC)**

UBC Uniform Building Code

d) **American Society for Testing and Materials (ASTM)**

ASTM Applicable Standards for various construction material

e) **American Water Work Association (AWWA)**

AWWA M-9 Concrete Pressure Pipe - a Guide for Design and Installation

AWWA  
C300 Reinforced Concrete Pressure Pipe steel-Cylinder  
Type, for Water and Other Liquids

f) **Hydraulic Institute Standard (HIS)**

5.02.03 **Materials  
Structural Steel**

IS:2062 : Steel for General Structural purpose.

**Reinforcing Steel**

IS:1786 : Specification for high strength deformed bars for concrete reinforcement.

IS:432 : Specification for mild steel & medium tensile steel bars and hard drawn steel wires for concrete reinforcement.

**Cement**

IS:269 : Specification for 33 grade ordinary Portland cement

IS:12330 : Specification for Sulphate resisting Portland cement

**Aggregate**



IS:383 : Specification for coarse and fine aggregates from natural sources for concrete

6.00.00 **MATERIALS FOR STRUCTURES**

The principle material, which shall be used for construction of all structures and building shall be concrete, reinforcement and structural steel.

6.01.00 Minimum grade of concrete for various structures shall be as follows:

- M10 - For screeding (unreinforced)
- M7.5 - For lean concrete (unreinforced)
- M20 (Controlled mix) - For Duct Banks, paving and Concrete encasing of CW ducts and underground steel pipes.
- M25 (Controlled mix) - For trenches, basements, foundations, piles, pile caps, water retaining structures, pre-cast concrete, GT foundation, raft, column and tabletop of steam turbine, all machine foundation and any other superstructure works.
- M25 (Controlled mix) - For pre-stressed concrete.

6.02.00 Higher grade of concrete than specified above may be used at the discretion of the bidder, which has to be stated at the time of bidding.

6.03.00 20mm and down aggregates shall be used for all concrete works. However 40mm and down aggregates may also be used for steam TG raft foundation.

6.04.00 Cold twisted ribbed bars ( $F_y = 425 \text{ N/mm}^2$ ) conforming to IS-1786 shall be used as reinforcement. However, in minor structure like lintels & chajjah, mild steel (grade - I) conforming to IS-432 can also be used.

6.05.00 All grades of concrete shall conform to IS-456 - 2000.

For further details regarding materials, testing, quality etc., technical specification of concrete shall be referred to.

6.06.00 Structural steel shall be as per IS-2062. High strength friction grip bolts shall be used for all bolted connections. Bidder may use high strength low alloy (HSLA) steel for structural steel works of various buildings. This HSLA steel shall conform to the requirement of IS-8500. In that case the bidder must submit along with his offer detailed fabrication & welding procedures of 'HSLA' steel.

7.00.00      **MISCELLANEOUS REQUIREMENTS**

Further to all requirements described in the preceding clauses, the following criteria shall be strictly complied with pertaining to analysis, design, layout & construction of aforesaid power plant.

- 7.01.00      Dense concrete with controlled water cement ratio preferably 0.45 shall be used for all underground concrete structure such as basement, pump houses, water-retaining structure, cable & pipe trenches etc., for achieving water tightness.
- 7.02.00      All joints, including construction and expansion joints for the water retaining structure shall be made watertight by using PVC ribbed water stops with central bulb. However, kicker type (Externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 6 mm and minimum width shall be 230 mm.
- 7.03.00      Floors of switchgear room shall have embedded channel suitable for easy movement of breaker panels.
- 7.04.00      Anti termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors etc., as per IS-6313 and other relevant standards.
- 7.05.00      Minimum 75 mm thick lean concrete 1 : 4 : 8 shall be provided below all underground structure, trenches etc., to provide a base for construction.
- 7.06.00      Aluminium nosing shall be provided for edge protection in all RCC stairs.
- 7.07.00      Bricks having minimum 50 kg/cm<sup>2</sup> compressive strength can only be used for masonry work. Bidder shall ascertain himself at site regarding the availability of bricks of minimum 50 kg/cm<sup>2</sup> compressive strength before submitting his offer.
- 7.08.00      All stairs shall have a maximum riser height of 180mm and a minimum tread width of 250mm. Minimum width of stairs in all buildings shall be 1200 mm.
- 7.09.00      All masonry walls from ground floor shall be placed on reinforced concrete grade beams. However, light internal partitions may be placed on ground floor slab. Minimum depth of the grade beam below grade level shall be 300 mm.
- 7.10.00      Each building shall be provided with minimum 1.0m wide reinforced concrete paving all round unless specified otherwise. Paving shall be slopped to provide a rapid run off of rainwater away from building.
- 7.11.00      The steel column base plate along with stiffening gusset plates shall not be protruded above floor level.
- 7.12.00      The steel columns below ground floors and upto minimum 100mm above finished floor level shall be encased in concrete.

- 7.13.00 Steel checkered plates and gratings shall be hot dip galvanised.
- 7.14.00 Angles 50 x 50 x 6 mm (min.) with lugs shall be provided for edge protection all round of cut-outs/opening in floors, edge of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of pre-cast covers and any other places where breakage of corners of concrete is expected.
- 7.15.00 All drains inside the building shall have minimum 40 mm thick grating covers and in areas where heavy equipment loads would be coming, pre-cast RCC covers shall be used in place of steel grating.
- 7.16.00 All steel platforms above grade shall be constructed with kick plates at edge of platform to prevent tools or materials from falling off platform.
- 7.17.00 For all buildings suitable arrangements for draining out of water collected from equipment blowdowns, leakage, floor washing, fire-fighting etc., shall be provided for each floor.
- 7.18.00 Finished ground floor level (plinth level) of all buildings shall be minimum 300mm above formation/grade level.
- 7.19.00 Duct banks consisting of PVC/GI conduits for cables shall be provided with concrete filling of M20 grade conforming to IS-456. The minimum depth of top of duct bank from grade level shall be 500mm.
- 7.20.00 All upstands and parapet walls on roof shall be of RCC construction for all buildings. Minimum height of parapet shall be 750 mm.
- 7.21.00 All architectural fins for the elevation of building shall be of RCC (M25). Minimum thickness shall be 75mm.
- 7.22.00 All sand filling shall be compacted to minimum 95% of the relative density.
- 7.23.00 Back filled earth material shall be compacted to minimum 95% of the standard proctor's density at OMC.
- 7.24.00 All buildings shall have framed super structure. All walls shall be non-load bearing infilled panel walls.
- 7.25.00 50mm thick DPC shall be provided at plinth level before starting the masonry work.
- 7.26.00 Increased cover to reinforcement for all RCC structures as per IS-456 - 2000 shall be provided to withstand corrosive environment if there be any.
- 7.27.00 Requirement of sulphate resistant cement (SRC) for sub-structural works shall be decided in accordance with the Indian standards based on the findings of the detailed soil report.
- 7.28.00 All gates and stop-logs shall be of structural steel, which shall be hot double dip galvanised.

- 7.29.00 All mild steel parts used in the water retaining structures shall be hot double dip galvanised. Galvanising shall be checked and tested in accordance with IS-2629.
- 7.30.00 A screed of concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to IS-456 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structure.
- 7.31.00 Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 3.0 m for a single flight.
- 7.32.00 Hand railing minimum 900 mm high shall be provided around all floors/ roof openings, projections, balconies, walkways, platforms, steel stairs etc. All hand rails and ladder pipes shall be 32mm nominal bores MS pipe (medium class) and shall be galvanised (as per IS-277). All rungs for ladder shall also be galvanised as per IS-277 (medium class).
- 7.33.00 For RCC stairs, hand railing with 20mm square MS bar balustrades with suitable MS flats & aluminium hand rails (32mm) shall be provided.
- 7.34.00 All underground concrete structure like basements, pump house, water retaining structure etc., shall have plasticizer cum waterproofing cement additive conforming to IS-9103. In addition limit on permeability as given in IS-2645 shall also be met with. The concrete surface of these structures in contact with earth shall also be provided with two coats of bituminous painting for water/damp proofing. In case of water leakage in the above structures, injection method shall be applied for repairing the leakage.
- 7.35.00 The ground surface treatment in the switchyard area and in area around transformers shall be minimum 150 mm thick good quality pebbles / broken stone with top layer of soil treated with antiweed chemical as per specification.
- 7.36.00 In the event the bidder encounter a difficult sub- soil condition which requires significant improvement incurring substantial expenditure, the bidder may adopt any patented method of soil improvement subject to Owner's approval. No extra cost shall be borne by the Owner in this respect.
- 7.37.00 For steel pipes encased in concrete, concrete encasement to steel pipe shall be with M20 grade of concrete and shall be minimum 300 mm thick.
- 7.38.00 Ramps for building entrance shall be cast in situ RCC slab designed as a slab spanning over supports or rigid pavement resting on subgrade provided that the thickness of slab and the property of subgrade shall be such to ensure of its being treated as rigid pavement. The slope of ramps will not be more than 20°. Minimum thickness of slab shall be 150mm.
- 7.39.00 No underground service piping except for drainage and sewage system shall run directly below (including upto 1.0 m from the edge of road) along its longitudinal directions.

- 7.40.00 Provisions of safety, health & welfare according to factories Act shall be complied with. These shall include provision of continuous walkway of minimum 600mm wide along the crane girder at crane girder level on both sides of the building, comfortable approach to EOT crane cabin, railing, fire escape, locker room for workmen, pantry, toilets, rest room etc.
- 7.41.00 Minimum 3.0 M high fencing above toe wall shall be provided around switchyard, transformer yard, and other area, where fencing is necessary due to statutory requirements. Fencing shall comprise of 2.4m high PVC coated galvanised chain link fencing of minimum 8 gauge (including PVC coating) of mesh size 75mm and galvanised concertina for switchyard/galvanised barbed wire for other areas upto a height of 0.6 m above chain link fencing excluding PVC coating shall not be less than 12 gauge. Steel entry gate shall be provided for all fenced areas. Top of toe wall shall be minimum 200 mm above the formation level.
- 7.42.00 Trenches located outside building shall project at least 150mm above the finished formation level so that no storm water shall enter into the trench. The bottom of the trench shall be sloped suitably for draining out the collected water into the sump pit. The pre-cast covers shall be of minimum M-20 grade and shall not weight more than 65 kg. lifting hooks shall be provided in the pre-cast covers.
- 7.43.00 All cables & pipes in outlying area shall run above ground over steel trestle or other supporting structures for easy inspection and maintenance except in transformer yard area and some other area where the same can run in RCC trenches. In case of trestles with overhead racks and bridges minimum 7.0m head clearance shall be provided for road crossing.
- 7.44.00 For all trench structures, the bottom slope perpendicular to the run of the trench shall be minimum 1 in 200 and shall be minimum 1 in 500 for slope along the length of the trench.
- 7.45.00 Top of CW ducts shall be minimum 1.0 m below grade level.
- 7.46.00 For open horizontal drains, reservoirs concrete lining of minimum M15 grade on sides & bottom shall be provided. The thickness of lining shall be minimum 100mm or as per design consideration whichever is higher.
- 7.47.00 Provision for firewater proof doors, nos. of staircases, fire separation walls etc., shall be made according to the recommendations of TAC.
- 7.48.00 Minimum size of structural elements shall be as follows:
- 7.48.01 **Concrete Slab & beam**
- |    |                   |   |       |
|----|-------------------|---|-------|
| a) | Floor & roof slab | - | 120mm |
| b) | Miscellaneous     | - | 50mm  |
| c) | Ground floor slab | - | 150mm |
| d) | Pre-cast cover    | - | 40mm  |
| e) | Width of beam     | - | 100mm |

7.48.02 **Structural steel**

For Joists	-	I - 150
For Channels	-	MC - 100
For Angles	-	< 50 x 50 x 6
Gusset plates	-	8mm thick

7.48.03 The maximum allowable deflection shall be as per relevant codes and / or specified below whichever is less:

TYPE OF MEMBERS	DEFLECTION		LOADING
	SIMPLE OR CONTINUOUS BEAM	CANTILEVER BEAM	
Girders, beams, supporting floors walkways	L/350	L/400	LL
Girders, beams, supporting floors walkways	L/350	L/250	DL+LL+WL/SL
Roof girders, purlins	L/350 L/400	L/400 L/250	LL DL+LL+WL/SL
Crane girder, trolley beams	L/1000	L/2500	DL+LL+WL/SL
Wall stanchions, girts, wall beams	L/400	-	WL/SL
Lateral deflection or drift of a story relative to adjacent stories	H/325	-	DL+LL+WL/SL

DL	:	Dead Loads
LL	:	Live Loads/Imposed Loads
WL	:	Wind Load
SL	:	Seismic Loads
L	:	Span of beam
H	:	Story height

8.00.00 **STATUTORY REQUIREMENTS**

The Civil Engineering and building works shall comply with all appropriate statutory requirements including all current Building Control regulations, and with all planning or other conditions as required by the relevant local, state, and National authorities.

8.01.00 The contractor shall provide full general arrangement drawing (Structural & Architectural) of all buildings and structures to the Owner for comment. The Contractor shall not proceed with these drawings further without such comment. Any work carried out by the Contractor using drawings unacceptable by the Owner shall be at the Contractor risk.

8.02.00 The Contractor shall seek and obtain all necessary approvals and detailed planning consents outstanding at the time of placing the contract and shall be responsible for all necessary liaison with such authorities to obtain the same and for the payment of due fees for such approvals.

8.03.00 The Contractor shall obtain approval from the appropriate authority regarding the safe means of escape in the event of fire or other hazard before relevant construction work proceeds. As a minimum, the Contractor is required to ensure that the works shall comply with all statutory requirements including:

- i) Central Government/State Government - for all building control regulation
- ii) State factories act - For Safety, health & welfare, use of hazardous substance
- iii) Central and State Pollution Board - For limits on pollution levels.
- iv) Central Water Authority/State Irrigation Department - For Water obstruction/supply for withdrawal of water from local source.
- v) State Water and Disposal Department - for waste & Foul Water disposal.
- vi) Ministry of Environment - for all matters relating to environment.
- vii) Ministry of Railway - for all matters for railway line construction.
- viii) Traffic Advisory Committee - for regulation concerning fire safety/means of escape.
- ix) Aviation Authorities - for clearance of tall structure like stack etc.
- x) State Public Works Department - for regulations on Civil work/ road works.
- xi) Ministry of Forestry - for deforestation, if any, for site development.

8.04.00 The Contractor shall make due allowance for all necessary negotiation/ administration required and the time needed to obtain these permission and approvals in his programme. Failure to obtain such approvals in a timely manner shall not be a reason for extension of the programme.

9.00.00 **DOCUMENTS TO BE SUBMITTED**

The Contractor shall be required to prepare a 'Basis of Design' for each Elements/Structures of Civil Works expanding on the information given in the specification. The 'Basis of Design' shall include the following:

- i) A concise description of the form of Structure considered.
- ii) A statement of salient assumptions made.
- iii) Codes of practice and references used
- iv) A description of the design approach
- v) Detail Calculations including Computer inputs and results with

conclusion.

vi) Working drawings showing necessary details

These documents shall be submitted to Owner for review at least 12 weeks prior to the commencement of the relevant construction activity.

9.01.00 The submission shall be in accordance with dates set down in Contractors civil works design and construction programme.

9.02.00 The Contractor shall be required to carry out at his own cost, any rectification, alteration or replacement of works progressed within 12 weeks of submission of the design basis and drawings and resulting from engineers comments on the design submission.

9.03.00 Acceptance of the Contractor 'Basis of Design' calculations or drawings by the Owner shall not relieve the Contractor of any of his obligations to meet all the requirements of the Contract or relieve the Contractor's responsibility for the correctness of such information. The Contractor shall make any changes in the design/drawing, which are necessary to make the work comply with the contract.

9.04.00 **Calculations, Reports & Drawings**

The Contractor shall prepare detailed calculations for all structure / elements. The Contractor shall also make available any additional calculations, other than routine structural calculation, as requested by the Owner during the period of Contract.

9.05.00 In addition to Geotechnical investigation report, the Contractor shall arrange and make available any other reports and investigations the Owner deems necessary for safety & stability of plant. The investigations shall be carried out in any standard laboratory of repute and as recommended by the Owner. All laboratory tests shall be carried out in the presence of Owner's engineer.

9.06.00 In the event, the Contractor adopts any patented method of design and Construction, not popular or practiced in this country; the Contractor shall sought prior approval of Owner in writing. The Contractor shall forward appropriate literatures, documents, certificates, case histories etc., to establish the viability of the method.

9.07.00 The bidder shall submit the tender with a schedule of proposed sub contractors for different construction packages (if necessary), structural consultants, (if any), any hired personnel for expertise, along with their name address, etc.

9.08.00 Each calculation document shall include the following

- i) Contractor's name
- ii) Package identification (if any)
- iii) Designer's name/initials
- iv) Checker's name/initials



- v) Reference No.
- vi) Index
- vii) Date & Revision No.
- viii) Revision identification mark
- ix) Detail calculations including computer input data and output.

Calculation packages shall preferably be bound at A4 size sheets.

9.10.00 All working & construction drawings shall preferably be drawn by CAD system, and shall be issued in A0/A1 size. The drawing shall include:

- i) Name of Project, Owner, Consultant & Contractor.
- ii) Title of the Drawing
- iii) Drawing No. Issue Date, Revision No.
- iv) Statement for Revision
- v) Revision Identification Mark
- vi) Release Status
- vii) Designer/Checker's/Draughtsman's name/initial

9.11.00 The Contractor, who shall maintain an upto date drawing & document register, shall monitor drawing & document issue. This register shall list all drawings & documents used in the design and construction for civil and structural works. The drawing register shall be a controlled document and shall be kept updated/ revised and shall be issued on A4 size sheets.

9.12.00 All numerical analysis shall be done through computer. The bidder shall have either their own system or have access in other system outside their premises.

The Contractor shall be a bonafide license holder of any software package used in this project. Any in-house developed software may also be used subject to the approval of the Owner through validation with standard computer programme. Any pirated & unlawful use of software shall not be permitted. The Contractor shall furnish:

- i) Name of Software
- ii) Developing Agency
- iii) A write-up/overview of the programme.  
As supplied by the copyrighter.
- iv) Relevant documents verifying users right for using this software in this country.

9.13.00 All drawings, design documents, reports, correspondence pertaining to civil structural works shall be in 'English Language'. Documents in any other language shall be translated in English before submitting to Owner.

All drawings, documents shall be forwarded in three (3) copies to Owner for approval/record.

10.00.00 **NOTES**

- i) This section C0 shall be read in conjunction with section G0 and general conditions of contract.
- ii) For Architectural requirements of the plant Section A0 shall be referred to.
- iii) For Technical Specification with regard to construction method, materials, workmanship, pertaining to civil & structural works, Section C1 to C12 shall be referred to. In case the bidder finds the technical specifications are not adequate or fails to describe the work undertaken by him, the bidder may generate his own technical specification and submit it for Owner's approval.
- iv) In the event, any contradictions, confusion arises for any statement / condition / terms pertaining to design of civil engineering systems, stated elsewhere in addition to this section, the statement furnished in this section shall prevail.
- v) In the event, the bidder notice any inadvertent fault/mistake published in the specification, the same shall be immediately brought to notice of the Owner for correction.

**SPECIFICATION NO. C-1**

**FOR**

**LAND SURVEY AND ESTABLISHING  
REFERENCE GRID  
AND BENCH MARK PILLARS**

**SPECIFICATION NO. C-1  
FOR  
LAND SURVEY AND ESTABLISHING REFERENCE GRIDS  
AND BENCH MARK PILLARS**

**C O N T E N T S**

<b>CLAUSE NO.</b>	<b>DESCRIPTION</b>	<b>PAGE NO.</b>
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**SPECIFICATION NO. C-1  
FOR  
LAND SURVEY AND ESTABLISHING REFERENCE GRIDS  
AND BENCH MARK PILLARS**

**1.00.00 SCOPE**

This specification is intended to cover topographical surveys and preparation of plans (maps) showing all permanent features including buildings, large trees, pucca & kutcha nullas, ditches, (with or without water), nearby roads/ approaches, railway track, culverts, overhead transmission & communication lines, ridges, boundary wall, fencing, demarcation line etc. of the project area as well as sectional views of the drains, ditches, creek, culverts and similar items (with all dimensions and invert levels). Carrying of the Bench Mark (existing reference BM outside the project area) to project site by levelling, establishing bench marks and grids in the field, spot level survey at specified intervals and on change points, contouring, constructing and fixing of bench mark pillars & grid pillars in the field, clearing of jungles & debris and cutting of trees (to the minimum extent as required for the work and as per instruction of the Owner) etc. shall also form a part of the scope of work. In addition, the true north, magnetic north and the angle between the grid lines (established at site) and the true north or magnetic north shall be indicated in all drawings.

It may also be necessary to interconnect the existing grid lines (with measured angles and distances) and level references as well as a few permanent buildings and permanent roads adjacent/near the specified project site area during the proposed survey work and thus incorporate the same in the survey plans/maps.

The drawing no. (Location Plan) and (Plot Plan) give location of the project and an indication of the project area to be surveyed. These drawings are preliminary and do not cover the entire scope of work. These may be modified, survey area increased/ decreased, and any new drawing may be given before award of the Work or during execution of the work (keeping sufficient time for field survey work and plotting).

Permanent features and levels of a few existing items as given in the above drawings shall not be used as reference without verification by actual survey with precision instruments by the contractor and plotted in his maps/drawings accordingly.

The grid pillars and B.M. pillars shall be maintained and checked frequently to ensure the correctness of the value of the pillar till the completion of the job and handing them over to the Owner. It shall be responsibility of the Contractor to check the pillars jointly with Owner/ Engineer at the time of final handing over of the work to the Owner.

The tenderers should visit the project site, at his own cost, before quoting rates for this tender. No extra claim (in terms of extension of time or revision in rates, etc.) shall be entertained at a later date on the ground of insufficient knowledge about the site or for lack of clarifications on this specification.

2.00.00      **GENERAL**

2.01.00      **Work to be provided for by the Contractor**

2.01.01      Work to be provided by the Contractor, unless specified otherwise, shall include but not be limited to the following :

- a)      Furnish necessary instruments and all other tools and materials including pegs, marking plates for reference grid and bench mark pillars, construction materials for pillars, labour & skilled surveyors, supervision by competent engineers, services, necessary transport, full insurance and all other incidental items as may be necessary for on-time and successful completion of the surveying and mapping work.
- b)      Furnish original field & level books, notes taken on special features and field drawings with readings & relevant features plotted.
- c)      Preparation, thorough checking & cross checking in the field and submission of completed survey plans/maps and drawings in specified scale incorporating sectional views and details as included under Section-1.0.
- d)      Construction and installation of reference grids and bench mark pillars at specified locations.

2.02.00      **Work to be provided for by others**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

2.03.00      **Information to be Submitted by the Tenderer**

2.03.01      **With Tender**

The tenderer shall indicate in his tender the number of different surveying instruments (with make and year of manufacture), skilled & experienced surveyors, and competent engineers that will be deployed at the site for this work. His experience during last five years in similar survey work shall be detailed in the tenderer's offer which shall also include his present commitments.

2.03.02      **After Award**

The contractor shall inform and satisfy the Engineer regarding deployment of personnel engaged by him for quality work under an agreed time-frame for completion of the work under this Contract.

He shall also prepare, discuss with Owner/Engineer and submit an agreed work programme within seven (7) days of award of the Work and during which period he shall also mobilize his instruments, tools, personnel at the project site.

The survey documents shall be submitted to the Owner/Engineer by the Contractor progressively during execution of the Work in order to enable him to review the work and, if necessary, cross-check at site along with Contractor's surveyor and engineer and point out the deficiencies/ discrepancies, if any, therein. However, the Contractor shall be still responsible for the correctness of the entire work and shall resurvey and replot any portion of the Work which may be found to be defective later on. During such checking/cross-checking as well as supervision during execution of the entire work, the Contractor shall extend all facilities including proper instruments, tools, other materials, surveyors & labour, etc. to the Owner/Engineer.

The Contractor shall engage qualified engineers, surveyors, drafting persons, etc. for executing the work under this Contract.

### 3.00.00 **INSTRUMENTS AND CONSTRUCTION MATERIALS**

#### 3.01.00 **Instruments**

The entire field surveying shall be done with the combination of transit/ optic Theodolites (which can read upto 20 seconds or less), Prismatic Compass, Precision Levelling Instruments with well-graduated & accurate staff, Chain, Measuring Steel Tapes and Plane Table Survey by Clinometer with the help of Clinograph Scale, ranging rods, etc.

Theodolite should be optically centered and the levels should be tilting type. Measuring tapes shall be used with calibrated tension. The calibration charts for the instruments shall be submitted before the start of the Work.

High quality surveying instruments (particularly, theodolites & levels) of reputed manufacturers shall be deployed for accurate and dependable survey work. Electronic instruments, if available with the Contractor, will be preferred.

#### 3.02.00 **Construction Materials for Reference Grid and Bench Mark Pillars**

Concrete for pillars shall be of mix 1:2:4 (one cement : two coarse sand : four 20 mm down stone aggregates). All the component materials shall be of best & acceptable quality and conforming to the provisions of the latest version of the Indian Standards.

Steel plates for engraving B.M. value and reference grids shall be of mild steel, conforming to IS : 2062.

### 4.00.00 **EXECUTION**

#### 4.01.00 **Permanent Adjustments**

All permanent adjustments of the instruments shall be made before starting the work, to the satisfaction of the Owner/Engineer.

4.02.00 **Contour Intervals and Scale of Drawings**

4.02.01 **Contour Intervals**

For contouring, spot levels shall be taken at 10 m horizontal intervals or less in both directions to establish the contours at 300 mm intervals for nearly flat terrains and at 0.5 m to 1.0 m intervals for undulating hilly terrains, as per schedule of items and direction of the Owner/Engineer.

4.02.02 **Scale of Drawings**

Depending upon the area to be covered, survey maps shall be prepared in the scale of 1 : 500 or 1 : 1000, as indicated in Schedule of Items, and all permanent features (as indicated under Section - 1.0), grid pillars, bench mark pillars, reference grid and bench mark pillars, contours (as specified in 4.2.1 above) etc. shall be plotted.

Sectional views of the drains, ditches, culverts, roads, etc., however, can be prepared in a scale suitable for furnishing all pertinent dimensions, levels and information, and in a separate drawing sheet.

4.03.00 **Submission of Drawings and Documents**

The following documents shall submitted to the Owner/Engineer :

4.03.01 Original field and level books and notes taken on special features, plus a photo-copy each of the above documents.

4.03.02 Field drawings with readings and relevant features and sectional views plotted - three (3) copies for review by Owner/Engineer. (One copy will be returned to the Contractor with comments, if any).

4.03.03 Original and one (1) copy of the above field drawings (item 4.3.2 above) after field verification of the comments and incorporating the corrected features.

4.03.04 Original tracing and four (4) prints of the final survey maps and drawings showing other details, all prepared in ink and in clear legible form. Format of & title block on the drawing/map shall be as per direction of Owner/ Engineer.

4.04.00 **Time of Completion**

Time shall be deemed to be the essence of the Contract. The entire survey work including submission of the final survey maps and drawings as well as other documents (ref. : 4.3 above) shall be completed within a period of weeks/months in the following manner :

- |    |   |           |
|----|---|-----------|
| a) | Mobilisation and firming up time schedule<br>and survey groups  | .....week |
| b) | Completion of field survey work and submission<br>of three (3) copies of the field drawings and<br>a photo-copy of the field & level books and the<br>field notes,. etc. (Items 4.3.1 & 4.3.2 above). | ... weeks |



- c) Submission of the final survey maps & drawings and other documents (item 4.3.1, 4.3.3 & 4.3.4 above). ... weeks

Construction and installation of grid and bench marks pillars, however, are to be subsequently completed within weeks of the clearance from Owner/ Engineer.

If the Owner/Engineer feels that the progress of the work is not satisfactory, he shall notify the Contractor to take necessary measures to complete the Work on time. If the Contractor fails to comply with the Owner's directive or fails to complete the Work on time, Owner will be at liberty to get the Work done by any other agency and forfeit the amount related to unfinished works and the Earnest Money/Security Deposit of the Contractor.

#### 4.05.00 **Security Rules and Statutory Regulations**

The Contractor shall strictly follow at site all security rules and regulations enforced by Owner from time to time regarding movement of materials, equipment/instrument, personnel to and from site, issue of identity cards, badges, control of entry and all similar matters.

The Contractor, his employees and agents shall not disclose any information or drawings prepared by him or furnished to him by the Owner/Engineer.

He shall also follow all safety rules and regulations and shall take sufficient measures to adhere to the same.

The Contractor shall conform in all respects with the provisions of any statute, ordinance law, rules, regulations, by-laws of Central, State, Local or other duly constituted Authority. The Contractor shall give all notices and fees to be given or paid.

In respect of labour, the Contractor shall comply with all rules framed by the Government for the protection of health, wages, welfare and safety of the workers. The Contractor shall be responsible for effective insurance under the Indian Workman's Compensation Act., Third Party Liability Insurance, etc. in accordance with the Indian Law and Regulation at his own cost.

In fine, the Contractor shall keep the Owner and Engineer indemnified against all penalties and liabilities of every kind.

#### 5.00.00 **TECHNICAL SPECIFICATIONS**

##### 5.01.00 **Establishing of Bench Marks**

At least two permanent bench marks at each site at approved locations shall be established from the existing bench marks. While carrying the bench mark, levels shall be established on permanent objects as directed by the Engineer. Levelling survey shall be done in the forward and reverse direction and the closing error should not be more than  $\pm 05\text{mm}$ .

##### 5.02.00 **Establishing of Grid Pillars**

Permanent grid pillars shall be established in either direction at every 100m intervals or as directed. \*One reference pillar and one reference grid direction shall be provided by the Owner. For carrying reference pillars, additional station points shall be established for traversing or triangulation as directed by the Engineer. The closing error for any closed traverse shall not exceed the specified limits as per clause 5.6. The maximum tolerance for any grid location shall be  $\pm 1$  mm. Generally for all angular measurements, transit of theodolite shall be done. Measurement shall be verified by cross-checking the diagonal angle as directed by the Engineer. For observing bearing from magnetic north, care should be taken that no magnetic substance to influence the bearing reading is there. The magnetic north should also be periodically verified.

Reference shall be taken from the existing permanent objects identifying from the Cadestal map for establishing the new grid line and shall be related to true north line where grids are not existing.

#### 5.03.00 **Reference Grid Pillars and Bench Marks**

All reference grid pillars and permanent bench marks shall be 900 mm x 200 mm x 200 mm cement-concrete pillars with 150 mm projecting above ground. 150 mm square x 12 mm thick steel plates (with two L-shaped 20 cm long M.S. lugs welded to the plate) or 6 mm thick aluminium plates with bolts shall be embedded or bolted on top of the pillars. Grid points & lines shall be accurately punched on the plates as also the numerical values of grid lines and levels. Grid lines and levels as required shall be painted.

#### 5.04.00 **Topographical Surveying and Mapping**

Positions, both in plan and elevation, of all natural and artificial features of the area in question (including permanent objects) are to be established and subsequently delineating them on survey maps by means of conventional symbols (preferably those of Survey of India maps). Necessary levelling work of the project area shall be combined with methods of establishing horizontal location so that location and sketching of contours for the area can be done at specified intervals and in specified scales on maps. Rock outcrops, springs/falls (if any) and other unusual ground formations/conditions shall be noted and locations plotted on the maps.

The field work shall be done in the following steps :-

- a) Establishing horizontal and vertical controls and locating reference grids and bench marks in the area.
- b) Levelling and plotting contours.
- c) Surveying and locating the natural, artificial and permanent features in details as described earlier.
- d) Taking of longitudinal and cross-sections of the corridors for pipe line and road/rail and drains, ditches, waterbodies, culverts, etc.

All survey work shall be related with true north and true north shall be established at site beforehand.

#### 5.05.00 **Traversing and Ground Controls**

Triangulation or Traversing or a combination of the two methods shall be adopted for the purpose of establishing horizontal controls, in order to determine the exact relationships between various existing points/ features on ground, so that surveys required under the present scope of work and in future may be correlated and tied together.

Before commencement of work, the plan showing base lines and the grid lines and their spacings shall be got approved by the Owner/ Engineer at site. First, a traverse covering the entire survey area shall be established with reference to a permanent object/reference grid pillar already existing at Site (as instructed by the Owner/Engineer).

The closing error in traverse (primary/secondary) shall not exceed one in three thousand in terms of length or,  $L \sqrt{N}$  second (total) in angular measurement, whichever is less. (Where, L = the least count of the instrument and N = the number of stations).

#### 5.06.00 **Contouring**

Spot level surveying at specified intervals shall be adopted for contouring the area, so that accurate contouring can be done. At places of sharp curvature or abrupt changes in direction and elevation, points selected shall be close to represent the actual ground configuration.

Levelling operation shall always start on a control station / nearby bench mark and end on the same.

#### 5.07.00 **Route Survey**

Route Survey shall be conducted along a narrow strip/belt of the terrain selected after field reconnaissance or as directed by Owner/Engineer at Site. Topographical survey for existing storm drainage lines as well as for routing pipe lines, transportation and communication lines, etc. shall be conducted. Longitudinal profiles as well as cross-sections shall be taken at 50 m intervals or less in nearly flat/undulating terrains and at 20 m intervals in hilly terrains, as per direction of the Owner/Engineer. All cross-sections shall be with reference to centre line of corridor showing levels at every 2 - 5 metre intervals and all breaks in the profile. The width of strip/corridor shall be as specified in the drawing or as directed by Owner/Engineer.

#### 6.00.00 **RATES**

The rates for the items of land survey and establishing reference grids and bench mark pillars shall include the cost of materials consumed in this work or incidental to it, the cost of instruments, tools and plants, labour, supervision, transport, installation, taxes, insurance, royalties and revenue expenses, security and safety measures, approaches, power, fuel, services, preliminary and enabling works, camps, stores, water, etc. and overheads & profits complete. In case no specific item is provided in the schedule to cover any particular item of work, it is implied that the contractor will include the cost of executing such work in the rates quoted for connected items in the schedule.

7.00.00      **METHOD OF MEASUREMENT**

Unless specified otherwise in the schedule of items, the measurement of items shall be done as follows :

7.01.00      **Carrying and Establishment of Bench Mark (B.M.)**

Carrying of the bench mark from nearby available permanent B.M. to site (at boundary point) shall be measured in running kilometre along the route of survey passing over all kinds of ground conditions which includes levelling, establishing bench marks, complete as per specification. Supply and installation of B.M. pillars shall be measured separately.

7.02.00      **Topographic Survey**

Areas of topographic survey shall be measured in Hectare which includes surveying and plotting of topographic features, physical features of all objects, areas of shallow water bodies, pucca & kutcha nallas, ditches, nearby roads/approaches, railway tracks, culverts, overhead transmission & communication lines and supports, ridges, etc., levelling and establishing grid lines complete as per specification. Supply and installation of grid pillars shall be measured separately.

7.03.00      **Route Survey**

Area of route survey shall be measured in Hectare for the specified corridor width of land which includes surveying and plotting of topographic features, physical features of all objects, pucca & kutcha nallas, ditches (with or without water), roads/approaches, railway tracks, overhead transmission & communication lines, and supports, ridges, etc., levelling and establishing grid lines complete as per specification. Supply and installation of grid pillars shall be measured separately.

7.04.00      **Bench Mark Pillars and Grid Pillars**

Pillars shall be measured in number as per specification and schedule of items.

**SPECIFICATION NO. C-2**

**FOR**

**GEOTECHNICAL INVESTIGATION**

**SPECIFICATION NO. C-2  
FOR  
GEOTECHNICAL INVESTIGATION**

**C O N T E N T S**

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**SPECIFICATION NO. C-2  
FOR  
GEOTECHNICAL INVESTIGATION**

**1.00.00 SCOPE**

This specification covers the complete soil exploration work including carrying out field tests and laboratory tests to evaluate static as well as dynamic parameters of soil/rock and preparation of detailed report including the recommendations regarding founding level, type of foundation for different kinds of structures/machines and methods of deep excavation.

**2.00.00 GENERAL**

The contractor shall perform all work under the purview of this specification along with all incidental and related work including setting out, staging, approach to test locations, contractor's office, stores and protection of adjacent buildings, structures or services/facilities. No separate payments shall be made on such accounts. The tenderer should therefore take into account all such relevant items while quoting his unit rates against the schedule of items.

**2.01.00 Work to be provided for the Contractor**

The work to be provided by the contractor, unless specified otherwise shall include but not be limited to the following.

- a) Furnish necessary plant and equipment, tools and tackles, instruments, necessary power, fuel, water, labour, supervision by qualified and experienced engineers and supervisors specialised in the type of investigation, transport of materials, men and equipment etc., services, full insurance and all other incidental items as may be necessary for entire and successful completion of the work as per tender terms, drawings, specifications and instruction of the Owner/Engineer.
- b) Locate in the field and in layout drawing all boreholes and other field investigation items.
- c) Furnish progressively and periodically field bore logs, investigation observations, test results with relevant data and features in triplicate.
- d) Prepare and submit draft (in duplicate) and final (after incorporating comments, if any) sub soil investigation report as per specification, schedule of items and instructions of the Owner/his Engineer.

**2.02.00 Work to be provided by others**

No work under this specification will be provided by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

2.03.00      **Location and Levels**

Location of all boreholes and field test points and levels of the existing ground at such locations shall be established by the contractor at his own cost from two reference grids and one bench mark given by the Owner/his Engineer and these shall be subsequently plotted in the layout plan, bore logs and other relevant field test data sheets/tables to be incorporated in the report by the contractor.

Making bench mark pillar (s) and reference line pillars (whatever are required for the work) and maintaining them upto the completion of the work shall be the responsibility of the contractor at no extra cost by the Owner.

2.04.00      **Codes and Standards**

The following is the general list of IS Codes to be used for the soil investigation work and preparation of report. In all cases latest revision along with amendments, if any, shall be referred to.

- |         |   |   |
|---------|---|---|
| IS:1498 | - | Classification and identification of soils for General Engineering purposes.          |
| IS:1888 | - | Method of load tests on soils   |
| IS:1892 | - | Subsurface investigation for foundation   |
| IS:1904 | - | Structural safety of buildings : shallow foundations                                  |
| IS:2131 | - | Method for standard penetration test for soils  |
| IS:2132 | - | Code of Practice for thin walled tube sampling of soils                               |
| IS:2720 | - | Methods of tests for soils  |
| IS:2809 | - | Glossary of terms and symbols relating to Soil Engineering.                           |
| IS:2810 | - | Glossary of terms relating to soil dynamics   |
| IS:3025 | - | Methods of sampling and testing for water used in industry                            |
| IS:3043 | - | Code of Practice for earthing   |
| IS:4078 | - | Indexing and storage of drill cores   |
| IS:4434 | - | Code of Practice for in-situ vane shear test for soils                                |
| IS:4453 | - | Code of Practice for exploration by pits, trenches, drifts and shafts                 |
| IS:4464 | - | Presentation of drilling information and core description in foundation investigation |



IS:4968 (Part-II)	-	Dynamic Cone Penetration Test.
(Part-III)	-	Static Cone Penetration Test.
IS:5249	-	Method of test for determination of dynamic properties of soil.
IS:5313	-	Guide for core drilling observations
IS:5529 (Part I)	-	In situ permeability tests - tests in over-burden
(Part II)	-	In situ permeability tests - tests in bed rock
IS:6403	-	Determination of allowable bearing pressure on shallow foundations.
IS:6926	-	Diamond core drilling for site investigation for river valley projects.
IS:6935	-	Method of determination of water level in boreholes
IS:7746	-	In situ shear test on rock
IS:8009 (Part-I)	-	Calculation of settlement of foundations - shallow foundations subjected to symmetrical static vertical loads
(Part-II)	-	deep foundations subjected to symmetrical static vertical loading.
IS:8763	-	Guide for undisturbed sampling of sands
IS:8764	-	Method for determination of point load strength index of rocks
IS:9143	-	Method for the determination of unconfined compressive strength of rock materials
IS:9179	-	Method for preparation of rock specimen for laboratory testing
IS:9214	-	Method of determination of modulus of subgrade reaction (k-value) of soils in field
IS:9221	-	Method for determination of modulus of elasticity and poisson's ratio of rock materials in uniaxial compression.
IS:9259	-	Liquid limit apparatus for soils
IS:9640	-	Specification for split spoon sampler

IS:10108	-	Sampling of soils by thin wall samples with stationary piston
IS:10589	-	Equipment for subsurface sounding of soils
IS:10837	-	Specification of moulds for determination of relative density and its accessories
IS:11229	-	Specification for shear box testing of soils
IS:11315 (Part II)	-	Description of discontinuities in rock mass - core recovery and rock quality

3.00.00 **SOIL EXPLORATION**

3.01.00 **Test Boring**

Test Boring through different layers of soil shall be carried out by the contractor at the locations marked in the drg no. and/or at such other locations as directed by the Engineer in a manner described below.

Various methods of boring as described in IS:1892 may be adopted. The tenderer shall furnish in his tender the complete details of the equipment and the method he proposes to follow. Minimum diameter of boring shall be 150 mm.

During the boring operations if rock strata is not encountered, the boring shall be continued upto 30 m depth for two bore holes and upto 20m depth for the remaining boreholes unless stated otherwise. Incase rock strata is encountered within the above depths, boring operations shall be discontinued and drilling operation as enumerated in clause 4.0 below shall be resorted to. If the present formation level is above the natural ground with filled-up soil, the depth of boring mentioned above shall exclude such filled-up soil.

The contractor shall describe in detail the equipment and method of boring he proposes to use. In the absence of dry boring equipment, wash boring at the discretion of the Engineer may be allowed, but the particular way of cleaning the casing by washing has to be approved by the Engineer. However, if the Engineer, at any time, feels that the washing process is disturbing the samples to be taken, he may stop the work and the contractor shall have no claim whatsoever on this score. If the contractor can, however, improve the method to the satisfaction of the Engineer, he may be allowed to resume the wash boring work.

When boring cannot be advanced due to presence of hard material, it should be checked whether there is continuous strata of hard material below before resorting to drilling methods. If only a local boulder is present it should be chopped using suitable chopping bits and the debris removed and normal boring continued.

Ground water level for each bore hole shall be checked during boring operation and shall be recorded in bore log. Sub-soil water samples shall also be collected from each borehole and recorded.

Where possible, completed boreholes shall be capped and a G.I. pipe inserted in order to preserve them for future ground water level observation. The contractor shall use his own materials for this and the unit rate quoted shall be inclusive of the same. These bore holes after completion of observation shall be handed over to the Owner in such condition as to enable future observation of ground water possible. The other boreholes not used for observation shall be backfilled by the contractor using sand fill as and when directed by the Engineer.

#### 3.01.00      **Stabilization of Boreholes**

Boreholes shall be stabilized, whenever required, against caving of the sides of the drill hole and heaving of the bottom of the hole. especially in cases where the hole is carried below the ground water level, by use of drive pipe or casing or by means of drilling fluids (water or mixtures of water and colloidal, gel forming thixotropic clays such as bentonite), grouting (in rack) or other suitable methods.

#### 3.02.00      **Open Trial Pits**

The location of open trial pits shall be as shown in drg. no. .... and/or at such other locations as directed by the Engineer. If the present formation level is above the natural ground level with filled-up soil, the depth of trial pits shall be upto a depth of 3.5m below natural ground level or not below the ground water table or as directed by the Engineer. In no case, the depth shall be extended over 5m. The size of pits shall be 3.0m x 3.0m or as directed by the Engineer. Samples of undisturbed soil shall be obtained preferably at every 1.5m or where a change in strata is noticed.

The contractor shall provide a suitable access to the bottom of the pits. Sampling in trial pits shall be done as directed by the Engineer.

The contractor shall be paid at contract unit price for each trial pit which will include all costs for earthwork in excavation with necessary side slope and backfilling and shoring/sheeting for side protection, if required. If the pits exceed over 3.5m in depth, the contractor shall be paid at unit price for the extra depths of excavation.

After completion of the test, sampling and visual examination, the pit shall be suitably backfilled as directed by the Engineer. Unless otherwise specified, excavated soil shall be used for this purpose.

#### 3.03.00      **Boring in River Bed**

For carrying out boring in river bed, the barge / boat should be properly anchored so that there is no movement of the platform due to waves which can cause damage to the drill rods and casing.

### 3.04.00 Rock Drilling

During boring operation, once rock strata is encountered, the normal method of boring operation as described under clause 3.01.00 earlier shall have to be stopped and drilling operation will be resorted to for determining depth and nature of rock strata, in a manner as described below.

Rotary core drilling technique with continuous core recovery should be adopted for drilling through rock. The tenderer shall indicate in his tender the type of coring bit he proposes to use. The behaviour of rock mass is governed more significantly by the nature of fractures in the rock than by the type and hardness of the material composing the rock itself. Hence, good drilling technique should be adopted to obtain an intact sample truly representative of the in-situ material and for achieving highest percentage of recovery possible. Variations in the speed of rotation, the downward pressure on the core barrel, the pressure at which the drilling fluid is introduced into the hole and the length of hole drilled (run length) prior to removal of the core are major items which must be controlled by the driller. In general, coring should be initiated with short runs both because the upper portions of rock masses are commonly highly fractured and also because the elevations at which core losses occur can be more accurately determined. If conditions indicate that it is possible, the length of the runs may be determined by the length of the core barrel.

In zones which are highly fractured or where the barrel continuously becomes blocked it is essential that short runs be used even though this means removal of the entire string of drilling tools every 300 mm or less. Reduced bit pressure should be resorted to when rod vibration or chatter occurs. The pressure under which the drilling fluid should be introduced into the hole will be the minimum to be consistent with adequate removal of cuttings from the hole and proper cooling of the bit. To minimise the erosive action of the drilling fluid on the core and thereby to improve core recovery, double tube core barrels should be used. The casing and core barrel to be used shall be of designation BX or NX.

During the drilling operation for each bore-hole the contractor shall record the rate of sinking of drill rods, ground water table elevations, if any, nature, type and sequence of rock drilled. From the recovered cores the contractor shall determine nature of fractures and degree of weathering of rock for each bore hole. The contractor shall also note and record any appreciable loss of drilling fluid throughout the entire drilling operations for each bore hole. The contractor shall also determine the percentage recovery ratio and rock quality designation from the recovered cores for each stages of core advance and for all the bore-holes. Rock quality designation is defined as the ratio of cumulative lengths of intact pieces of core greater than 10 cm to the length of core advance.

The contractor shall furnish all the information mentioned above fully verified and signed by the Engineer at site and submit them in triplicate to the Engineer.

The drilling operation shall be terminated when more than 75% of the core recovery is possible. If core recovery is lower and the nature of rock is weathered, drilling must be continued upto 30m for two bore holes and 20m for the remaining boreholes below the natural ground level.

In addition to the above mentioned points the contractor shall also take into consideration the provisions of the latest revisions of the following Codes of Practice :

- a) IS:6926 - Code of practice for diamond core drilling for site investigation for river valley projects (optional).
- b) IS:4078 - Code of Practice for indexing and storage of drill cores.
- c) IS:4464 - Code of Practice for presentation of drilling information and core description in foundation investigation.

### 3.05.00 **Adits and Test Shafts**

An exploratory adit is a horizontal or near horizontal excavation made by mining methods in rock. The term "test shaft" is used to refer to a vertical excavation, generally in rock and to very deep test pits. These are used for in-situ examination of the nature of the rock and its structural features such as joints, fractures, faults and shear zones. Adits may also be used for in-situ tests to determine the modulus of deformation of rock.

### 3.06.00 **Sampling**

Bored spoil shall be collected continuously during boring to note any change of strata. Samples of undisturbed soil shall be obtained preferably at every 1.5 m where a change in strata is indicated by the slurry flowing out. In no case shall the depth between successive sampling be more than 3.0 m and a sample shall be obtained on the average for every 2.0 m depth of boring, since it is intended to ascertain the characteristics of the soil at various depths. If, however, there is fair uniformity in the characteristics of the soil for certain depths the Engineer may limit the number of samples stipulated above.

#### 3.06.01 **Tube Sampling**

For obtaining undisturbed samples in its simplest form, an open drive thin wall tube sampler shall be attached to a rod and shall be lowered to the bottom after completely cleaning the borehole bottom by washing. The samplers to be used should have area ratio less than 13 percent and preferably less than 10 percent. The head should have check valve and ports to permit easy escape of drilling fluid or air from the sample tube as the sample enters it.

Sampling will be accomplished by jacking or driving the tube depending on the type of soil to be sampled. Upon completion of the sampling operation the sampler shall be withdrawn from the borehole and the sample of soil carefully taken out. Approximately one inch length of soil is to be removed from each end for identification. If there is any surface water on the sample, this shall be wiped off with soaking paper, all sludge or cuttings from advancement of borehole removed and the sample immediately packed in an airtight, close fitting container marked with respective test bore numbers, elevation at which the sample was taken and other relevant information as per IS:1892. The size of soil test samples shall preferably be 65 mm dia x 200 mm high, but not less than 50 mm dia. x 150 mm high.

Representative/disturbed samples shall also be taken in different strata for visual classification, water content, grain size analysis, Atterberg limits, determination of specific gravity and compaction tests.

### 3.06.02 **Chunk Samples**

In cohesive soils, undisturbed samples of regular shapes shall be collected. The samples shall be cut and trimmed to a suitable size (0.3 x 0.3 x 0.3 m). A square area (0.35 x 0.35 m) shall be marked at the centre of the levelled surface at the bottom of the pit. Without disturbing the soil inside the marked area, the soil around this marking shall be carefully removed upto a depth of 0.35 m. The four vertical faces of the soil block protruding at the centre shall be trimmed slowly so that its size reduced to 0.3 x 0.3 m. Wax paper cut to suitable size shall be wrapped uniformly and covered with two layers of thin cloth over all the 5 exposed surfaces of the soil block and sealed properly using molten wax. A firmly constructed wooden box of size 0.35m x 0.35m (internal dimensions) with the top and bottom open shall be placed around the soil block and held in such a manner that its top edge protrudes just above the surface of the block. The space between the soil block and the box shall be filled uniformly and tightly with moist saw dust. The top surface shall also be covered with saw dust before nailing the wooden lid to cover the box firmly taking care that the soil block is not disturbed. The area of contact between the bottom portion of the block and the ground shall be reduced slowly by removing soil in small quantities using small rods, so that the block can be separated from the ground slowly without disturbance. After inverting the wooden box along with the soil block, the bottom portion shall be trimmed and covered with wax paper, cloth and sealed with molten wax. A wooden lid shall be nailed to the box after providing proper saw dust cushion below it. An arrow mark shall be made on the vertical face of the wooden box to indicate the top surface along with the coordinates and depth of sampling.

### 3.06.03 **Sampling in rock**

Sampling in rock shall be accomplished during the drilling process by employing double tube core barrels for continuous core recovery. The drilling procedure to be followed should be the one which brings about the highest percent recovery and the exact procedure must be determined in the field.

### 3.07.00 **Record of Boring**

Detailed chronological record of drilling and sampling operations shall be maintained in the field log and should be submitted to the Owner after completion of boring work at site. The final log showing pertinent subsurface information and results of field and laboratory testing should be submitted with the soil report.

The field log should contain at least the following information :

- a) Reference information like project number, title and location, exploration number and location by coordinates, inclination of the boring and if inclined the bearing or azimuth of the dip of the hole, reference level and datum.

- b) Personnel information - name of drilling contractor, driller and inspecting Engineer.
- c) Equipment data - manufacturer's name and model designation.
- d) Sampling and coring information
  - i) General : Sample type and number, sampler dimension, depth at start and completion of sampling, length of sample, recovery ratio and complete visual description of each sample in "as retrieved" state.
  - ii) Drive samplers : weight and height of drop of hammer and number of blows for each 150 mm penetration.
  - iii) Push samplers : hydraulic pressure and rate of penetration.
  - iv) Soil or rock coring : average rotational speed, downward hydraulic pressure and rate of penetration.
  - v) Rock coring : Rock quality designation (R Q D)
- e) Description of material penetrated but not sampled.
- f) Casing information - size, depth at which required, length and depth of bottom of casing; weight and height of drop of hammer and number of blows for each 300 mm of penetration for driven casing, and average rotational speed and downward pressure on casing and average rate of penetration for drilled casing.
- g) Seepage pressure test information-depth and duration of test.
- h) Groundwater information - depth to water surface recorded daily and continued till water level has stabilized.
- i) Artesian pressure information - depth at which encountered, measured head and time at which each measurement is made.
- j) Elevation of top and bottom of hole and top of rock
- k) Date and time of all operations and delays with reasons.
- l) Miscellaneous information to aid interpretation of subsurface conditions.
- m) Additional pertinent information.

The final log shall be a condensation of the field log refined on the basis of field and laboratory tests. The final log should present a clear, concise and accurate picture of subsurface conditions to be utilized by the Engineer.

#### 4.00.00 **PENETRATION TESTS**

Penetration tests using various types of equipment as specified shall be conducted to measure the resistance of soil to penetration.

##### 4.01.00 **Standard Penetration Test**

Standard penetration test (SPT) shall be carried out in accordance with IS:2131 at every change in strata or at 1.5 m intervals or as directed by the Engineer. The contractor shall record the number of blows for each 150 mm penetration of the standard split spoon sampler over a depth of 450 mm. The number of blows for the first 150 mm of penetration shall not be considered in evaluating the penetration resistance. Rammer used for driving the sampler rod shall be 65 kg and drops of 750 mm shall be maintained. Records of the test including depth at which driving is initiated and the number of blows for each 150 mm penetration shall be shown in the field log, the final log shall indicate the actual SPT value (sum of number of blows for last 300 mm of penetration) at appropriate depths.

##### 4.02.00 **Static Cone Penetration Test**

The test shall be carried out at locations as shown on the drawing and/or at such other locations as directed by the Engineer. A steel cone with an apex angle of 60 deg. and overall base diameter of 35.7 mm giving a cross-sectional area of 10 Sq.cm shall be pushed through soil strata through a distance in accordance with the design of the equipment and cone resistance is noted. Thereafter the cone and the friction jacket with 36 mm OD are pushed together for a distance depending upon the design of the cone and the friction jacket assembly and combined values of cone and friction resistance noted. The procedure shall be repeated upto the desired depth. Rate of penetration shall be 1 cm/sec. unless otherwise instructed by the Engineer. The test shall be carried out upto a depth of ... m or upto the top of rock layer whichever is earlier.

The driving mechanism shall have a capacity of not less than 10 tonne for the mechanically operated equipment. If approved by the Engineer, manually operated equipment may be used for shallow depths (Not greater than 10 m) in case of soft clay layer.

The contractor shall get the dial and pressure gauges calibrated by an approved testing laboratory before commencing the actual test and produce the test certificates to the Engineer.

The test shall be carried out in accordance with IS:4968 (Part-III), latest edition. Cone resistance and frictional resistance shall be separately provided in the report together with a borehole log.

##### 4.03.00 **Dynamic Cone Penetration Test**

Dynamic cone penetration test shall be conducted to predict stratification, density, bearing capacity etc. of soils. The test shall be conducted by driving a standard size cone attached to the bottom of a string of drill rods. The test shall



be conducted upto the specified depth or terminated earlier if the number of blows exceeds 35 for 100 mm penetration when the cone is driven dry and 20 for 100 mm penetration when the cone is penetrated by circulating bentonite, in order to avoid damage to the equipment.

The specification for the equipment and accessories for performing this test, test procedure, field observations and reporting or results shall conform to IS:4968 Part - II. the driving system shall comprise of a 65 kg. drive mass having a free fall of 0.75m. The cone shall be of 62.5mm diameter provided with vents for continuous flow of bentonite slurry through the cane and rods in order to avoid friction between the rods and soil. The use of bentonite slurry may not be necessary when the investigation required is upto a depth of 6m only. On completion of the test, the results shall be presented as a continuous record of the number of blows required for every 300 mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300 mm penetration vs depth.

#### 5.00.00 **GROUNDWATER INVESTIGATION**

Groundwater investigation shall comprise determination of groundwater levels and pressures and permeability of subsurface materials. The effect of tidal variations (if applicable for the site) on ground water level shall also be observed by noting the water level in boreholes during high and low tide periods.

##### 5.01.00 **Ground Water Level Observation**

The contractor shall make necessary arrangements to prepare the boreholes for ground water observation. Completed boreholes should be capped and a G.I.pipe inserted in order to preserve them for future ground water observation. These observations will be taken by the contractor during the period of investigation. At the end of the site investigation work, these boreholes shall be handed over to the Owner in such a condition that further observations can be taken by the Owner for a period of at least a year.

Piezometers will have to be installed in boreholes as directed by the Owner. A piezometer consisting of either a simple standpipe of PVC tubing with a slotted end and surrounded by granular filter of plastic fabrics shall be used for granular soils or permeable rocks. In impermeable soils, hydraulic piezometer consisting of a porous element connected by twin small-bore plastic tubing to a remote reading station will be used.

##### 5.02.00 **In-Situ Permeability Test**

In-situ permeability test shall be performed in the ..... boreholes specified in drg. no. .... and/or at such other locations at specified depths as directed by the Engineer for determination of the permeability co-efficient of the soil. The type of test shall be either pump-in or pump-out test depending on the sub-soil and ground water conditions. Pump-in test shall be conducted whether ground water in the borehole exists or not. Pump-out test with piezometer installations shall be conducted to obtain data for dewatering purposes when ground water is met in the borehole.

The specification for the equipment required for the test and the procedure of testing shall be in accordance with IS:5529, Part-I. The contractor shall provide all necessary equipment (diesel operated). When it is required to carry out the permeability test for a particular section of the soil strata above the ground water table, bentonite slurry shall not be used while boring.

#### 5.02.01 **Pump-in Test**

Pump-in test shall be conducted in the borehole/trial pit by allowing water to percolate into the soil. Choice of the method of testing shall depend on the soil permeability and prevailing ground water level. Only clear water shall be used for conducting the test. Before conducting the test, the bore hole shall be cleaned. Water shall be allowed to percolate through the test section for sufficient period of time to saturate the soil before starting the observation.

##### a) **Constant Head Method (in borehole)**

This test shall be conducted in boreholes where soils have a high permeability. Water shall be allowed into the bore hole through a metering system ensuring gravity flow at constant head so as to maintain a steady water level in the bore hole. A reference mark shall be made at a convenient level which can be easily seen in the casing pipe to note down the fluctuations of water level. The fluctuations shall be counteracted by varying the quantity of water flowing into the bore hole. The elevation of water shall be observed at every 5 minute interval. When three consecutive readings show constant level of water surface above test depth, diameter of casing pipe, etc. shall be noted and recorded as per the proforma recommended in IS : 5529, Part-I, Appendix-A.

##### b) **Falling Head Method (in borehole)**

This method shall be adopted for soils of low permeability and which can stand without casing. The test section shall be sealed by the bottom of the boreholes and a packer at the top of test section. If the test has to be conducted at an intermediate section of prebored hole then, double packers shall be used. Access to the test section through the packer shall be by means of a pipe which shall extend to above the ground level. Water shall be filled into the pipe upto the level marked just below the top of the pipe and water allowed to drain into the test section. The water level in the pipe shall be recorded at regular intervals as mentioned in IS : 5529, Part-I, Appendix-B. The test shall be repeated till constant records of water level are achieved.

##### c) **Percolation test (in trial pit)**

Percolation test shall be conducted in the trial pit in areas where effluent is stored/discharged in ground level tanks. The loss of water due to percolation into the soil shall be estimated by the soil absorption capacity. This test shall be conducted in trial pits as per the procedure given in IS : 2470-Part-I, Appendix-A.

5.02.02      **Pump-Out Test**

This test shall be adopted to determine accurate values of permeability of soil below water table. Observation pipes of 50 mm dia shall be installed at regular intervals along three radial lines extending from the borehole at 120 degrees to each other. Length of these pipes shall depend on the ground level and estimated lowering of the ground water table. The test shall be carried out by pumping out the water to a known depth and recording the water levels in the observation pipes at regular intervals of time till the water level is stabilized. The observations shall be recorded as specified in IS : 5529, Part-I, Appendix-D.

6.00.00      **FIELD TESTS**

In situ tests shall be performed as desired by the Engineer to measure properties of soil during the field investigation work.

6.01.00      **Menard Pressuremeter Test**

This test shall be carried out as per clause 3.7 of IS:1892 in the..... bore holes specified in drg. no. .... and/or at such other locations as directed by the Engineer to the full depth of bore holes, to assess the co-efficient of earth pressure at rest and the stress-strain modulus of soil. The tests shall be carried out at every 3.0 m intervals.

The tenderer shall furnish in his tender the complete details of the equipment and method he proposes to follow.

The contractor will submit, for approval of the Engineer detailed arrangement drawings for the tests including the detail of the equipment he proposes to use and satisfy the Engineer about its adequacy. The contractor shall also check and confirm whether the equipment he proposes to use will be suitable for carrying out this test in bore holes of size specified under clause 3.01.00 of this section. If not, separate bore holes of suitable diameter shall be made at locations approved by Engineer for conducting this test.

6.02.00      **Direct Load Tests on Soils**

The direct load tests on soil shall be carried out in the trial pits specified in drg. no. .... and/or at such other locations as directed by the Engineer. This test is to be carried out at 2.5m/3.5m below the natural ground level as indicated in the above drawing/as directed by the Engineer. The plate sizes to be used shall depend on the nature of the soil, a 45 cm square plate will be used in clayey soil and in sandy soils, three plates of size varying between 30 cm to 75 cm will be used. The test shall be carried out in a manner as to give dependable assessment of bearing capacities of the soils at particular level. The results of the test shall also be used for arriving at the modulus of subgrade reaction and deformation modulus of soil.

The tenderer shall furnish in his tender the complete detail of the equipment and method he proposes to follow.

The excavation and side protection during the test and back- filling after the test shall be carried out by the contractor. If ground water table is at a depth higher than the specified test depth, the ground water table shall be lowered and maintained at the test depth for the entire duration of the test. The cost of dewatering shall be borne by the contractor.

The contractor will submit, for approval of the Engineer, a detailed arrangement drawing for the tests and satisfy the Engineer about its adequacy in respect of strength and safety and of its being capable of giving accurate data. However, the contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The contractor must get the dial and pressure gauges calibrated by an approved testing laboratory before commencing the direct load tests at the site and produce the certificates of the tests to the Engineer. There shall be adequate number of standby gauges available at the site for quick replacement of faulty gauges. The contractor shall bring not less than two dial gauges and one pressure gauge as standby.

In no case settlement observations by means of level and staff shall be accepted.

The tests shall be carried out as described in IS:1888 unless otherwise specifically directed. The application of load may be by gravity or by reaction as detailed out in the above standard.

The test plate shall be preloaded with a load of 700 Kg/ sq.m. retained for a reasonable period and then replaced to take out all slacks of the arrangement. All settlement observations shall start thereafter. Unless the ultimate bearing capacity can be calculated from the available soil data, the contractor shall assess ultimate bearing capacity of the soil under test. Increments of the load shall be of about one fifth of the ultimate bearing capacity. The increments shall continue to an extent that allows locating the 'Yield Value of the Soil' as defined in IS:1888 or upto practicable limit of testing.

While releasing the loads, the rebounds are to be observed in a similar manner as the settlement observations.

The observations shall be recorded directly in log books, proforma of which has to be approved by the Engineer, who shall also be present to check the data. The Engineer shall be notified well in advance of the detailed programme of the test and shall also be informed prior to start of releasing the load so that the total settlement can be checked by him.

In addition to carrying out plate load tests, undisturbed/disturbed soil samples shall also be collected at regular intervals during excavation.

The payment shall be lumpsum for each test and shall include all costs inclusive of earthwork in excavation upto 3.5m depth below natural ground level, shoring for side protection, if necessary, and back filling after the test. For the depths over 3.5m extra payments shall be made only for earthwork and shoring, if any. If water table is required to be lowered during the test, necessary diesel operated pumping arrangement will have to be provided by the contractor

himself. All expenses in this connection shall be included in his quoted rates.

**6.03.00 Vane shear Tests**

Vane shear test shall be conducted for measuring the strength of soft clay in-situ at all depths from the surface to at least 30m and at locations as specified. The test shall be conducted by pushing into the clay a small four-bladed vane of suitable size (75mm or 100 mm diameter depending upon the soil condition), attached to the end of a rod and then measuring the maximum torque necessary to cause rotation. This torque is a measure of the moment developed by the shear strength of the clay acting over the surface of the cylinder.

The test can be performed at desired depths either inside boreholes or by direct penetration from ground surface. If cuttings at the test depth in the bore hole show any presence of gravel, sand, shells, decomposed wood etc., which are likely to influence the test results, the test at that particular depth may be omitted with the permission of the Engineer.

The specification for the equipment and accessories required for performing this test procedure, field observations and reporting of results shall conform to IS:4434.

**6.04.00 Determination of Dry-Density of Soils**

In place dry density of soil is required for assessment of bearing capacity of soils, analysis for stability of natural slopes and in settlement calculations for estimating overburden pressure at different depths. The following methods depending on the scope of application in different types of soils shall be adopted as directed by the Engineer for determination of in-place dry density of soils.

**6.04.01 Sand Replacement Method**

This method is suitable for fine, medium and coarse grained soils. Small sand pouring cylinder should be used when the soil consists of fine to medium size grains while for soils containing stones where difficulties would be encountered with this method, a large sand pouring cylinder should be used. The sand used for filling shall be clean, uniformly graded natural sand, passing 1.00 mm IS sieve and retained on 600 micron IS sieve. It shall be free from organic matter, oven dried and stored for suitable period to allow its water content to reach equilibrium with atmospheric humidity.

Equipment and accessories, test procedure, observations and reporting of results shall conform to IS:2720 (Part XXVIII)

**6.04.02 Core-cutter Method**

The specification for this test shall be as per IS:2720 (Part XXIX) . The method should be applied for fine grained soil, free from aggregates . Fine grained soils for the purpose of application of this method is defined as soil with not less than 90 percent passing 4.75 mm IS sieve.

6.04.03      **Ring and Water Replacement Method**

The specification for equipment, test procedure, observation and reporting of results for this test shall conform to IS:2720 (Part XXXIII). The test equipment shall consist of a circular ring placed at the surface of the ground and plastic film inserted in the hole to retain the water. The method should be applied in coarse grained soils including gravels, cobbles, boulders and rock. Density can be determined for either the total material or material smaller than specified or given size.

6.04.04      **Rubber balloon Method**

The equipment, testing method, observations and reporting of results shall be as per IS:2720 (Part XXXIV) . This method should be applied for firmly bonded soils, it is unsuitable for very soft soils which will deform under slight pressure or in which the volume of the hole cannot be maintained at a constant value.

6.05.00      **In-situ Block Shear/Wedge Shear Test**

The test shall be carried out in a manner as to give a dependable assessment of shear resistance of rock, when at a shallow depth, rock is encountered.

The tenderer shall furnish in his tender the complete detail of the equipment and the method he proposes to follow.

The test shall be carried out in the trial pits marked in drg. no. and/or ..... at such other locations as directed by the Engineer. The interpretation of test data and report shall be as per the provisions of IS:7746. The set up without an arrangement for direct application of normal load as detailed in the above standard shall be followed.

Regarding the approval of detailed arrangement drawings for the test, adequacy of conducted test, dial gauges to be used for the test and recording of observations for the test the provisions as laid down for direct load tests on soils shall hold good.

The payment terms as indicated for clause 3.02.00 above shall hold good for this test.

6.06.00      **Test for Measurement of soil Resistivity**

For designing the earthing system for the project it is necessary to find out the electric resistivity of the soil at some representative locations of the project site.

Soil resistivity is determined in Ohmmeter by using "WENNER's FOUR ELECTRODE METHOD". The principle of the above method is generally as under :

Four electrodes are driven into the earth along a straight line at equal intervals of 'S'. This distance 'S' can be varied and different readings taken for electrode spacing  $S = 5, 10, 15, 20$  metres etc. to detect the vertical variations of resistivity at a certain location. A current  $I$  is passed through the two outer electrodes and the earth. The voltage difference,  $V$ , between the two inner

electrodes is measured. The current  $I$  flowing into the earth produces an electric field proportional to its density and to the resistivity of the soil. The voltage  $V$  measured between the inner electrodes is, therefore, proportional to this field. Consequently, the resistivity will be proportional to the ratio of voltage to current.

If the depth of burial of electrodes in the ground is negligible compared to the spacing between the electrodes, then the soil resistivity.

$$= 2 \times 3.14 \times S.V / I$$

Where, Resistivity of soil in Ohm-meter

$S$  = Spacing between electrodes in metre

$V$  = Voltage difference between two inner electrodes in volts.

$I$  = Current flowing through two outer electrodes in amp.

Earth testers normally used for the above purpose comprise the current source and meters in a single instrument and directly read the resistance. Such an instrument is known as four terminal meggar. Using such meggar for measurement, above formula becomes

$$= 2 \times 3.14 \times S.R.$$

where  $R$  is meggar reading in Ohms.

Depth of burial of electrodes shall not be more than  $1/20$  of the spacing between the electrodes.

Correction of the test results should be done, if necessary, using the method outlined in IS:3043.

The location and number of the test points are shown in the plant layout. The number shall be increased if the test results obtained in different locations show a significant difference.

7.00.00

## TESTS FOR DYNAMIC PROPERTIES

For evaluation of in-situ dynamic and damping properties of soils, Block Vibration Test, Cyclic Plate Load Test and Wave Propagation Test shall be conducted. The triaxial test method using repeated static loading should also be carried out for arriving at the value of the Young's Modulus.

The Tenderer shall furnish in his tender the complete details of the equipment and method of testing he proposes to follow.

The locations at which such tests are to be carried out are indicated in drg. no. .... and/or at such locations as directed by the Engineer. If the present formation level is above the natural ground level with filled-up soil, the depth of trial pits shall exclude such filled-up soil.

The tests shall be carried out as described in IS:5249 or IS:1888 as applicable. The contractor will submit, for approval of the Engineer, a detailed arrangement drawing for the tests and satisfy the Engineer about its adequacy in respect of strength and safety and of it being capable of giving accurate data. However, the contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The observations shall be recorded directly in log books, proforma of which has to be approved by the Engineer, who shall also be present to check the data. The Engineer shall be notified well in advance of the detailed programme of the test and shall also be informed prior to the start of releasing the load so that the total settlement can be checked by him.

The payment shall be lumpsum for each test and shall include all costs inclusive of earthwork in excavation, shoring for side protection (if necessary) construction/curing of plain concrete test block, supply and embedment of foundation bolts etc. and backfilling after the test.

#### 7.01.00 **Block Vibration Test**

Test pits of size 4.5m x 2.75m at the bottom shall have to be made. Then at the bottom of the pit a Plain Cement Concrete block of grade M15 and of size 1.5m x 0.75m x 0.70m shall be constructed. Suitable foundation bolts shall be embedded in the concrete block during casting for fixing the oscillator assembly. The concrete block shall be cured for a minimum of fifteen days and then the following Block Forced/Free vibration Test shall be carried out as per the recommendations of IS:5249 :

- a) Vertical Vibration Test
- b) Longitudinal Horizontal Vibration Test
- c) Free Vertical Vibration Test
- d) Horizontal Free Vibration Test.

#### 7.02.00 **Wave Propagation Test**

The wave propagation test for determination of shear modulus shall be conducted both by exciting the block to steady state vibrations in the vertical direction and by making seismic waves to pass through the ground by impact of hammer and determining the time of travel of these waves between two points at a known distance apart.

#### 7.03.00 **Cyclic Plate Load Test**

The test shall be carried out in a manner as to give a dependable assessment of load-deformation characteristics within the soil mass.

The provisions of IS:1888 shall be followed for conducting the test. The application of load may be by gravity or by reaction as detailed out in the above Standard.

The contractor must get the dial gauges and pressure gauges calibrated by an



approved testing laboratory before commencing the test at site and produce the certificates of the test to the Engineer. There shall be adequate number of standby gauges available at the site for quick replacement of faulty gauges. The contractor shall bring not less than two dial gauges and one pressure gauge as standby.

The contractor shall provide a layer of cement-sand mortar (1:1 mix) below the bearing plate to level-off any uneven parts and interstices on the rock surface. Also to achieve a uniform distribution of pressure over the loaded surface, the contractor shall provide a flexible layer in the form of rubber pad over the loaded surface.

For conducting the load test the contractor shall apply cyclic loading and unloading, with four or five cycles, increasing in successive of 20% to 25% of full load. While releasing the loads the rebounds to be observed in a similar manner as the settlement observations. The range of cyclic loading shall be decided only after the static net bearing capacity is established by conventional plate load tests.

#### 8.00.00 **FIELD DETERMINATION OF CALIFORNIA BEARING RATIO**

The test shall be carried out at locations as shown on the drawing or at locations as directed by the Engineer. The test shall be carried out at a depth of 500 mm below the finished ground level.

The contractor shall submit, for approval of the Engineer complete detail of the equipment and the method he proposes to use. However, the contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The surface area to be tested shall be exposed, cleaned of all loose and dried material, levelled and then soaked till saturation with a surcharge weight of 15 kg. After soaking is complete, the test surface shall be drained of all free water and allowed to stand for at least 15 minutes before starting further operations.

The test shall be carried out strictly in accordance with the provisions as laid down in IS:2720 (Part XXXI) latest edition. Surcharge weights of 15 kg including that of the annular weight of 5 kg shall be applied before application of load on the penetration piston. Load shall be applied on the penetration piston such that the penetration is approximately 1.25 mm/min. The load readings shall be recorded at penetrations of 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm. The maximum load and penetration shall be recorded if it occurs for a penetration of less than 12.5 mm.

After completion of the test, a sample of soil shall be taken from the point of penetration for moisture content determination. In place density shall also be determined.

From the plot of load penetration curve, after necessary correction, the bearing ratios shall be calculated for penetrations of 2.5 mm and 5 mm. If the bearing ratio at 2.5 mm penetration is greater than that at 5 mm penetration the former shall be taken as the bearing ratio. If bearing ratio at 2.5 mm penetration is less than that at 5 mm penetration, the test shall be repeated and if the ratio at 5

mm penetration is consistently greater than that at 2.5 mm penetration, the ratio at 5 mm penetration shall be taken.

9.00.00      **LABORATORY TESTS ON SOIL SAMPLES/ROCK CORES**

The contractor shall carry out the tests as listed out in the Schedule of Items, and/or as decided by the Engineer, in laboratory. He shall furnish the name/s of laboratories where he proposes to have the tests carried out and have them approved by the Engineer.

The Owner shall have the right of access to contractor's laboratory and/or any other laboratory where tests have been arranged to be carried out during the progress of this investigation.

Adequate volume of test samples of soil/rock cores shall have to be collected from site and stored, labelled and transported carefully to the approved laboratory for carrying out the tests. The method and procedure of testing to be followed shall be as per the relevant Indian Standard Codes of Practice. The results of the tests shall be submitted to the Engineer in sextuplicate duly signed by the laboratory-in-charge. In tests for rock cores L/D = 1.0 of samples must be maintained.

10.00.00      **REPORT ON SUB-SOIL INVESTIGATION**

10.01.00      **General**

- a) On completion of all the field and laboratory work, the contractor shall submit a formal report containing geological information of the region, procedure adopted for investigation, field observations, summarised test data, conclusion & recommendations. The report shall include detailed borelogs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, the supporting calculation for the conclusions drawn etc. Initially, the contractor shall submit ----- copies of the report in draft form for the Owner's review.
- b) The contractor's qualified geotechnical Engineer shall visit the Owner's corporate office for a detailed discussion on the Owner's comments on his draft report. During the discussions, it shall be decided as to the modifications that need to be done in the draft report. Thereafter the contractor shall incorporate in his report the agreed modifications and after getting the amended draft report approved, ----- copies of the detailed final report shall be submitted alongwith one set of reproducibles of the graphs, tables, etc.
- c) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different type of structures envisaged in the area under investigations. The contractor shall acquaint himself about the type of structures, foundations loads and other information required from the Engineer.

10.02.00      **Data to be furnished**

The report shall include the enlisted items but not be limited to them.

- a) Purpose and scope of investigation
- b) Authorization enabling the contractor to carry out the work at the site.
- c) Project description including proposed facilities and construction materials required for the works.
- d) Description of the site which shall include
  - i) Location of the site and existing facilities.
  - ii) Topography of the site
  - iii) Drainage Characteristics
- e) A plot plan showing the locations and reduced levels of all field tests e.g., boreholes, trial pits, static cone penetration tests, dynamic cone penetration tests, plate load tests etc., properly drawn to scale and dimensioned with reference to the established grid lines.
- f) A true cross section of all individual bore holes and trial pits with reduced levels and coordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted and samples collected at different depths and the rock stratum, if met with.
- g) A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how soil/rock strata is varying vertically and horizontally.
- h) **Geological information**
  - i) Regional geology - geologic province, topographic position of site, processes of formation of subsurface materials at site.
  - ii) Description of overburden and bedrock at the site (if applicable for the site)
  - iii) Comments on texture and structure of rock, joints, bedding planes, fissures, weathering condition etc. (if applicable for the site)
  - iv) Effect of geologic features on design.
- i) Past observations and historical data, if available, for the area or for other areas with similar profile or for similar structures in the nearby area.

- j) Bore hole & trial pit logs on standard proforma showing the depths, extent of various soil strata etc.
- k) Plot of SPT (N) value (both uncorrected and corrected) with depth.
- l) Procedure of investigations employed - field tests and laboratory investigation.
- m) Results of all laboratory test summarised (i) for each sample as well as (ii) for each layer along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores.
- n) For all triaxial shear tests stress vs strain diagrams as well as Mohr's circle envelopes shall be furnished. If back pressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity E shall be furnished for all tests along with relevant calculations.
- o) For all consolidation tests, the following curves shall be furnished:
  - e vs log p
  - e vs p and
  - compression vs log t or
  - Compression vs square root of t (depending upon the shape of the plot for proper determination of co-efficient of consolidation).
  - The point showing the initial conditions (e, P) of the soil shall be marked on the curves.
- p) The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements, if significant, shall also be calculated.
- q) For pressure meter tests, the following curves shall be furnished:
  - Field pressure meter, creep and air calibration curves indicating Po, Pf and P1.
  - Corrected pressure meter and creep curves indicating P'o, P'f & P'1.
- r) From the pressure meter test results the value of cohesion, angle of internal friction, pressure meter modulus, shear modulus and coefficient of subgrade reaction shall be furnished along with sample calculation. Calculation for allowable bearing pressures and corresponding total settlements, for shallow foundations mentioned below and capacity calculation of piles in various modes shall also be included.

### 10.03.00 Recommendations

Recommendations shall be given areawise duly considering the type of soil, structure and foundation in the area. The recommendations shall include but not be limited to the following :

- a) Type of foundations to be adopted for various structures, duly considering the sub soil characteristics, water table, total settlements permissible for structures and equipment. Minimum depth and width of foundation shall also be recommended. The provision in relevant IS codes indicated in clause 2.04.00 shall be considered.
- b) For shallow foundations, the following shall be indicated with comprehensive supporting calculations :
  - i) Net safe allowable bearing pressure for isolated square and continuous strip footings of different sizes at different founding depths below ground level considering both shear failure and settlement criteria, giving reasons for type of shear failure adopted in the calculation.
  - ii) Net safe allowable bearing pressure for mat foundations at different founding depths below ground level considering both shear failure and settlement criteria.
  - iii) Rate and magnitude of settlement expected of the structure.
  - iv) Modulus of subgrade reaction, modulus of elasticity, deformation modulus from plate load test results alongwith time-settlement and load- settlement curves for the various footing sizes at different founding levels indicated above. The recommended values shall include the effect of size, shape and depth of foundation.
- c) If piling is envisaged, the following shall be indicated with comprehensive supporting calculations.
  - i) Type of pile and reasons for recommending the same considering soil characteristics.
  - ii) Suitable founding strata for pile.
  - iii) Estimated length and diameter of pile for various values of pile capacities. End bearing and frictional resistance shall be indicated separately.
  - iv) Magnitude of negative skin friction, if any, to be considered in pile design.
- d) Recommendations on foundations for special structures like tanks, transformers, sub-station structures, conveyor trestles, silo/stack like structures, etc.

- e) Recommendations regarding bases of roads and pavements.

10.04.00 **Additional Recommendations**

- a) Coefficient of permeability of various sub soil and rock strata based on in-situ permeability tests.
- b) Cone resistance, frictional resistance, total resistance, relation between cone resistance and SPT(N) value and settlement analysis for different footing sizes based on CPT/SPT.
- c) Electricity resistivity of sub-soil based on electrical resistivity tests including electrode spacing vs cumulative resistivity curve.
- d) Evaluation of design parameters for design and analysis based on dynamic parameters of soil like Amplitude vs. Frequency curves, co-efficient of elastic uniform compression and elastic uniform shear of soil, co-efficient of elastic non-uniform compression, co-efficient of elastic non-uniform shear, value of damping co-efficient, elastic and shear modulus of soil and Poisson's ratio of soils.
- e) Coefficient of earth pressure at rest and stress strain modulus of soil from Menard pressuremeter test.
- f) Recommendations regarding earth pressure as a function of depth below grade as applied to side walls of underground structures. Values of co-efficient of permeability shall be included in the report.
- g) Recommendations regarding method and slope of deep excavations.
- h) Recommendations regarding stability of slopes, during excavations, etc.
- i) Potential of rock slides and methods of stabilisation of slides for very steep cut.
- j) If expansive soil is met with recommendation on removal or retainment of the same under the structures/roads etc. shall be given. In the latter case detailed specification of any special treatment required including specification for materials to be used, construction method, equipment to be deployed etc. shall be furnished.
- k) Susceptibility of sub soil strata to liquefaction in the event of earthquake and recommendation on remedial measures, if necessary.
- l) Information of special significance like dewatering schemes etc. which may have a bearing on design and construction.
- m) Aggressiveness of percolating water through sub-soil/ rock fissures to reinforced concrete foundation/sub-structures and also recommended protective measures, if required.

- n) Recommendation for the type of cement to be used and any treatment to the underground concrete structures based on the chemical composition of soil and sub-soil water.
- o) Recommendation on suitability of the overburden soil as material of construction of earthen embankments and in back filling of excavated pits/trenches.
- p) Recommendation on the use of rock available as construction material.
- q) Recommendation on the availability of material for use as aggregates at the site.
- r) Recommendation for additional investigation beyond the scope of the present work if the contractor considers it necessary.
- s) **Plates**
  - i) General plan showing location of site, and areal geology.
  - ii) Plan showing existing features, proposed facilities, contours and locations of boring and other investigations.
  - iii) Geologic sections and soil profiles.
- t) **Appendices**
  - i) Logs of subsurface explorations
  - ii) Field test results
  - iii) Laboratory test results

**SPECIFICATION NO. C-3**

**FOR**

**AREA GRADING**



**SPECIFICATION NO. C-3  
FOR  
AREA GRADING**

**C O N T E N T S**

<b>CLAUSE NO.</b>	<b>DESCRIPTION</b>	<b>PAGE NO.</b>
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**SPECIFICATION NO. C-3  
FOR  
AREA GRADING**

**1.00.00 SCOPE**

This specification shall govern all clearing, grubbing, excavating, area filling, grading and compacting soils for areas designated on the drawings. The work shall include excavation, blasting, if required, hauling, dumping and spreading of soil, undercutting to remove unstable soil areas, compacting existing soil surfaces and bottom of excavated areas to receive fills, compacting excavated areas for subgrade, placing and compacting soils in fills, pumping to keep excavated areas dry, final grading of designated areas, disposing off unsuitable and excess excavated materials and incidentals thereof.

**2.00.00 GENERAL**

**2.01.00 Work to be provided for by the Contractor**

The work to be provided for by the Contractor, unless specified otherwise, shall include but not be limited to the following :

- a) Furnish all labour, supervision, services, earth-moving machineries and equipment, tools and plants, survey instruments, transportation etc. required for the work.
- b) Prepare and submit working drawings showing the approaches, slopes, beams, sumps for dewatering, space for temporary stacking of spoils, disposal area, borrow pits, fencing etc. and all other details as may be required by the Engineer.
- c) To carry out and submit to the Engineer, results of soil compaction tests whenever required by the Engineer to assess the degree of compaction.
- d) If blasting is resorted to, necessary licenses to be procured from the proper authorities.

**2.02.00 Work to be provided for by others**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

However, the Owner reserves the right to award the whole work to one Contractor or to split up the work for awarding to two or more Contractors.

**2.03.00 Codes and Standards**

All work under this specification, unless specified otherwise, shall conform to the latest revision and/or replacements of the following or any other relevant Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not covered specifically by Indian Standard Specification any

other standard practice as may be specified by the Engineer shall be followed :

- IS-3764 : Indian Standard for Safety Code for Excavation Work.
- IS-1200 : Indian Standard Method of Measurement of Building (Part-I) and Civil Engineering Work Part-I - Earthwork.
- IS-4701 : Indian Standard Code of Practice for Earthwork on Canals.
- IS-4081 : Safety Code for Blasting and Related Drilling Operations.

#### 2.04.00 **Conformity with Designs**

The Contractor shall carry out the work as per the drawings issued to him and/or Contractor's drawings which are approved by the Engineer and/or the Engineer's instructions.

#### 2.05.00 **Materials to be used**

##### 2.05.01 **General**

All materials required for the work shall be of best commercial variety and as approved by the Engineer.

##### 2.05.02 **Borrow Material**

Borrow material required for area filling shall be excavated from approved locations and levels and shall consist of selected material, approved by the Engineer, free from roots, vegetation, decayed organic matter, harmful salts and chemicals, free from lumps and clods. If specified, clean graded sand, free from harmful and deleterious materials from approved quarries, shall be used as fill material.

#### 2.06.00 **Quality Control**

The Contractor shall establish and maintain quality control on the various aspects of the work, method, materials and equipment used. The quality control operation shall include but not be limited to the following items of work:

- a) Lines, Levels and Grades :
  - i) Periodic Surveys
  - ii) Establishment of markers, Boards etc.
  - iii) Checking levels and slopes of the graded surface.
- b) Area filling :
  - i) Checking the quality of fill material
  - ii) Checking moisture content of the fill
  - iii) Checking the degree of compaction.

2.07.00      **Information regarding Site Conditions**

Boring and sub-surface data regarding the nature of soil, rock, sub-soil water etc. shown on drawings or otherwise furnished to the Contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the Contract. The Contractor must satisfy himself regarding the character and volume of all work under this contract and expected surface, sub-surface and/or sub-soil water to be encountered. He must also satisfy himself about the general conditions of site and ascertain the existing and future construction likely to come up during the execution of the Contract so that he may evolve a realistic programme of execution.

3.00.00      **EXECUTION**

3.01.00      **Setting Out**

Within 15 days of award of Contract, the Contractor will prepare and submit to the Engineer, detailed drawings of the excavation and filling work necessary, as proposed to be executed by him, showing the dimensions as per drawings and specification, adding his proposals for slopes, approaches, dewatering sumps, beams etc. On receiving the approval from the Engineer with modifications and corrections if necessary, the Contractor will set out the work from the control points furnished by the Engineer and fix permanent points and markers for future checking. These permanent points and markers will be checked by the Engineer and certified by him after which the Contractor will proceed with the work. Engineer shall be provided with necessary men, material and instruments for such checking. It should be noted that this checking by the Engineer prior to start of the work will in no way absolve the Contractor of his responsibility of carrying out the work to true lines, levels and grades as per drawing and subsequent corrections, if any. In case any errors are noticed in the Contractor's work at any stage, the same shall be remedied by the Contractor at his own cost.

3.02.00      **Initial Levels**

Initial levels either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out. These initial levels will be used for preparing cross-sections for volume measurement or for cross-checking the depths obtained from tape measurements.

3.03.00      **Clearing and Grubbing etc.**

The area to be excavated shall be cleared out of fences, trees, logs, stumps, bush vegetation, rubbish, slush, etc. and levelled up. Trees upto 300 mm girth shall be uprooted. Trees above 300mm girth which are required to be cut, shall be got identified by the Engineer and then marked.

Felling of trees shall include taking out roots upto 600 mm below ground level. After the tree is cut and roots taken out, the pot-holes formed shall be filled with good earth in 250 mm layers and compacted to acceptable degree unless directed by the Engineer otherwise. The trees shall be cut in suitable pieces as instructed by the Engineer and then shall be transported to the Owner's store

or any other space as directed by the Engineer.

Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be burnt or removed from the site to approved disposal areas as may be specified. Ash shall be spread or removed as directed by the Engineer. Useful materials, saleable timber, firewood, etc. shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Engineer.

#### 3.04.00 **Classification**

Materials involved in earthwork shall be classified under the following categories. No distinction will be made whether the material is dry or wet. The Engineer's decision in regard to such classification shall be final and binding on the Contractor :

##### a) **Ordinary And Hard Soil**

This shall include clay, silt, sand, moorum, shingle, kankar, gravel, loam, peat, ash and other similar materials in soft, hard or dense state which can generally be excavated with ordinary spade, pick axe, shovel etc. and does not require the use of wedges, pneumatic breaking equipment and/or blasting for removal. It shall also include loose rock boulders present in the soil, with dimensions not exceeding 500 mm in any direction. Breaking of consolidated brick ballast and mud concrete shall be considered equivalent to excavation work under this type of soil.

##### b) **Soft and Decomposed Rock**

This shall include rocks like chalk, slate, mica schist, laterite and other similar materials which in the opinion of the Engineer is rock, but does not require blasting for removal and could be removed with picks, hammers, crow bars, wedges, pneumatic breaking equipment etc. It shall also include boulders with dimensions greater than 500 mm but not exceeding 1000 mm in any direction. The mere fact that the Contractor resorts to blasting for his own convenience shall not mean that the rock will be classified as hard rock.

Excavation in macadam and tarred roads and pathways, brick work etc. shall be considered at the same rate as excavation of this type of soil.

##### c) **Hard Rock**

This shall include rocks occurring in large masses which cannot be removed except by blasting. Harder varieties of rock such as trap, with or without veins and secondary mineral which in the opinion of the Engineer require blasting for removal shall also be considered as hard rock. It shall also include boulders bigger than 1000mm in any direction. Construction in concrete, both re-inforced and unreinforced, which is required to be dismantled during earthwork, shall be measured under this item, unless a separate provision is made in the schedule of Quantities for the same.

3.05.00 **Earthwork in Excavation**

3.05.01 **General**

All excavation shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Engineer shall be obtained by the Contractor, in each individual case, for the method he proposes to adopt for the excavations including dimension, side slopes, dewatering, disposal, etc.

This approval, however, shall not in any way make the Engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the Engineer.

The rough excavation may be carried upto a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the Engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the Engineer and the Contractor shall be paid for the extra excavation and the filling at the appropriate item rates.

If the excavation is done to a depth greater than that shown on the drawing, or directed by the Engineer, due to the Contractor's fault, the excess depth shall be filled up to the required level at the latter's cost with selected earth and compacted to 95% of modified Proctor Density or as directed by the Engineer.

The excavation shall be carried out as per the approved proposal, modified and corrected where necessary by the Engineer. The work shall be carried out in a workmanlike manner without endangering the safety of nearby structures or works roads, railway tracks, cables, pipelines etc. if any, and without causing hindrance to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the work will be checked by the Engineer thoroughly and the balance work will be carried out carefully to avoid any over-excavation.

On completion, the work will be finally checked and approved by the Engineer. In cases where excavation in soil, soft and decomposed rock and/or hard rock are involved, the soil or soft and decomposed rock layers, shall be removed by turn and levels of the underlying rock surfaces observed to enable measurements. Further work shall be resumed after getting clearance from the Engineer.

3.05.02 **Excavation in Hard Rock**

Overburden, if any, consisting of top soil, ordinary and hard soil, soft and decomposed rock as per classification of soil, which do not require blasting shall be completely stripped off and the levels of the hard rock surface shall be taken to enable measurement. Further work in hard rock shall be resumed after clearance from the Engineer.

Personnel deployed for rock excavations shall be protected from all hazards

such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is such that it is not stable against sliding, necessary supports, props, bracings or bulkheads shall be provided and maintained during the period of construction. Where danger exists of loose rock/boulder falling from the excavated surfaces deeper than 2 metres, steel mesh anchored to the lower edge of excavation and extending over and above the rock face, adequate to retain the dislodged material shall be provided and maintained.

In case where blasting, though otherwise required, is prohibited for any reasons, the excavation shall be carried out by chiselling, wedging or any other approved method. All loose or loosened rock in the sides shall be removed by barring, wedging, etc. The unit rate for excavation in hard rock shall include the cost of all these operations.

3.05.03 **Blasting**

3.05.04 **General**

Excavation shall be continued in hard rock to such widths, lengths, depths and profiles as are shown on the drawings or such other lines and grades as may be specified by the Engineer. As far as possible all blasting shall be completed prior to commencement of construction. At all stages of excavation, precautions shall be taken to preserve the rock below and beyond the lines for the excavation, in the soundest possible condition. The quantity and strength of explosive used, shall be such as will neither damage nor crack the rock outside the limits of excavation. All precautions, as directed by Engineer, shall be taken during the blasting operations and care shall be taken that no damage is caused to adjoining buildings or structure as a result of blasting operations. In case of damage to permanent or temporary structures, Contractor shall repair the same to the satisfaction of Engineer at his cost. As excavation approaches its final lines and levels, the depth of the charge holes and amount of explosives used shall be progressively and suitably reduced.

Unless otherwise stated herein, I.S. Specification IS:4081 "Safety Code for Blasting & Related Drilling Operation" shall be followed.

Specific permission of Engineer will have to be taken by Contractor for blasting rock and he shall also obtain a valid Blasting license from the authorities concerned.

Contractor shall obtain necessary license for storage of explosives, fuses and detonators issued to him from owner's stores or from supplier arranged by him, from the authorities dealing with explosives.

The fees, if any, required for obtaining such license, shall be borne by Contractor. Contractor shall have to make necessary storage facilities for the explosives etc. as per rules of local, State and Central Govt. authorities and statutory bodies/regulations.

In no case shall blasting be allowed closer than 30 metres to any structure or to locations where concrete has just been placed. In the latter case the concrete must be at least 7 days old.

Contractor shall employ a competent experienced supervisor and licensed blaster in-charge of each set of operation, who shall be held personally responsible to ensure that all safety regulations are carried out.

Before any blasting is carried out, Contractor shall intimate Engineer and obtain his approval in writing for resorting to such operations. He shall intimate the hours of firing charges, the nature of explosive to be used and the precautions taken for ensuring safety.

The blasting of rock near any existing buildings, equipments or any other property shall be done under cover and Contractor has to make all such necessary muffling arrangements. Covering may preferably be done by M.S. plates with adequate dead weight over them. Blasting shall be done with small charges and where directed by Engineer, a trench shall have to be cut by chiselling prior to the blasting operation separating the area under blasting from the existing structures.

When excavation has almost reached the desired level, hand trimming shall have to be done for dressing the surface to the desired level. Any rock excavation beyond an overbreak limit of 75 mm shall be filled up as instructed by Engineer, with concrete of strength not less than M 100. The cost of filling such excess depth shall be borne by Contractor and the excavation carried out beyond the limit specified above will not be paid for. Stepping in rock excavation shall be done by hand trimming.

Contractor shall be responsible for any accident to workmen, public or Owner's property due to blasting operations. Contractor shall also be responsible for strict observance of rules, laid by Inspector of Explosives, or any other authority duly constituted under the State and/or Union Government.

Storage, handling and use of explosives shall be governed by the current explosive rules laid down by the Central and the State Governments. The Contractor shall ensure that these rules are strictly adhered to. The following instruction, wherever found in variance with the above rules, shall be considered as superseded by the above rules.

No child under the age of 16 and no person who is in a State of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives.

#### 3.05.05 **Storage of Explosive**

Storage of explosives shall be governed by the current Explosive Rules, Explosives shall be stored in a clean, dry, well ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400 m of the actual work site or any source of fire. A space surrounding the magazine shall be fenced in. The ground inside the fence shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be by one gate only and no person shall be allowed inside this fence



without permission of the Officer-in-charge. The clear space between the fence and the magazine shall not be less than 90m. The magazine shall be perfectly well drained.

Two lightning conductors shall be provided to the magazine, one at each end. The lightning conductors shall be tested once in every year.

Fuses and detonators shall be stored in separate magazines. However, detonators can be kept in an annexe adjoining the magazine provided that their number does not exceed 25,000 and that the annexe is so constructed that not less than 60 cm masonry and 100 cm of air space shall intervene between any detonators in such annexe and the interior of the main magazine. Cases containing explosives are not to be opened in a magazine. Explosive in open cases are not to be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine, but must be removed without delay to a safe distance and destroyed.

Artificial light is not to be allowed in any magazine. No smoking shall be allowed within 100 m of a magazine.

Magazine shoes without nails shall be used while entering the magazine.

The mallets, levers, wedges etc. for opening barrels or cases are to be of wood. Inside a magazine the cases of explosives are to be carried by hand and shall not be rolled or dragged. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been longest in store are to be issued first.

Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides, special care is to be taken to keep the floor free from grains of powder or portions of explosive matter fallen on the floors due to leakage of cases etc.

The magazine shall not be opened during any dust storm or thunder-storm nor any person shall be allowed in the vicinity of the magazine.

All magazines shall be officially inspected at definite intervals and a record kept of the results of such inspections.

#### 3.05.06 **Carriage of Explosives**

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from the direct rays of the sun, naked lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each cage or package is to be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on a vehicle conveying explosives. No carriage or vessel shall be used for transporting explosives unless all iron or steel therein with which a package containing any explosive is likely to come in contact is effectually covered with lead, leather, wood, cloth or other suitable material. No lights shall be carried on the vehicle carrying explosives.

No operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

### 3.05.07 **Use of Explosives**

The Contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with the responsibilities imposed on him.

Holes for charging explosives shall be drilled with Pneumatic drills, the drilling pattern being so planned that the rock pieces after blasting will be suitable for handling.

The hole diameter shall be of such a size that cartridges can easily pass down them and undue force is not required during charging. Charging operations shall be carried out by or under the personal supervision of the shotfirer. Wrappings shall never be removed from explosive cartridges. Only wooden rods shall be used for loading and stemming shotholes. Only one cartridge at a time shall be inserted and gently passed home with the wooden tamping rod.

Only such quantities of explosives as are required for the particular amount of work to be done shall be brought to the works. Should any surplus remain when all the holes have been charged, it shall be carefully removed to a point at least 300 m from the firing point.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges the electric detonators shall be connected with the exploder through the shotfiring cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current and to keep the lead wires short circuited until ready to fire. Any Kinks in detonator leading wire shall be avoided.

For simultaneous firing of a large number of shotholes, use of cordtex may be done. Cordtex shall be initiated by an electric detonator attached to its side with adhesive tape, connecting wire or string.

All connections shall be made by the authorised shotfirer himself. The shotfiring cable shall not be dragged along the ground to avoid possible damage to the insulation. The shotfiring cable shall be tested for continuity and possible short circuiting before it is used each time.

The shotfirer shall always carry the exploder handle on his person until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits.

Before any blasting is carried out, it shall be ensured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300 metres radius from the firing point, or as required by statutory regulations, at least ten minutes before the time of firing by sounding a warning siren. The area shall be encircled by red flags.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations the authorised shotfirer shall return to the blast area and inspect carefully the work and satisfy himself that all charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole not less than 600mm from the misfired hole and by exploding a new charge. The authorised shotfirer shall be present during removal of the debris liable to contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until at least half an hour after firing.

Adequate safety precautions as per building bye-laws, safety code, statutory regulations etc. shall be taken during blasting operations.

#### 3.05.08 **Disposal**

The excavated spoils will be disposed off within the specified lead in any or a combination of some of the following manners, as directed by the Engineer :

- a) By stacking separately the materials suitable for area filling and materials not suitable.
- b) By stacking it temporarily for use in backfilling at a later date.
- c)
  - i) By either spreading or
  - ii) Spreading and compacting at designated disposal areas.
- d) By selecting the useful material and stacking it neatly in areas designated by the Engineer for use in back-filling or other purposes by some other agency.

The rate for excavation in soil should include the cost of filling and compaction in case (c) (ii). The rate for excavation in rock should include the cost of disposal as per (d).

#### 3.05.09 **Dewatering**

All areas shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove by pumping or other means approved by the Engineer, any water inclusive of rain water and subsoil water accumulated in the area without any extra cost. Method of dewatering shall be got approved by the Engineer.

#### 3.06.00 **Treatment of Slips**

The Contractor will take all precautions to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides. These precautions along with proper slopes, beams & control of ground water should cause no slips to occur. If however slips do occur due to causes beyond control of the Contractor, the same shall be removed by him and payment shall be made to him on appropriate item rate of earthwork. Slips caused due to negligence of the Contractor will be cleared and backfilled later by him at his own expenses.

3.07.00      **Earthwork in Filling**

3.07.01      **Area Filling for Grading**

The material to be used for area filling shall be selected material, approved by the Engineer, obtained directly from excavation for area grading, from nearby areas where excavation work by the same agency is in progress, from temporary stacks of excavated spoils or from borrow pits in selected areas designated by the Engineer. The quality of the material shall conform to that mentioned in clause 2.5.2 of this specification.

Where excavated material is mostly rock, the boulders shall be broken into pieces not longer than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill up the voids and the mixtures used for filling.

If any material is rejected by the Engineer, Contractor shall remove the same forthwith from the site at no extra cost of the owner. Surplus fill material shall be deposited/disposed off as directed by the Engineer after the fill work is completed.

No earthfill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by the Engineer.

Before commencement of area filling the existing top soil shall be removed upto a minimum depth of 150 mm, or more, as directed by the Engineer in order to clear the surface of undesirable materials. After this the filling operation shall be performed with earth in layers not exceeding 250 mm, loose thickness. Each layer shall be watered and properly compacted to 95% of modified Proctor Density unless otherwise permitted/directed by the Engineer. Earth shall be compacted with approved machine and usually manual compaction shall not be allowed unless specifically permitted by the Engineer.

Since the degree of compaction depends on the moisture content of the soil, a close watch shall be kept on this aspect and corrections done to optimise the moisture content. The adequacy of the compaction and moisture control of the soil shall be determined by performing field density tests and other tests as and when directed by the Engineer and shall conform to the stipulations laid down in IS:4701.

Field compaction test shall be carried out at different stages of filling and also after the fill to the entire height has been completed. This shall hold good for embankments as well.

The fill shall be carried out to such dimensions and levels as indicated on the drawings after the stipulated compaction. The fill will be considered as incomplete if the desired compaction has not been obtained.

If so specified, the rock as obtained from excavation may be used for filling and levelling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cms. approximately. After rock filling to the approximate level, indicated above has been carried out, the void in the

rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12 tonne roller. No less than 12 passes of the roller shall be accepted before subsequent similar operations are taken up.

#### 3.07.02 **Filling in Disposal Areas**

Excavated materials if not used in area filling, will be disposed off in designated disposal areas as directed or as indicated in the drawings. The earth shall not be dumped haphazardly but shall be spread in horizontal layers not exceeding 500 mm in thickness and nominal compaction done to the satisfaction of the Engineer. All clods shall be broken before placing the fill. Earthmoving machinery including dumpers, dozers and trucks shall be allowed to ply over the fill to permit compaction to take place.

In wide areas rollers may be employed and nominal compaction done to the satisfaction of the Engineer. No payment for compaction shall be made for such nominal compaction.

#### 3.08.00 **Approaches and Fencing**

The Contractor shall provide and maintain proper approaches for workmen and for inspection. The roads and approaches around the area shall be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the Project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress, if directed by the Engineer.

#### 3.09.00 **Lighting**

Full scale area lighting is to be provided if night work is permitted or directed by the Engineer. Even if no night work is in progress, red warning lights should be provided at the top in edges of the excavated area and the edges of the fill, unless otherwise permitted by the Engineer.

### 4.00.00 **TESTING AND ACCEPTANCE CRITERIA**

#### 4.01.00 **Excavation**

On completion of excavation, the dimensions of the area will be checked as per the drawings after the area is completely dewatered.

The work will be accepted after all undercuts have been set right and all over excavations filled back to required lines, levels and grades by compacted earth, at the Contractor's cost.

Over excavation of the sides will be made good free of cost by the Contractor. The excavation work will be accepted after the above requirements are fulfilled & all temporary approaches encroaching inside the required dimension of the excavation have been removed.

4.02.00      **Area-filling**

The degree of compaction required will be as per the stipulations laid down in appropriate sections of this specification. The actual method for measuring the compaction achieved will be as decided by the Engineer. The work of area filling will be accepted after the Engineer is satisfied with the degree of compaction achieved.

5.00.00      **INFORMATION TO BE SUBMITTED**

5.01.00      **With Tender**

Following details of Machineries, transport vehicles, equipment proposed to be used for excavation, area-filling and compaction have to be submitted along with the tender :

- i)      Equipment, machinery & earthmoving vehicles, available with the Contractor and proposed to be used for excavation and haulage giving details regarding make, model, capacity, year of manufacture, numbers available for this contract and general condition.
- ii)     Equipment proposed to be used for area filling and compaction giving similar details as in item 5.1.0 (i) above.
- iii)    Method of transportation.

5.02.00      **After Award**

After award of contract the successful tenderer shall submit the following for approval and adoption :

- a)      Within 15 days of Award of the contract, the Contractor shall submit a detailed programme of work as proposed to be executed giving completion dates of excavation of the various areas and the time required for area-filling and compaction. The programme should also show how the excavation and area-filling quantities will be balanced, minimising temporary stacking of spoils. It is to be noted that the Engineer even after initial approval of the programme, may instruct to enhance or retard the progress of work during the actual execution, in order to match with overall construction schedule without attracting any claims from the Contractor. The initial programme being submitted by the Contractor should have sufficient flexibility to take care of such reasonable variations.
- b)      Within 15 days of award, the Contractor shall submit drawings showing details of slopes, approaches, sump pits, dewatering lines, borrow pits, if any, fencing etc. for approval of the Engineer for adoption.

**SPECIFICATION NO. C-4**

**FOR**

**EARTHWORK IN EXCAVATION  
AND BACKFILLING**

**SPECIFICATION NO. C-4  
FOR  
EARTHWORK IN EXCAVATION AND BACKFILLING**

**C O N T E N T S**

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**SPECIFICATION NO. C-4  
FOR  
EARTHWORK IN EXCAVATION AND BACKFILLING**

**1.00.00 SCOPE**

This specification covers excavation in all types of soil, soft and decomposed rock not requiring blasting and rocks requiring blasting, shoring, dewatering, filling around foundations and to grade, compaction of fills and approaches, protective fencing, lighting, etc. relevant to structures and locations covered under the scope of this contract.

**2.00.00 GENERAL**

**2.01.00 Work to be provided for by the Contractor**

The work to be provided for by the Contractor, unless specified otherwise, shall include but not be limited to the following :

- a) Furnish all labour, supervision, services including facilities as required under statutory labour regulations, materials, scaffolds, equipment, tools and plants, transportation, etc. required for the work.
- b) Prepare and submit working drawings showing the approaches, slopes, beams, shoring, sumps for dewatering, including drains and outfall for drainage, space for temporary stacking of spoils, disposal area, fencing, etc. and all other details as may be required by the Engineer.
- c) To carry out sampling and testing and submit to the Engineer, results of soil compaction tests if required by the Engineer to assess the degree of compaction.
- d) Construction, maintenance and removal after completion of Magazine of proper capacity as well as design for storing of explosives required for blasting work to be carried out under the scope of this tender.

**2.02.00 Work to be provided for by others**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

**2.03.00 Codes and Standards**

All works under this specification, unless specified otherwise, shall conform to the latest revision and/or replacement of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not covered specifically by Indian Standard Specification any other standard practice as may be specified by the Engineer shall be followed :-

IS:3764 : Indian Standard for Safety Code for Excavation work

- IS:1200 : Indian Standard Method of Measurement of Building and (Part-I)Civil Engineering work, Part-I : Earthwork.
- IS:4701 : Indian Standard Code of Practice for Earthwork on Canals.

2.04.00 **Conformity with Designs**

The Contractor is to carry out the work as per the drawings issued to him and/or Contractor's drawings which are approved by the Engineer and/or the Engineer's instructions.

2.05.00 **Materials to be used**

2.05.01 **General**

All materials required for the work shall be of best commercial variety and approved by the Engineer.

2.05.02 **Borrow Material**

Borrow material required for back-filling shall be excavated from approved locations and levels and shall consist of material, approved by the Engineer, free from roots, vegetation, decayed organic matter, harmful salts and chemicals, free from lumps and clods. If specified, clean graded sand free from harmful and deleterious material from approved quarries, shall be used as fill material.

2.06.00 **Quality Control**

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. The quality control operation shall include but not be limited to the following items of work-

- a) Lines, Levels and Grades :
  - i) Periodic surveys
  - ii) Establishment of markers, boards etc.
- b) Back-filling :
  - i) Checking the quality of fill material
  - ii) Checking moisture content of the backfill
  - iii) Checking the degree of compaction

3.00.00      **EXECUTION**

3.01.00      **Setting Out**

Within 15 days of award of Contract, the Contractor will prepare and submit to the Engineer, detailed drawings of the excavation work as proposed to be executed by him showing the dimensions as per drawings and specification adding his proposals of slopes, shorings, approaches, dewatering sumps, beams, etc. On receiving the approval from the Engineer with modifications and corrections, if necessary, the Contractor will set out the work from the control points furnished by the Engineer and fix permanent points and markers for ease of future checking. These permanent points and markers will be fixed at intervals prescribed by the Engineer and checked by the Engineer and certified by him after which the Contractor will proceed with the work. It should be noted that this checking by the Engineer prior to start of the work will in no way absolve the Contractor of his responsibility of carrying out the work to true lines and levels and grades as per drawing and subsequent corrections, if necessary, shall be made free of cost to the Owner in case any errors are noticed in the Contractor's work at any stage.

3.02.00      **Initial Levels**

Initial levels of the ground either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out. These initial levels will be used for preparing cross-sections for volume measurement or for cross-checking the depths obtained from tape measurements.

All records of levels, measurements etc. and also any drawing, cross section etc. made therefrom, shall be jointly signed by the authorised representative of the contractor and the engineer before the commencement of work and they shall form the basis of all payments in future.

3.03.00      **Clearing and Grubbing, etc.**

The area to be excavated shall be cleared out of fences, trees, logs, stumps, bush, vegetation, rubbish, slush, etc. and levelled up. Trees upto 300mm girth shall be uprooted. Trees above 300mm girth to be cut, shall be approved by the Engineer and then marked. Felling of trees shall include taking out roots upto 600mm below ground level or 150mm below formation level whichever is lower. After the tree is cut and roots taken out the pot-holes formed shall be filled with good earth in 250mm layers and consolidated unless directed by the Engineer otherwise. The trees shall be cut in suitable pieces as instructed by the Engineer.

Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be burned or removed from the site to approved disposal areas as may be specified. Ash shall be spread or removed. Useful materials, saleable timber, firewood, etc. shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Engineer.

3.04.00      **Classification**

All earthwork shall be classified under the following categories :

a)      Ordinary Soil

This shall comprise vegetable or organic soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick and shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having diameter in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

b)      Hard Soil

This shall include :

- i)      Stiff heavy clay, hard shale, or compact moorum requiring grafting tool or pick or both and shovel, closely applied ;
- ii)      Gravel and cobble stone having maximum diameter in any one direction between 75 and 300 mm ;
- iii)      Soling of roads, paths, etc., and hard core ;
- iv)      Macadam surfaces such as water bound, and bitumen/tar bound;
- v)      Lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar, below ground level ;
- vi)      Soft conglomerate, where the stones may be detached from the matrix with picks ; and
- vii)      Generally any material which requires the close application of picks, or scarifiers to loosen and not affording resistance to digging greater than the hardest of any soil mentioned in (i) and (vi) above.

c)      Soft and Decomposed Rock

This shall include :

- i)      Limestone, sandstone, laterite, hard conglomerate or other soft or disintegrated rock which may be quarried or split with crowbars ;
- ii)      Unreinforced cement concrete which may be broken up with crowbars or picks and stone masonry in cement mortar below ground level ;

- iii) Boulders which do not require blasting having maximum diameter in any direction of more than 300 mm, found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin; and
  - iv) Any rock which in dry state may be hard, requiring blasting, but which when wet becomes soft and manageable by means other than blasting.
- d) Hard Rock (requiring blasting)
- This shall include :
- i) Any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required ;
  - ii) Reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and
  - iii) Boulders requiring blasting.
- e) Hard Rock (blasting prohibited)
- Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.
- In case of any dispute regarding classification, the decision of the Engineer shall be final.

### 3.05.00 **Excavation for Foundations and Trenches**

#### 3.05.01 **General**

All excavations shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Engineer shall be obtained by the Contractor, in each individual case, for the method he proposes to adopt for the excavations including dimension, side slopes, shoring, dewatering, disposal, etc. This approval, however, shall not in any way make the Engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner.

All excavation in open cuts shall be made true to line, slopes and grades shown on the drawing or directed by the Engineer. No material shall project within the dimension of minimum excavation lines marked. Boulders projecting out of the excavated surfaces shall be removed, if in the opinion of the Engineer they are likely to be a hindrance to the workers.

Method of excavation shall be in every case subject to the approval of the Engineer and the Contractor shall ensure the stability and safety of the excavation, adjacent structures, services and works.

The Contractor shall have full responsibility of the stability of the excavation and safety of the workmen. If any slip occurs, the Contractor shall remove all slipped material from the excavated pit.

All loose boulders, semi-detached rocks, not directly in excavation but so close to the area to be excavated as to be liable, in the opinion of the Engineer, to fall or otherwise endanger the workmen, equipment of the work, etc., shall be stripped off and removed away from the areas of excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe. Any materials not requiring removal as contemplated in the work, but which, in the opinion of the Engineer, is later to become loose or unstable shall also be promptly and satisfactorily removed as directed by the Engineer.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the Engineer.

The rough excavation may be carried upto a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the Engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the Engineer and the Contractor shall be paid for the extra excavation and the filling at the appropriate item rates.

If the excavation is done to a depth greater than that shown on the drawing, or directed by the Engineer, due to the Contractor's fault, the excess depth shall be filled up to the required level at the latter's cost (with cement concrete not leaner than 1:4:8 ordinary concrete or richer) as directed by the Engineer in each individual case.

In formation of rock requiring blasting, those overcuts which are unavoidable will be made up by ordinary cement concrete 1:2:4 which will be paid for under appropriate rate, provided this overcut is not due to negligence of the Contractor. The decision of the Engineer as to the admissibility of such overcut for payment will be final. All excavated materials such as hard rock, boulders, bricks, dismantled concrete blocks, etc. shall be stacked separately as directed by the Engineer and shall be the property of the Owner.

### 3.05.02 **Excavation in Ordinary Soil, Hard Soil and Soft and Decomposed Rock**

The excavation in ordinary soil, hard soil, soft and decomposed rock will be carried out as per the approved proposal, modified and corrected where necessary by the Engineer. The work will be carried out in a workmanlike manner without endangering the safety of nearby structures/services or works and without causing hindrance to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the work will be checked by the Engineer thoroughly and the balance work will be carried out carefully to avoid any over-excavation. On completion, the work will be finally checked and approved by the Engineer. In certain cases, where deterioration of the ground, upheaval, slips, etc. are expected, the Engineer may order to suspend the work at any stage and instruct the Contractor to carry out the balance work just before the foundation work of the structure can be started. No extra will be paid to the Contractor for such unavoidable temporary suspension of work.

3.05.03      **Excavation in Hard Rock**

In case where excavation, both in ordinary soil and hard rock, are involved, the ordinary soil comprising of soft, hard and dense soils (including laterite formations) and rock including weathered rocks, lateritic rocks, etc. which can be excavated without blasting, shall be completely stripped off and the levels of the hard rock surface shall be taken to enable measurements. Further work in hard rock shall be resumed after clearance from the Engineer.

Personnel deployed for rock excavations shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is such that it is not stable against sliding, necessary supports, props, bracings or bulkheads shall be provided and maintained during the period of construction. Where danger exists of loose rock/boulder falling from the excavated surfaces deeper than 2 metres, steel mesh anchored to the lower edge of excavation and extending over and above the rock face, adequate to retain the dislodged material shall be provided and maintained.

In case where blasting, though otherwise required, is prohibited for any reasons, the excavation shall be carried out by chiselling, wedging or any other approved method and payment appropriate to blasting shall be made, unless otherwise mentioned in the Schedule.

3.05.04      **Blasting**

3.05.04      a)      **General**

Storage, handling and use of explosives shall be governed by the current explosive rules laid down by the Central and the State Governments. The Contractor shall ensure that these rules are strictly adhered to. The following instruction, wherever found in variance with the above rules, shall be considered as superseded by the above rules.

No child under the age of 16 and no person who is in a State of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives.

b)      **Storage of Explosive**

Storage of explosives shall be governed by the current Explosive Rules, Explosives shall be stored in a clean, dry, well ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400 m of the actual work site or any source of fire. A space surrounding the magazine shall be fenced in. The ground inside the fence shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be by one gate only and no person shall be allowed inside this fence without permission of the Officer-in-Charge. The clear space between the fence and the magazine shall not be less than 90m. The magazine shall be perfectly well drained.

Two lightning conductors shall be provided to the magazine, one at each end. The lightning conductors shall be tested once in every year.

Fuses and detonators shall be stored in separate magazines. However, detonators can be kept in an annexe adjoining the magazine provided that their number does not exceed 25,000 and that the annexe is so constructed that not less than 60 cm masonry and 100 cm of air space shall intervene between any detonators in such annexe and the interior of the main magazine. Cases containing explosives are not to be opened in a magazine. Explosive in open cases are not to be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine, but must be removed without delay to a safe distance and destroyed.

Artificial light is not to be allowed in any magazine. No smoking shall be allowed within 100 m of a magazine.

Magazine shoes without nails shall be used while entering the magazine.

The mallets, levers, wedges etc. for opening barrels or cases are to be of wood. Inside a magazine the cases of explosives are to be carried by hand and shall not be rolled or dragged. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been longest in store are to be issued first.

Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides, special care is to be taken to keep the floor free from grains of powder or portions of explosive matter fallen on the floors due to leakage of cases etc.

The magazine shall not be opened during any duststorm or thunderstorm nor any person shall be allowed in the vicinity of the magazine.

All magazines shall be officially inspected at definite intervals and a record kept of the results of such inspections.

c) **Carriage of Explosives**

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from the direct rays of the sun, naked lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each cage or package is to be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on a vehicle conveying explosives. No carriage or vessel shall be used for transporting explosives unless all iron or steel therein with which a package containing any explosive is likely to come in contact is effectually covered with lead, leather, wood, cloth or other suitable material. No lights shall be carried on the vehicle carrying explosives.



No operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

d) **Use of Explosives**

The Contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with the responsibilities imposed on him.

Holes for charging explosives shall be drilled with Pneumatic drills, the drilling pattern being so planned that the rock pieces after blasting will be suitable for handling.

The hole diameter shall be of such a size that cartridges can easily pass down them and undue force is not required during charging. Charging operations shall be carried out by or under the personal supervision of the shotfirer. Wrappings shall never be removed from explosive cartridges. Only wooden rods shall be used for loading and stemming shotholes. Only one cartridge at a time shall be inserted and gently passed home with the wooden tamping rod.

Only such quantities of explosives as are required for the particular amount of work to be done shall be brought to the works. Should any surplus remain when all the holes have been charged, it shall be carefully removed to a point at least 300 m from the firing point.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges the electric detonators shall be connected with the exploder through the shotfiring cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current and to keep the lead wires short circuited until ready to fire. Any Kinks in detonator leading wire shall be avoided.

For simultaneous firing of a large number of shotholes, use of cordtex may be done. Cordtex shall be initiated by an electric detonator attached to its side with adhesive tape, connecting wire or string.

All connections shall be made by the authorised shotfirer himself. The shotfiring cable shall not be dragged along the ground to avoid possible damage to the insulation. The shotfiring cable shall be tested for continuity and possible short circuiting before it is used each time.

The shotfirer shall always carry the exploder handle on his person until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits.

Blasting shall only be carried out at certain specified times to be agreed jointly by the contractor and the Engineer.

Before any blasting is carried out, it shall be ensured that all workmen,

vehicles and equipment on the site are cleared from an area of minimum 300 metres radius from the firing point, or as required by statutory regulations, at least ten minutes before the time of firing by sounding a warning siren. The area shall be encircled by red flags.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations the authorised shotfirer shall return to the blast area and inspect carefully the work and satisfy himself that all charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole not less than 600 mm from the misfired hole and by exploding a new charge. The authorised shotfirer shall be present during removal of the debris liable to contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until at least half an hour after firing.

When blasting is conducted in the neighbourhood of roads, structures, buildings etc. controlled blasting has to be carried out by drilling shallow shotholes and filling the same with light charge of explosives.

Adequate safety precautions as per building bye-laws, safety code, statutory regulations etc. shall be taken during blasting operations.

#### 3.05.05 **Disposal**

The excavated spoils will be disposed off in any or all the following manners :-

- a) By using it for backfilling straightway.
- b) By stacking it temporarily for use in backfilling at a later date during execution of the Contract.
- c)
  - i) By either spreading, Or
  - ii) Spreading and compacting at designated disposal areas.
- d) By selecting the useful material and stacking it neatly in areas designated by the Engineer for use in backfilling by some other agency.

#### 3.05.06 **Disposal of Surplus**

All surplus material from excavation shall be carried away from the excavation site to designated disposal area selected by the Engineer.

All good and sound rock excavated from the pits and all assorted materials of dismantled structures shall be the property of the Owner and if the Contractor wants to use it, he shall have to obtain it from the Engineer at a mutually agreed rate for the same.

All sound rock and other assorted materials like excavated bricks, etc. shall be stacked separately and shall be measured in stacks deducting 30% volumetric measure for voids.

#### 3.05.07 **Protection**

The Engineer shall be notified by the Contractor as soon as the excavation is expected to be completed within a day so that it may be inspected by him at the earliest. Immediately after approval of the Engineer, the excavation must be covered up in the shortest possible time. But, in no case the excavation shall be covered up or worked on before approval and measurement by the Engineer. Excavated material shall be placed beyond 1.5 metres from the edge of the pit or trench or half the depth of the pit or trench whichever is more or further away if directed by the Engineer.

Excavation shall not be carried out below the foundation level of structure close by until required precautions have been taken.

Adequate fencing is to be made enclosing the excavation.

The Contractor shall protect all under-ground services exposed by excavation. The Contractor shall also divert all surface drains, etc. affected by the excavation to maintain the working area neat and clean.

#### 3.05.08 **Dewatering**

All excavations shall be kept free of water and slush. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove by pumping or other means approved by the Engineer any water inclusive of rain water and subsoil water accumulated in excavation & keep the trench dewatered until the construction of foundation structure and backfilling are complete in all respects. (except where such dewatering would need installation of well points or deep wells for which separate payment will be made) Sumps made for dewatering must be kept clear of the foundations. Method of pumping shall be approved by the Engineer but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping.

If necessary, the Engineer may direct the Contractor to continue dewatering beyond his original or extended contract period in which case he will be paid separately for dewatering as per terms mentioned elsewhere under payment and measurement, provided the Contractor has completed all the work satisfactorily.

#### 3.05.09 **Timber Shoring**

Timber Shoring made out of approved quality of timber shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench and the type of timbering shall be determined by the Engineer. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of trenches and pits from collapsing.

##### a) **Close Timbering**

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. These shall be of minimum 250 x 40 mm sections as directed

by the Engineer. The boards shall generally be placed in position vertically in pairs, one board on each side of cutting, and shall be kept apart by horizontal walers of strong wood at maximum 1.2 metres spacings, cross strutted with ballies or as directed by the Engineer. The length of the bally struts shall depend on the width of the trench or pit.

In case where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical walers, which shall be strutted to similar timber pieces on the opposite face of the trench or pit. The lowest board supporting the sides shall be taken into the ground. No portion of the vertical side of the trench or pit shall remain exposed, so that the earth is not liable to slip out.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.

b) **Open Timbering**

In the case of open timbering, the entire surface of the side of trench pit is not required to be covered. The vertical board of minimum 250 mm width and minimum 40 mm depth shall be spaced sufficiently apart to leave unsupported strips of maximum 500 mm average width. The detailed arrangement, sizes of the timber and the distances apart shall be subject to the approval of the Engineer. In all other respects, specification for close timbering shall apply to open timbering.

3.06.00 **Treatment of Slips**

The Contractor will take all precaution to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides. These precautions along with proper slopes, beams, shoring and control of ground water should cause no slips to occur. If however slips do occur due to causes beyond the control of the Contractor, the same shall be removed by him and payment shall be made to him on appropriate item rate of earthwork. Slips caused due to negligence of the Contractor will be cleared and back-filled later by him at his own expenses.

3.07.00 **Back-filling**

3.07.01 **General**

The material used for backfilling shall consist of material, approved by the Engineer obtained directly from nearby areas where excavation work by the same agency is in progress, from temporary stacks of excavated spoils or from borrow pits from selected areas designated by the Engineer. The material shall be free from lumps and clods, roots and vegetation, harmful salts and chemicals, organic materials, etc.

In certain locations, the Engineer may direct sand fillings. The sand should be clean, well graded and be of quality normally acceptable for use in concrete.

#### 3.07.02 **Filling and Compaction in Pits and Trenches around Structures**

As soon as the work in foundations has been accepted and measured, the spaces around the foundation structures in pits and trenches shall be cleared of all debris, brick bats, mortar droppings, etc., and filled with earth in layers not exceeding 250 mm in loose thickness each layer being watered, rammed and properly compacted to the satisfaction of the Engineer. Earth shall be rammed with approved mechanised compaction machine. Usually, no manual compaction shall be allowed unless specifically permitted by the Engineer. The final surface shall be trimmed and levelled to proper profile as desired by the Engineer.

Since the degree of compaction depends on the moisture content of the soil, a close watch should be kept on it and corrections done to optimise the moisture content.

#### 3.07.03 **Plinth Filling**

The plinth shall be filled with earth in layers not exceeding 250 mm in loose thickness, watered and compacted with approved compaction machine or manually, if specifically permitted by the Engineer. When the filling reaches the finished level, the surface shall be flooded with water for at least 24 hours, allowed to dry and then rammed and compacted, in order to avoid any settlement at a later stage. The finished level of the filling shall be trimmed to the slope intended to be given to the floor.

#### 3.07.04 **Filling in Trenches for Water Pipes and Drains**

Earth used for filling shall be free from salts, organic or other foreign matter. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not bigger than 150 mm size in any direction, mixed with fine material consisting of disintegrated rock, moorum or earth as available, so as to fill up the voids as far as possible and then the mixture used for filling.

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed.

Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of pipes in layers not exceeding 150 mm, watered, rammed and compacted taking care that no damage is caused to the pipe below.

In case of excavation of trenches in rock, the filling upto a depth of 300 mm or the diameter of the pipe whichever is more, above the crown of pipe or barrel shall be done with fine material such as earth, moorum, disintegrated rock or ash according to the availability at site. The remaining filling shall be done with rock filling of boulders of size not exceeding 150 mm mixed with fine material as available to fill up the voids, watered, rammed and compacted.

#### 3.07.05 **Filling in Disposal Area**

Surplus material from excavation which is not required for backfilling will be disposed of in designated disposal areas. The spoils shall not be dumped haphazardly but should be spread in layers approximately 250 mm thick when loose and compacted with the help of compacting equipment. In wide areas rollers will be employed and compaction done to the satisfaction of the Engineer at the optimum moisture content which shall be checked and controlled by the Contractor.

In certain cases the Engineer may direct disposal without compaction which can be done by tipping the spoils from a high bench neatly maintaining always a proper level and grade of the bench.

3.08.00      **Approaches and Fencing**

The Contractor should provide and maintain proper approaches for workmen and for inspection. The roads and approaches around the excavated pits should be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the Project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress.

3.09.00      **Lighting**

Full scale area lighting is to be provided if night work is permitted or directed by the Engineer. If no night work is in progress, red warning lights should be provided at the corners of the excavated pit and the edges of the fill.

4.00.00      **TESTING AND ACCEPTANCE CRITERIA**

4.01.00      **Excavation**

On completion of excavation, the dimensions of the pits will be checked as per the drawings after the pits are completely dewatered the work will be accepted after all undercuts have been set right and all over excavations filled back to required lines, levels and grades by placing ordinary concrete of 1:4:8 proportion and/or richer and/or by compacted earth, as directed by the Engineer, at the Contractor's cost. The choice of grade of concrete will be a matter of unfettered discretion of the Engineer. Over excavation of the sides will be made good free of cost by the Contractor while carrying out the back-filling. The excavation work will be accepted after the above requirements are fulfilled and all temporary approaches encroaching inside the required dimension of the excavation have been removed.

4.02.00      **Back-filling**

The degree of compaction required will be as per the stipulation laid down in IS:4701, if not otherwise mentioned in the Schedule and the actual method of measuring the compaction achieved will be as decided by the Engineer. The work of back-filling will be accepted after the Engineer is satisfied with the degree of compaction achieved.

5.00.00      **INFORMATION TO BE SUBMITTED**

5.01.00      **With Tender**

Details of Equipment proposed to be used for excavation, back-filling and compaction have to be submitted along with the tender.

5.02.00      **After Award**

After award of the Contract the successful tenderer shall submit the following for approval and adoption :

- a)      Within 15 days of Award of the Contract, the Contractor shall submit a detailed programme of the work as proposed to be executed giving completion dates of excavation of the various foundations and the time required for back-filling and compaction after completing the foundation for structures. In case the Earthwork Contractor is also the agency for the foundation work, the Earthwork programme is to be connected with the foundation programme. The programme should also show how the excavation and back-filling quantities will be balanced, minimising temporary stacking of spoils. It is to be noted that the Engineer even after initial approval of the programme, may instruct to enhance or retard the progress of work during the actual execution, in order to match with the progress of foundations without attracting any claims from the Contractor. The initial programme being submitted by the Contractor should have sufficient flexibility to take care of such reasonable variations.
- b)      Within 15 days of award, the Contractor shall submit drawings showing details of slopes, shorings, approaches, sump pits, dewatering lines, fencing etc. for approval of the Engineer for adoption.

6.00.00      **RATES**

The rates for the items shall include cost of all materials consumed in the works, hire charges of materials, tools and plant, cost of labour, insurance, all transport, taxes, royalties, security and safety arrangements, supervision, profit etc. The rates of excavation shall also include the cost of dewatering (except where such dewatering would need installation of well points or deep wells for which separate payment will be made) and stacking the excavated spoils properly within a lead of 30M, unless otherwise mentioned in the Schedule of items.

The Contractor will have to give a rebate if the excavated earth is directly used for back-filling.

Where back-filling is to be done with sand, it shall be of good quality from quarries approved by the Engineer. The rate shall include all operations including the cost of sand.

In case the Contractor is required to continue dewatering of the excavated pits beyond the period of the contract, original or extended, he will be paid separately for it as per the schedule of items only for the period beyond the

final terminal date of the contract. The rate will be complete in all respects including the cost of consumables, if any.

7.00.00      **MEASUREMENTS**

7.01.00      **Clearing and Grubbing**

No separate measurement shall be done for this item for the purpose of payment in general except for cutting of trees having girth more than 30 cms. and works connected to this.

7.02.00      **Excavation**

Actual quantity of excavation required and approved by the Engineer shall be measured in Cu.M. No extra shall be paid for keeping the excavations dewatered as required for completion of the structure to come in. Necessary disposal of the spoils as described in the schedule of items shall be included in the quoted rate.

7.03.00      **Shoring**

The actual effective area of shoring as approved by the Engineer, shall be measured in Sq.M. All planks, wallings, verticals, struts, props and all other materials as required for the shoring and subsequent safe dismantling and removal shall be included in the rates quoted.

7.04.00      **Back-filling**

7.04.01      **With Assorted Earth from Excavations  
for Foundations, Trenches etc.**

Actual quantity of consolidated backfill shall be measured in Cu.M. The cost of lead, lift, etc. shall be as per schedule of items and included in the rate quoted.

7.04.02      **With Earth from Borrow Pits and Stacks**

Actual quantity of consolidated back-filling or actual quantity of excavation in the borrow pits, or the excavated volume of the stack with a deduction of 30% for voids, in case filling is done by earth from stack, whichever is less, shall be paid in Cu.M. The lead, lift, etc. as mentioned in the Schedule of Items shall be included in the rates quoted.

7.04.03      **Sand filling**

Actual quantity of consolidated sand filling shall be measured in Cu.M. The rate shall include cost of sand and all necessary works for execution of the items.

7.05.00      **Leads and Lifts**

The leads for excavation and/or back-filling will be measured between the centroid of the actual disposal area and that of the plan of the pit. The distance between these two points will be measured along the shortest practicable haulage path as decided by the Engineer.



Lifts will be measured vertically between the average ground level from where the pit excavation was started and the bottom level of the excavated pit. Level lines corresponding to the stages where lifts become payable will be drawn on the cross section of the pit and the volumes of excavation contained between these horizontal planes will be computed and paid according to the corresponding rates.

7.06.00      **Dewatering**

Dewatering for work beyond the Contract period original or extended will be measured on the basis of horse power - hour which will be obtained by multiplying the estimated requirement of horse power required to run the pumps or actually employed, whichever is less, by the actual hours run, approximated to the nearest half hour.

**SPECIFICATION NO. C-5**

**FOR**

**CEMENT CONCRETE (PLAIN & REINFORCED)**

**SPECIFICATION NO. C-5  
FOR  
CEMENT CONCRETE (PLAIN & REINFORCED)**

**C O N T E N T S**

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**SPECIFICATION NO. C-5  
FOR  
CEMENT CONCRETE (PLAIN OR REINFORCED)**

**1.00.00 SCOPE**

**1.01.00 General**

This specification covers all the requirements, described hereinafter for general use of Plain and Reinforced Cement Concrete work in Structures and locations, cast-in-situ or precast, and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work.

1.02.00 This specification shall also apply to the extent it has been referred to or applicable with the special requirements of structures covered in SCOPE of IS:456.

1.03.00 IS:456 shall form a part of this specification and shall be complied with unless permitted otherwise. For any particular aspect not covered by this Code, appropriate IS Code, specifications and/or replacement by any International Code of practice as may be specified by the Engineer shall be followed. All codes and Standards shall conform to its latest revisions. A list of IS codes and Standards is enclosed hereinafter for reference.

**2.00.00 GENERAL**

**2.01.00 Work to be provided for by the Contractor**

The work to be provided for by the Contractor, unless otherwise specified shall include but not be limited to the following :-

- a) Furnish all labour, supervision, services including facilities as may be required under statutory labour regulations, materials, forms, templates, supports, scaffolds, approaches, aids, construction equipment, tools and plants, transportation, etc. required for the work.
- b) Except where it is excluded from the Scope of Contract, Contractor shall prepare progressively and submit for approval detailed drawings and Bar Bending Schedules for reinforcement bars showing the positions and details of spacers, supports, chairs, hangers etc.
- c) Design and prepare working drawings of formworks, scaffolds, supports, etc. and submit for approval.
- d) Submit for approval shop drawings for various inserts, anchors, anchor bolts, pipe sleeves, embedments, hangers, openings, frames etc.
- e) Submit for approval detailed drawings of supports, templates, hangers, etc. required for installation of various embedments like inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

- f) Submit for approval detailed schemes of all operations required for executing the work, e.g. Material handling, Concrete mixing, Placement of concrete, Compaction, curing, services, Approaches, etc.
- g) Design and submit for approval concrete mix designs required to be adopted on the job.
- h) Furnish samples and submit for approval results of tests of various properties of the following :-
  - i) The various ingredients of concrete
  - ii) Concrete
  - iii) Embedments
  - iv) Joint seals
- i) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings, specifications and Schedule of Items.
- j) For supply of certain materials normally manufactured by specialist firms, the Contractor may have to produce, if directed by the Engineer, a guarantee in approved proforma for satisfactory performance for a reasonable period as may be specified, binding both the manufacturers and the Contractor, jointly and severally.

2.02.00 **Work by Others**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the contract.

2.03.00 **Information to be submitted by the Tenderer**

2.03.01 **With Tender**

The following technical information are required with the tender :

- a) Source and arrangement of processing of aggregates proposed to be adopted.
- b) Type of plant and equipment proposed to be used.
- c) Names of firms, if any, with which association is sought for to execute the special items of work in the contract.
- d) Types of formwork proposed to be used.

2.03.02 **After Award**

The following information and data including samples where necessary, shall be submitted by the Contractor progressively during the execution of the contract.

a) Programme of Execution and Requirement of Materials

Within 30 days of the award of contract, the Contractor will submit a Master Programme for completion of the work giving monthwise requirements of materials, particularly mentioning in details the materials which are to be supplied by the Owner and for the procurement of which the help of the Owner is required as per the terms and conditions of the Contract. In case the Contractor proposes to take on hire any machineries or tools and plants from the Owner, the detailed phased out programme of such hire is also to be submitted.

This Master Programme may have to be reviewed and updated by the Contractor, quarterly or at more frequent intervals as may be directed by the Engineer depending on the exigencies of the work.

Detailed day to day programme of every month is to be submitted by the Contractor before the end of the previous month.

b) **Samples**

Samples of the following materials and any other materials proposed to be used, shall be submitted as directed by the Engineer, in sufficient quantities free of cost, for approval. Approved samples will be preserved by the Engineer for future reference. The approval of the Engineer shall not, in any way, relieve the Contractor of his responsibility of supplying materials of specified qualities :-

- i) Coarse and fine aggregates.
- ii) Admixtures.
- iii) Plywood for Formwork.
- iv) Embedded and anchorage materials as may be desired by the Engineer.
- v) Joint sealing strips and other waterproofing materials.
- vi) Joint filling compounds.
- vii) Foundation quality Rubber Pads.

c) Design Mix

Design mix as per Clauses 2.1 (g) & 3.4 of this specification giving proportions of the ingredients, sources of aggregates and cement, along with accompanying test results of trial mixes as per relevant I.S., is to be submitted to the Engineer for his approval before it can be used on the works.

d) Detail Drawings and Bar Bending Schedules

Detailed working drawings and Bar Bending Schedules in accordance with Clause 2.1(b) and 3.16.1 of this specification.

e) Detailed Drawings and Designs of Formworks to be used

Detailed design data and drawings of standard formworks to be used as per clause 2.1 (c).

f) Detailed Drawings for Templates & Temporary Supports for Embedments

As per Clause 2.1 (e).

g) Mill Test Reports for Cement & Reinforcing Steel

Mill Test Reports for Cement and Reinforcing Steel in case these materials are supplied by the Contractor.

h) Inspection Reports

Inspection Reports in respect of Formwork and Reinforcement and any other item of work as may be desired by the Engineer in accordance with Clause 2.4 of this specification.

i) Test Reports

Reports of tests of various materials and concrete as required under Clause 4.0 : SAMPLING & TESTING of this specification.

j) Any other data which may be required as per this specification.

2.04.00

**Conformity with Design**

The Contractor will prepare check lists in approved proforma which will be called 'Pour Cards'. These Pour Cards will list out all items of work involved. The Contractor will inform the Engineer, sufficiently in advance, whenever any particular pour is ready for concreting. He shall accord all necessary help and assistance to the Engineer for all checking required in the pour. On satisfying himself that all details are in accordance to the drawings and specifications, the Engineer will give written permission on the same 'Pour Card' allowing the Contractor to commence placement of concrete. Details of all instructions issued by the Engineer and the records of compliance by the Contractor, deviations allowed by the Engineer and any other relevant information will be written on accompanying sheets attached to the Pour Cards. These sheets, termed as 'Progress Cards', will be prepared by the Contractor on approved proforma. The Pour Cards along with accompaniments will be handed over to the Engineer before starting placement of concrete. One of the mix designs developed by the Contractor as per the I.S. Specifications and established to the satisfaction of the Engineer by trial mixes shall be permitted to be used by the Engineer, the choice being dictated by the requirements of designs and workability. The methods of mixing, conveyance, placement, vibration,

finishing, curing, protection and testing of concrete will be as approved or directed by the Engineer.

2.05.00 **Materials to be used**

2.05.01 **General Requirement**

All materials whether to be incorporated in the work or used temporarily for the construction shall conform to the relevant IS Specifications unless stated otherwise and be of best approved quality.

2.05.02 **Cement**

Generally cement shall be 33 grade ordinary Portland Cement conforming to IS-269. In special cases any of the following type of cement may be permitted or directed to be used with prior approval by the Engineer :

- a) 43 Grade ordinary Portland Cement conforming to IS-8112
- b) 53 Grade ordinary Portland Cement conforming to IS-12269
- c) Rapid hardening Portland Cement conforming to IS-8041
- d) Portland slag cement conforming to IS-455
- e) Portland Pozzolona Cement (fly ash based) Conforming to IS-1489 (Part-1)
- f) Portland pozzolona Cement (calcined clay based) conforming to IS-1489 (part-2)
- g) Hydrophobic Cement conforming to IS-8043
- h) Low heat Portland Cement conforming to IS : 12600
- i) Sulphate Resisting Portland Cement conforming to IS-12330

2.05.03 **Aggregates**

Aggregates shall be natural or crushed gravel or crushed rock and free from deleterious material. It shall comply with the requirements of IS-383. All fine and coarse aggregate shall be tested for susceptibility to Alkali Silicate reaction in a laboratory approved by the Engineer.

a) **Coarse Aggregate**

Aggregate of sizes ranging between 4.75 mm and 150 mm will be termed as Coarse Aggregate. Only Coarse Aggregate from approved quarries and conforming to IS:383 will be allowed to be used on the works. Aggregates shall be washed to make it free from deleterious materials, if necessary.



The grading of coarse aggregates by sieve analysis shall be as per IS:383. If by the analysis the deficiency of a particular grain size is found, which could affect the density of the concrete, the Engineer may ask the contractor to avoid such quantities of aggregate of the particular size or and such quantity of aggregate of any particular size to achieve the required grading as per IS:383.

b) **Fine Aggregate**

Aggregate smaller than 4.75 mm and within the grading limits and other requirements set in IS:383 is termed as Fine Aggregate or Sand. Only Fine Aggregate from approved sources and conforming to the above IS Specification will be allowed to be used on works.

In certain cases there may be two types of sand, one very fine and the other very coarse. In such cases, the two types shall be combined to meet the requirements of a particular zone of IS:383. In all cases, the preferred zone is Zone - II.

In certain cases crushed stone sand may be added to natural sand in order to achieve the required grading.

Crushed stone sand alone may be used only with the approval of the Engineer.

2.05.04 **Water**

Water for use in Concrete shall be clear and free from injurious oils, acids, alkalis, organic matter, salt, silts or other impurities. Normally potable water is found to be suitable. Generally, IS:3550 will be followed for routine tests. Acceptance test for water shall be as per IS:3025, and Table-I of IS:456.

In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by compressive strength and initial setting time tests as per method of tests in accordance with the requirements of IS-516 & IS- 4031 respectively. The PH value of water shall generally be not less than 6.

2.05.05 **Admixture**

Only admixture of approved quality will be used when directed or permitted by the Engineer. The different types of admixtures which may be necessary to satisfy the concrete mix and the design requirement shall be as per the following I.S. Standards :

IS:2645 - Integral cement water proofing compound

IS:9103 - Indian standard specification for Admixtures for Concrete

or equivalent American Codes (ASTM C494 and ASTM C260) or British Codes (BS 5075, Part 1 to 3) and may be one of the following :

- a) Accelerating admixtures :  
  
Set accelerating admixtures like "Sigunit Powder" or "Sigunit LN10" or approved equivalent.
  - b) Retarding admixtures :  
  
Modified ligno sulphonate based set retarding concrete admixture like, "Plastiment" or approved equivalent.
  - c) Water reducing admixtures :  
  
Modified sulphonated melamine formaldehyde based water reducing concrete admixture like, "Sikament" or approved equivalent.
  - d) Air entraining admixtures :  
  
Modified ligno sulphonate based air entraining concrete admixture like "FLOMO AEP" or surface - active agents like "Sika AER" or approved equivalent.
  - e) Water proofing admixtures :  
  
Modified lingo-sulphonate based waterproofing admixture like "Plastocrete Super" or approved equivalent.
- However, the Contractor shall furnish following technical information about the admixtures (alongwith the manufacturer's Catalogue) which he is planning to use in different areas within the scope of work for the approval of the Engineer :
- i) Type of admixture
  - ii) Mix proportion & mode of application in concrete/mortar
  - iii) Manufacturer's specification & necessary quality assurance certificates (mainly on chloride & sulphate content, PH value, infra red analysis & solid content.)

## 2.05.06 Reinforcement

Reinforcement shall be as per relevant IS Specification as mentioned in the Contract/Drawing/Instructions. All bars shall be of tested quality.

## 2.06.00 Storage of Materials

### 2.06.01 General

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for concrete and shall be removed from site immediately, failing which, the Engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the Contractor's dues. The Contractor shall maintain upto-date accounts of

receipt, issue and balance (stackwise) of all materials. Storage of materials shall conform to IS:4082.

#### 2.06.02 **Cement**

Sufficient space for storage, with open passages between stacks, shall be arranged by the Contractor to the satisfaction of the Engineer.

Cement shall be stored off the ground in dry, leak proof, well-ventilated ware-houses at the works in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter.

Cement shall be stored in easily countable stacks with consignment identification marks. Consignments shall be used in the order of their receipts at site. Sub-standard or partly set cement shall not be used and shall be removed from the site, with the knowledge of the Engineer, as soon as it is detected.

Different types of cement shall be clearly marked with the type & different types of cement shall not be intermixed.

#### 2.06.03 **Aggregates**

Aggregates shall be stored on planks or steel plates or on concrete or masonry surface. Each size shall be kept separated with wooden or steel or concrete or masonry bulk-heads or in separate stacks and sufficient care shall be taken to prevent the material at the edges of the stock piles from getting intermixed. Stacks of fine and coarse aggregates shall be kept sufficiently apart with proper arrangement of drainage. The aggregates shall be stored in easily measurable stacks of suitable depths as may be directed by the Engineer.

#### 2.06.04 **Reinforcement**

Reinforcing steel shall be stored consignment-wise and size wise off the ground and under cover, if desired by the Engineer. It shall be protected from rusting, oil, grease and distortions. If necessary, the reinforcing steel may be coated with cement wash before stacking to prevent scale and rust at no extra cost to the Owner. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage.

#### 2.07.00 **Quality Control**

Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same. The quality control operation shall include but not be limited to the following items of work :

- a) Admixture : Type, quantity, physical and chemical properties that affect strength, workability and durability of concrete. For air entraining admixtures, dosage to be adjusted to maintain air contents within desirable limits.

- |    |                                  |   |   |
|----|----------------------------------|---|---|
| b) | Aggregate                        | : | Physical, chemical and mineralogical qualities. Grading, moisture content and impurities.   |
| c) | Water                            | : | Impurities tests.   |
| d) | Cement                           | : | Tests to satisfy relevant IS Specifications (only association with Owner's tests, if the supply is made by Owner).  |
| e) | Formwork                         | : | Material, shapes, dimensions, lines, elevations, surface finish, adequacy of form, ties, bracing and shoring and coating.   |
| f) | Reinforcement                    | : | Shapes, dimensions, length of splices, clearances, ties and supports. Quality and requirement of welded splices. Material tests or certificates to satisfy relevant IS Specification (If Contractor's supply).  |
| g) | Grades of concrete               | : | Usage and mix design, testing of all properties.  |
| h) | Batching & Mixing                | : | Types and capacity of plant, concrete mixers and transportation equipment.  |
| i) | Joints                           | : | Locations of joints, water stops and filler materials. Dimension of joints, quality and shape of joint material and splices.  |
| j) | Embedded and Anchorage Items     | : | Material, shape, location, setting.   |
| k) | Placing                          | : | Preparation, rate of pouring, weather limitations, time intervals between mixing and placing and between two successive lifts, covering over dry or wet surfaces, cleaning and preparation of surfaces on which concrete is to be placed, application of mortar/slurry for proper bond, prevention of cold joint, types of chutes or conveyors. |
| l) | Compaction                       | : | Number of vibrators, their prime mover, frequency and amplitude of vibration, diameter and weight of vibrators, duration of vibration, hand-spreading, rodding and tamping.   |
| m) | Setting of base & Beaming plates | : | Lines, elevations and bedding mortar.   |

- n) Concrete Finishes : Repairs of surface defects, screening, floating, steel trowelling and brooming, special finishes.
- o) Curing : Methods and length of time.

Copies of records and tests for the items noted above, as well as, records of corrective action taken shall be submitted to the Engineer for approval as may be desired.

### 3.00.00 **INSTALLATION**

All installation requirements shall be in accordance with IS:456 and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification do not cover all the aspects to the full satisfaction of the Engineer.

#### 3.01.00 **Washing and Screening of Aggregates**

Washing and Screening of coarse aggregate shall be carried out to remove fines dirt or other deleterious materials.

Washing of fine aggregate shall not be allowed, Fine aggregates shall be screened only to remove dirt or other deleterious materials.

However, all washing & screening of aggregates shall be carried out by approved means to ensure compliance with the aggregate specification.

#### 3.02.00 **Admixture**

All concrete shall be designed for normal rate of setting and hardening at normal temperature. Variations in temperature and humidity under different climatic conditions will affect the rate of setting and hardening, which will, in turn, affect the workability and quality of the concrete. Admixtures may be permitted to be used in accordance with IS:456 to modify the rate of hardening, to improve workability or as an aid to control concrete quality. The Engineer reserves the right to require laboratory test or use test data, or other satisfactory reference before granting approval. The admixture shall be used strictly in accordance with the manufacturer's directions and/or as directed by the Engineer.

#### 3.03.00 **Grades of Concrete**

Concrete shall be in any of the grades designated in IS:456. Grade of concrete to be used in different parts of work shall be as shown on the drawing or as per the Engineer's instructions. In case of liquid retaining structures, IS:3370 will be followed.

#### 3.04.00 **Proportioning and Works Control**

##### 3.04.01 **General**

Proportioning of ingredients of concrete shall be made by any of the two following methods as directed by the Engineer.

- a) With preliminary tests by designing the concrete mix. Such concrete shall be called 'Design Mix Concrete'.
- b) without preliminary tests adopting nominal concrete mix. Such concrete shall be called 'Nominal Mix Concrete'.

As far as possible, design mix concrete shall be used on all concrete works. Nominal mix concrete, in grades permitted in accordance with IS:456, may be used if shown on drawings or approved by the Engineer. In all cases the proportioning of ingredients and works control shall be in accordance with IS:456 and shall be adopted for use after the Engineer is satisfied regarding its adequacy and after obtaining his approval in writing.

#### 3.04.02 **Mix Design Criteria**

Concrete mixes will be designed by the Contractor to achieve the strength, durability and workability necessary for the job, by the most economical use of the various ingredients. In general, the design will keep in view the following considerations :-

- a) Consistent with the various other requirements of the mix, the quantity of water should be kept at the lowest possible level.
- b) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.
- c) The various fractions of coarse and fine aggregates should be mixed in such a proportion as to produce the best possible combined internal grading giving the densest and most workable mix.
- d) Chemical admixtures may be used to modify the rate of hardening, to improve workability (maintaining low water - cement ratio) or as an aid to control concrete quality.
- e) The finished concrete should have adequate durability in all conditions, to withstand satisfactorily the weather and other destructive agencies which it is expected to be subjected to in actual service.

The requirement of adequate structural strength is catered for by the choice of proper grade of concrete by the Engineer. The Contractor will strictly abide by the same in his design of concrete mix installation.

Notwithstanding anything mentioned in various tables given in IS:456 giving specific values and degrees of workability for different condition of concrete placing, minimum cement content and maximum water-cement ratio for concrete exposed to sulphate attack and for concrete to ensure durability under different condition of exposure, strength requirement for different grades of concrete, proportion for nominal mix concrete, the following tables in the specification are included. For identical condition if values given in the tables shown herein below are different from those mentioned in IS:456, the values as indicated in the table shown herein below shall prevail.

Various trials shall be given by the contractor with specific cement content on each trial. In some cases, plasticizers and other admixtures may be necessary to achieve the desired results.

**TABLE-I**  
**STRENGTH REQUIREMENT OF CONCRETE**

Specified Characteristic Compressive Grade of concrete strength of 15 cm Cubes at 28 days conducted in accordance with IS:516 (All values in N/Sq.mm)

M - 10	10
M - 15	15
M - 20	20
M - 25	25
M - 30	30
M - 35	35
M - 40	40

- Note :** 1 Nominal mix concrete of proportions 1:4:8 or 1:3:6 may be used as lean concrete for simple foundations for masonry walls, below the reinforced concrete foundations and mass filling. These mixes need not be designed.
- 2 Grades of concrete lower than M-15 shall not be used in reinforced concrete.

**TABLE-II**  
**MIX PROPORTIONS (BY WEIGHT) EXPECTED TO GIVE**  
**DIFFERENT DEGREES OF WORKABILITY WITH DIFFERENT**  
**VALUES OF WATER - CEMENT RATIO**

(FOR GUIDANCE)  
CEMENT/TOTAL AGGREGATE RATIOS

Workability	Water/ Cement Ratio	Ratio by weight of Cement to Gravel Aggregate		Ratio by weight of Cement to Crushed Stone Aggregate	
		20mm Size	38mm Size	20mm Size	38mm Size
Very low Slump 0- 25mm	0.4	1:4.8	1:5.3	1:4.5	1:5.0
	0.5	1:7.2	1:7.7	1:6.5	1:7.4
	0.6	1:9.4	1:10	1:7.8	1:9.6
	0.7	1:10	1:12	1:8.7	1:10.6
Low Slump 25-50mm	0.4	1:3.9	1:4.5	1:3.5	1:4.0
	0.5	1:5.5	1:6.7	1:5.0	1:5.5
	0.6	1:6.8	1:7.4	1:6.3	1:7.0
	0.7	1:8.0	1:8.5	1:7.4	1:8.0
Medium Slump 50-100mm	0.4	1:3.5	1:3.8	1:3.1	1:3.6
	0.5	1:4.8	1:5.7	1:4.2	1:5.0
	0.6	1:6.0	1:7.3	1:5.2	1:6.2
High Slump 100- 175mm	0.4	1:3.2	1:3.5	1:2.9	1:3.3
	0.5	1:4.4	1:5.2	1:3.9	1:4.6
	0.6	1:5.4	1:6.7	1:4.7	1:5.7
	0.7	1:6.2	1:7.4	1:5.5	1:6.5

- Note :**
- 1 Notwithstanding anything mentioned above, the cement/Total aggregate ratio is not to be increased beyond 1:9.0 without specific permission of the Engineer.
  - 2 It should be noted that such high aggregate cement ratios will be required for concretes of very low slump and high water- cement ratios which may be required to be used in mass concrete work only.
  - 3 The above figures are for guidance only, the actual cement/ aggregate ratios are to be worked out from the specific gravities of coarse aggregates and sand being used and from trial mixes.

### 3.05.00 **Strength Requirements**

The strength requirements of both design mix and nominal mix concrete where ordinary Portland Cement or Portland slag cement is used, shall be as per Table-2 of IS:456. All other relevant clauses of IS:456 shall also apply.



3.06.00 **Minimum Cement Content**

The minimum cement content for each grade of concrete shall be as shown below:-

**TABLE-III**

**MINIMUM CEMENT CONTENT SPECIFIED  
FOR DIFFERENT GRADES OF CONCRETE**

<b>Grade of Concrete</b>	<b>Minimum Cement Content/Cu.M of Finished Concrete</b>
M-15	310 Kg
M-20	360 Kg
M-25	410 Kg
M-30	450 Kg
M-35	490 Kg
M-40	540 Kg

The minimum cement contents mentioned above are for average conditions and for 20 mm size aggregate. For 40 mm size aggregate the cement content may be reduced. In case the cement content can be reduced due to continuous and consistent favourable conditions, on account of better quality of cement control or by the addition of suitable plasticizer/super plasticizers, then the Engineer may instruct lower cement content, and the Contractor shall abide by the stipulations laid down hereunder :

- a) The Contractor shall design the mixes for 10% (Ten per cent) higher strength over and above those specified in Table-I under Clause 3.4, for the various grades of concrete and different slump requirements.
- b) Sufficient number of trial mixes (to be decided by the Engineer) will be taken at the laboratory for the various designs and graphs of w/c ratio Vs crushing strengths at various ages will be plotted.
- c) All tests will be done in presence of the Engineer who shall be the final authority to decide upon the adoption of any revised minimum cement content. The Contractor will always be responsible to produce quality concrete of the required grade as per the acceptance criteria of IS:456.
- d) The Engineer will always have the unquestionable right to revise the minimum cement content as decided above, if, in his opinion, there is any chance of deterioration of quality on account of use of lower cement content or any other reason.

In case there is a downward revision of the minimum cement content from that specified in the contract, the particular unit rate of concrete will be reduced by an amount equal to the cost of cement saved, calculated at the issue rate. The relevant cost of wastage and handling on the cement saved, which is inherent in the total cost of structure, will not be deducted from the unit rate and will thus pass on to the Contractor.

### 3.07.00 **Water-Cement Ratio**

The choice of water-cement ratio in designing a concrete mix will depend on -

- a) The requirement of strength.
- b) The requirement of durability.

### 3.07.01 **Strength Requirement**

In case of 'Design Mix Concrete', the water-cement ratio of such value as to give acceptable test results as per IS:456, will be selected by trial and error. The values of water-cement ratios for different grade and mix designs will have to be established after conducting sufficiently large number of preliminary tests in the laboratory to the satisfaction of the Engineer. Frequent checks on test will have to be carried out and the water-cement ratios will be revised if the tests produce unsatisfactory results. Notwithstanding anything stated above the Contractor's responsibility to produce satisfactory test results and to bear all the consequences in case of default remains unaltered.

In case of nominal mix concrete, the maximum water-cement ratio for different grades of concrete is specified in Table- 3 of IS:456 and no tests are necessary. The acceptance test criteria for nominal mix concrete shall be as per IS:456.

### 3.07.02 **Durability Requirement**

Tables 19 & 20 of IS:456 give the maximum water-cement ratio permissible from the point of view of durability of concrete subjected to adverse exposure to weather, sulphate attacks, and contact with harmful chemicals. Impermeability may also be an important consideration.

Whenever the water-cement ratio dictated by durability consideration is lower than that required from strength criterion, the former shall be adopted.

However, water-cement ratio, from the point of view of durability as well as from strength consideration, should meet the requirement given in Table No. IV.

In general the water cement ratio between 0.4 and 0.45 will be desirable to satisfy the durability requirement and from the consideration of impermeability of concrete. The contractor may propose lower water cement ratio as mentioned above by addition of a suitable plasticizer / super-plasticizer. However the contractor has to propose specifically along with field trials in the event of lower cement content if found suitable along with a plasticizer. It will be preferable to use Melamine based plasticizer.

TABLE-IV

**MAXIMUM PERMISSIBLE WATER/CEMENT RATIOS FROM  
DURABILITY CONSIDERATIONS FOR DIFFERENT TYPES OF  
STRUCTURES AND DEGREES OF EXPOSURE USING ORDINARY PORTLAND CEMENT**

Type of Structure	Exposure Conditions					
	Severe wide range of Temp. Frequent alterations of freezing and thawing (use Air Entrained concrete only)			Mild Temp. rarely below freezing or rainy or arid		
	At the water line or within the range of fluctuating water level or spray			At the water line or within the range of fluctuating water level or spray		
	In Air	In Fresh Water	In Sea water or in contact with sulphate (concentration more than 0.2pc)	In Air	In Fresh Water	In Sea water or in contact with sulphate (concentration more than 0.2pc)
This sections such as railings kerbs, sills, ledges, ornamental or Arch. concrete reinforced concrete piles, pipes and all sections with less than 25mm concrete cover to reinforcement	0.49	0.44	0.40	0.53	0.49	0.40
Moderate sections such as Retaining Walls, abutments, piers, girders, beams	0.53	0.49	0.40	*	0.53	0.44
Exterior portions of heavy mass sections	0.58	0.49	0.44	*	0.53	0.44
Concrete deposited by Tremie under water	-	0.44	0.44	-	0.44	0.44
Concrete slabs laid on ground	0.53	-	-	*	-	-
Concrete which will later be protected by enclosure or backfill but which may be exposed to freezing & thawing for several years before such protection is offered.	0.53	-	-	*	-	-
Concrete protected from the water, interiors of buildings, concrete below ground which is free from sulphate attacks.	*			*		

**Note :** \* Water/Cement ratios should be selected on basis of strength and workability requirement.

### 3.08.00 Workability

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embedments and to give the required surface finish shall depend on the type and nature of structure and shall be based on experience and tests. The usual limits of consistency for various types of structures are given below :-

**TABLE-V**  
**LIMITS OF CONSISTENCY**

Degree of Workability	Slump in mm with Standard Cone as per IS:1199		Use for which concrete is suitable
	Min.	Max.	
Very low	0	25	Large Mass concrete structure with heavy compaction equipments, roads and like.
Low	25	50	Uncongested wide and shallow RCC structures.
Medium	50	100	Deep but wide RCC structures with congestion or reinforcement and inserts.
High	100	100	Very narrow and deep RCC structures with congestion due to reinforcement and inserts.

(**Note** : Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer)

With the permission of the Engineer, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. No extra payment will be made for this additional cement.

The workability of concrete shall be checked at frequent intervals by slump tests. Alternatively where facilities exist or if required by the Engineer, the compacting factor test in accordance with IS:1199 and Clause 6 of IS:456 shall be carried out.

### 3.09.00 Size of Coarse Aggregates

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer :-

Very narrow space	-	12 mm
Reinforced concrete except foundation	-	20 mm
Ordinary Plain concrete and Reinforced concrete foundations	-	40 mm
Mass concrete	-	80 mm
Mass concrete in very large structure	-	150 mm

Grading of coarse aggregates for a particular size shall conform to relevant I.S. Codes and shall also be such as to produce a dense concrete of the specified proportions, strength and consistency that will work readily into position without segregation.

Coarse aggregate will normally be separated into the following sizes and stacked separately in properly designed stockpiles :

150 mm to 80 mm, 80 mm to 40 mm, 40 mm to 20 mm and 20 mm to 5 mm. In certain cases it may be necessary to further split the 20 mm to 5 mm fraction into 20 mm to 10 mm and 10 mm to 5 mm fractions.

This separation of aggregates in different size fractions is necessary so that they may be remixed in the desired proportion to arrive at a correct internal grading to produce the best mix.

### 3.10.00 **Mixing of Concrete**

Concrete shall always be mixed in mechanical mixer unless specifically approved by the Engineer for concrete to be used in unimportant out of the way locations in small quantities. Water shall not normally be charged into the drum of the mixer until all the cement and aggregates constituting the batch are already in the drum and mixed for at least one minute. Mixing of each batch shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall mixing be done for less than 2 (two) minutes and at least 40 (forty) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Engineer. Mixers shall not be loaded above their rated capacity as this prevents thorough mixing.

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

Regular checks on mixer efficiency shall be carried out as directed by the Engineer as per IS:4634 on all mixers employed at site. Only those mixers whose efficiencies are within the tolerances specified in IS:1791 will be allowed to be employed.

Ingredients for design mix concrete shall be measured by weight. For small jobs portable swing weigh Batcher's conforming to IS:2722 may be used.

Batching plant conforming to IS:4925 shall be used for large jobs. The accuracy of the measuring equipment shall be within  $\pm 2\%$  of the quantity of Cement, water or total aggregates being measured and within  $\pm 5\%$  of the quantity of any admixture being used. The batching equipment shall be fitted with an accurate mechanism for weighing separately the cement, fine aggregate and coarse aggregate. Water may be measured by volume or by weight. All measuring equipment should be maintained in a clean serviceable condition, and their accuracy shall be checked periodically.

Mechanical/electrical control shall be provided on the mixing equipment to ensure the batch cannot be discharged until approved mixing time has elapsed and the entire batch shall be discharged before the mixer is recharged.

Where admixtures are employed, separate containers & measuring devices shall be used.

For minor concreting works, batching by volume according to specific weight may be permitted by the Engineer. In that case the whole bags of cement shall be used and gauge boxes used for measuring aggregates.

When hand mixing is permitted by the Engineer, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand-mixing, 10% extra cement shall be added to each batch at no extra cost to the Owner.

#### 3.11.00 **Conveying Concrete**

Concrete shall be handled and conveyed from the place of mixing to the place of laying as rapidly as practicable by approved means and placed and compacted in the final position before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation or loss of any of the ingredients. For long distance haulage, agitator cars of approved design will be used. If, in spite of all precautions, segregation does occur during transport, the concrete shall be properly re-mixed before placement. During very hot or cold weather, if directed by the Engineer, concrete shall be transported in deep containers which will reduce the rate of loss of water by evaporation or loss of heat. If necessary, the container may have to be covered and insulated. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipments shall be kept free from set concrete.

#### 3.12.00 **Placing and Compacting Concrete**

Where specifically covered, the relevant I.S. Code will be followed for the procedure of surface preparation, placement, consolidation, curing, finishes, repairs and maintenance of concrete. If, however, there is no specific provision in the relevant I.S. Code for any particular aspect of work, any other standard Code of practice, as may be specified by the Engineer, will be adopted. Concrete may have to be placed against the following types of surfaces :-

- a) Earth foundation
- b) Rock foundation
- c) Formwork
- d) Construction joint in concrete or masonry

The surface on or against which concrete is to be placed has to be cleaned thoroughly. Rock or old construction joint has to be roughened by wire brushing, chipping, sand blasting or any other approved means for proper bond. All cuttings, dirt, oil, foreign and deleterious material, laitance, etc. are to be removed by air water jetting or water at high pressure. All excavated areas for foundations, ring beams, plinths, pile caps etc. shall be rammed & consolidated properly before blinding with nominal mix plain concrete, as per drawing and/ or direction of the Engineer and shall be allowed to cure prior to setting out steel fixing, shuttering and concrete pouring for the main structural element.

Formwork, reinforcement, preparation of surface, embedments, joint seals etc., shall be approved in writing by the Engineer before concrete is placed. As far as possible, concrete shall be placed in the formwork by means approved by the Engineer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1500 mm shall have to be approved by the Engineer.

Rock foundation or construction joint will be kept moist for at least 72 hours prior to placement. Concrete will be placed always against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and precaution, as directed by the Engineer will have to be adopted.

Formwork will be cleaned thoroughly and smeared lightly with form oil or grease of approved quality just prior to placement.

A layer of mortar of thickness 12 mm of the same or less w/c ratio and the same proportion as that of the concrete being placed and cement slurry will be spread thoroughly on the rock foundation or construction joint just prior to placement of concrete. The cost of application of such cement slurry and mortar will be deemed to be included in the unit rate of concrete.

After concrete has been placed, it shall be spread, if necessary and thoroughly compacted by approved mechanical vibration to maximum subsidence without segregation and thoroughly worked around shape. Vibrators shall not be used for pushing concrete into adjoining areas. Vibrators must be operated by experienced workmen and the work carried out as per relevant IS Code of Practice. In thin members with heavy congestion of reinforcement or other embedments, where effective use of internal vibrator is, in the opinion of the Engineer, doubtful, in addition to immersion vibrators the contractor may have to employ form vibrators conforming to IS:4656. For slabs and other similar structures, the contractor will additionally employ screed vibrator as per IS:2506. Hand tamping may be allowed in rare cases, subject to the approval

of the Engineer. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or distorted during placing and consolidation of concrete.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green concrete which is still plastic and workable. No concrete shall be placed in open, during rains. During rainy season, no placement in the open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete.

The size of the concrete pours must be carefully considered prior to commencement to ensure the structural elements are poured in on continuous shift to avoid cold joints.

Slabs, beams and similar members shall be poured in one operation, unless otherwise instructed by the Engineer. Moulding, throating, drip course, etc., shall be poured as shown on the drawings or as directed by the Engineer. Holes shall be provided and bolts, sleeves, anchors, fastenings or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the Engineer. Any deviation therefrom shall be set right by the Contractor at his own expense as instructed by the Engineer.

In case the forms or supports get displaced during or immediately after the placement and bring the concrete surface out of alignment beyond tolerance limits, the Engineer may direct to remove the portion and reconstruct or repair the same at the Contractor's expense.

The Engineer shall decide upon the time interval between two placements of concrete of different ages coming in contact with each other, taking in consideration the degree of maturity of the older concrete, shrinkage, heat dissipation and the ability of the older concrete to withstand the load imposed upon it by the fresh placement.

Once the concrete is deposited, consolidated and finished in its final position, it shall not be distributed.

### 3.13.00 **Construction Joints and Cold Joints**

#### 3.13.01 **Construction Joints**

It is always desirable to complete any concrete structure by continuous pouring in one operation. However, due to practical limitation of methods and equipment and certain design considerations, construction joints are formed by discontinuing concrete at certain predetermined stages. These joints will be formed in a manner specified in the drawings/Instruction. Vertical construction joints will be made with rigid stop-board forms having slots for allowing passage of reinforcement rods and any other embedments and fixtures that may be shown. Next stage concrete shall be placed against construction joint as



per clause 3.12. For water retaining structures and leak-proof buildings suitable approved water bars will be installed at the construction joints.

Where the location of the joints are not specified, it will be in accordance with the following :-

- a) In a column, the joint shall be formed 75 mm below the lowest soffit of the beam framing into it.
- b) Concrete in a beam shall preferably be placed without a joint, but if provision of a joint is unavoidable, the joint shall be vertical and within the middle third of the span.
- c) A joint in a suspended floor slab shall be vertical and within the middle third of the span and at right angles to the principal reinforcement.
- d) Feather-edges in concrete shall be avoided while forming a joint.
- e) A construction joint should preferably be placed in a low-stress zone and at right angles to the direction of the principal stress.
- f) In case the Contractor proposes to have a construction joint anywhere to facilitate his work, the proposal should be submitted well in advance to the Engineer for study and approval without which no construction joint will be allowed.

#### 3.13.02 Cold Joint

An advancing face of a concrete pour, which could not be covered by fresh concrete before expiry of initial setting time (due to an unscheduled stoppage or delay on account of breakdown in plant, inclement weather, low rate of placement or any other reason), is called a cold joint. The Contractor should always remain vigilant to avoid cold joints.

If, however, a cold joint is formed due to unavoidable reasons, the following procedure shall be adopted for treating it :-

- a) If the concrete is so green that it can be removed manually and if vibrators can penetrate the surface without much effort, fresh concrete can be placed directly against the old surface. The old concrete should be covered by fresh concrete as quickly as possible and the joint thoroughly and systematically vibrated.
- b) In case concrete has hardened a bit more than (a) but can still be easily removed by a light hand pick, the surface will be raked thoroughly and the loose concrete removed completely without disturbing the rest of the concrete in depth. A rich mortar layer 12 mm in thickness, will be placed on the cold joint fresh concrete shall be placed on the mortar layer and the joint will be thoroughly and systematically vibrated penetrating the vibrator deep into the old layer of concrete.

- c) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not rise inspite of extensive vibration, the joint will be left to harden for at least 12 - 24 hrs. It will then be treated as a regular construction joint, after cutting the concrete to required shape and preparing the surface as described under clause 3.12.

### 3.14.00 Repairs, Finishes and Treatment of Concrete surfaces

- 3.14.01 Adequate and sound concrete surfaces, whether formed or unformed, can be obtained by employing a concrete mix of proper design, competent formwork, appropriate methods of handling, placing and consolidation by experienced workmen.

Unsound concrete resulting from improper mix design, incompetent methods, equipment and formwork, poor workmanship and protection will not be accepted and will have to be dismantled, removed and replaced by sound concrete at the Contractor's cost. The Engineer may, at his sole discretion, allow to retain concrete with minor defects provided the Contractor is able to repair it by approved methods at no extra cost to the Owner. All concrete work shall be inspected by the Contractor immediately after the forms are removed and he will promptly report occurrence of any defects to the Engineer. All repair works will be carried out as per the instructions and in the presence of the Engineer or his representative. Generally, repair work will consist of any or all of the following operations :-

- a) Sack rubbing with mortar and stoning with carborundum stone.
- b) Cutting away the defective concrete to the required depth and shape.
- c) Cleaning of reinforcement and embedments. It may be necessary to provide an anti-corrosive coating on the reinforcement.
- d) Roughening by sand blasting or chipping.
- e) Installing additional reinforcement/welded mesh fabric.
- f) Dry packing with stiff mortar.
- g) Plastering, guniting, shotcreting etc.
- h) Placing and compacting concrete in the void left by cutting out defective concrete.
- i) Grouting with a cement sand slurry of 1:1 mix.
- j) Repairing with a suitable mortar either cement or resin modified mortar.
- k) Polymer modified patching and adhesive repair mortar for beams & columns.

### 3.14.02 **Finishing Unformed Surface**

The Contractor is to include in his quoted rate for concrete, the provision of normal finishes in unformed surfaces which can be achieved by screeding, floating, trowelling etc., as and where required by the Engineer without any extra cost to the Owner. A few typical and common cases of treatment of concrete surface are cited below :-

#### a) Floor

Whenever a non-integral floor finish is indicated, the surface of reinforcement concrete slab shall be struck off at the specified levels and slopes and shall be finished with a wooden float fairly smooth removing all laitance. No over-trowelling, to obtain a very smooth surface, shall be done as it will prevent adequate bond with the subsequent finish. If desired by the Engineer, the surface shall be scored and marked without any extra cost to the Owner to provide better bond.

Where monolithic finish is specified or required, concrete shall be compacted and struck off at the specified levels and slopes with a screed, preferably a vibrating type and then floated with a wooden float. Steel trowelling by hand or by rotary power float is then started after the moisture film and shine have disappeared from the surface and after the concrete has hardened enough to prevent excess of fines and water to rise to the surface but not hard enough to prevent proper finishing of aberrations. Steel trowelling properly done will flatten and smoothen sandy surface left by wooden floats and produce a dense surface free from blemishes, ripples and trowel marks. A fine textured surface that is not slick and can be used where there is likelihood of spillage of oil or water can be obtained by trowelling the surface lightly with a circular motion after initial trowelling keeping the steel trowel flat on the surface.

To provide a better grip the Engineer may instruct marking the floor in a regular geometric pattern after initial trowelling.

#### b) Beams, Columns & Walls

If on such or any other concrete structure it is intended to apply plaster or such concrete surfaces against which brickwork or other allied works are to be built, the Contractor shall hack the surface adequately as soon as the form is stripped off so that proper bond can develop. Pattern, adequacy and details of such hacking shall meet with the approval of the Engineer, who shall be informed to inspect such surfaces before they are covered up.

### 3.15.00 **Protection and Curing of Concrete**

Newly placed concrete shall be protected by approved means from rain, sun and wind. Concrete placed below the ground level shall be protected against contamination from falling earth during and after placing. Concrete placed in ground containing deleterious substances, shall be protected from contact with

such ground, or with water draining from such ground, during placing of concrete and for a period of at least three days or as otherwise instructed by the Engineer. The ground water around newly poured concrete shall be kept to an approved level by pumping out or other adequate means of drainage to prevent floatation or flooding. Steps, as approved by the Engineer, shall be taken to protect immature concrete from damage by debris, excessive loadings, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.

As soon as the concrete has hardened sufficiently, it shall be covered either with sand, polythene sheet, hessian, canvas or similar materials and kept continuously wet for at least 14 (fourteen) days after final setting. Curing by continuous sprinkling of water will be allowed if the Engineer is satisfied with the adequacy of the arrangements made by the Contractor.

If permitted by the Engineer, curing compound like "ANTISOLE (WP)" or approved equivalent may be used for prevention of premature water loss in concrete and thereby effecting curing of concrete. This type of curing compound shall be sprayed on newly laid concrete surfaces to form thin film barrier against premature water loss without disturbances to normal setting action. The curing compound shall comply with ASTM requirements for acceptance.

The curing compound shall be applied following the final finishing operation and immediately after disappearance of water sheen from concrete surface. It is important not to apply the curing compound when standing water is still present on concrete.

The contractor shall arrange for the manufacturer's supervision at no extra cost to the owner.

The Contractor shall remain extremely vigilant and employ proper equipment and workmen under able supervision for curing. The Engineer's decision regarding the adequacy of curing is final. In case any lapse on the part of the Contractor is noticed by the Engineer, he will inform the Contractor or his supervisor verbally or in writing to correct the deficiency in curing. If no satisfactory action is taken by the Contractor within 3 (three) hours of issuance of such instruction, the Engineer will be at liberty either to employ sufficient means through any agency to make good the deficiency and recover the cost thereof from the Contractor, or pay for the part where adequate curing was noticed at a reduced rate, entirely at the discretion of the Engineer.

### 3.16.00 Reinforcement

Mild steel round bars, cold twisted and deformed bars as medium tensile or high yield strength steel, plain hard drawn steel wire fabric etc., will be used as reinforcement as per drawings and directions. In an aggressive environment an anti-corrosive coating on the reinforcement may be provided as per IS:9077, as shown on the drawing or as directed by the Engineer.

### 3.16.01 **Bar Bending Schedules**

The Contractor shall submit to the Engineer for approval Bar Bending Schedules with working drawings in triplicate, showing clearly the arrangements proposed by the Contractor to match available stock of reinforcing steel, within one month of receipt of the Letter of Intent or of the receipt of the relevant design drawings, whichever is later. Upon receipt of the Engineer's final approval of the Bar Bending Schedule and drawings, the Contractor shall submit 6 (six) prints of the final drawings with one reproducible print after incorporating necessary modifications or corrections, for final record and distribution. Approval of such detailed drawings by the Engineer shall not relieve the Contractor of his responsibility for correctness nor of any of his obligations to meet the other requirements of the Contract.

### 3.16.02 **Cleaning**

All steel for reinforcement shall be free from loose scales, oil, grease, paint or other harmful matters immediately before placing the concrete.

### 3.16.03 **Cutting & Bending of Reinforcement**

Unless otherwise specified, reinforcing steel shall be bent in accordance with the procedure specified in IS:2502 or as approved by the Engineer. Bends and shapes shall comply strictly with the dimensions corresponding to the approved Bar Bending Schedules. Bar Bending Schedules shall be rechecked by the Contractor before any bending is done.

No reinforcement shall be bent when already in position in the work, without approval of the Engineer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Engineer. Reinforcing bars above 16 mm diameter shall be bent by machine producing a gradual and even motion. Bars of 16 mm or below may be bent by hand. All the bars shall be cold bent unless otherwise approved. Bending hot at a cherry-red heat(not exceeding 845 Deg C) may be allowed under very exceptional circumstances except for bars whose strength depends on cold working. Bars bent hot shall not be cooled by quenching.

Reinforcing bars, whether high yield or mild steel shall be cut using either hand held shears, guillotines or foot operated pneumatic cutters. Cutting bars using cold chisels may be allowed by the Engineer at exceptional cases.

### 3.16.04 **Placing in Position**

All reinforcements shall be accurately fixed and maintained in position as shown on the drawings by such approved and adequate means like mild steel chairs and/or concrete spacer blocks irrespective of whether such supports are payable or not. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by No. 20 G annealed soft iron wire. Tack welding of bars should not be done unless permitted by the Engineer. Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer

bars. They should be spaced such that the main bars do not sag perceptibly between adjacent spacers. Before actual placing, the Contractor shall study the drawings thoroughly and inform the Engineer in case he feels that placement of certain bars is not possible due to congestion. In such cases he should not start placing any bar before obtaining clearance from the Engineer.

3.16.05      **Welding**

Normal bond laps in reinforcement may be placed by lap or butt welding reinforcement bars, if asked by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian Standards for welding of mild steel bars used in reinforced concrete construction as per IS:2751 and IS:456. Welded mesh fabrics conforming to IS:1566 may also be used if specified in the Schedule of Items and Drawings.

3.16.06      **Control**

The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be examined by the Engineer for accuracy of placement and cleanliness. Necessary corrections as directed by him shall be carried out. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length. The laps shall be staggered as far as practicable and as directed by the Engineer. Arrangements for placing concrete shall be such that reinforcement in position do not have to bear extra load and get disturbed.

The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Engineer. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar not leaner than 1 (one) part cement to 2 (two) parts sand by volume and cured in a pond for at least 14 (fourteen) days. The type, shape, size and location of the concrete blocks shall be as approved by the Engineer.

3.17.00      **Cold Weather Concreting**

When conditions are such that any operation of concreting may be expected to be done at 5 Deg.C atmospheric temperature or below the work shall conform to the requirement of Clause 13 of IS:456 and IS:7861. (Part-II).

3.18.00      **Hot Weather Concreting**

When depositing concrete in very hot weather, the Contractor shall take all precautions as per IS:7861 ( Part-I) and stagger the work to the cooler parts of the day to ensure that the temperature of wet concrete used in massive structures does not exceed 40 Deg.C while placing. Positive temperature control by precooling, postcooling or any other method, if required, will be specified and paid for separately.

3.19.00      **Concreting under Water**

When it is necessary to deposit concrete under water it shall be done in accordance with the requirements of clause 13 of IS:456.

3.20.00      **Form Work**

3.20.01      **General**

Formwork shall conform to the shape, grade, lines, levels and dimension as shown on the drawings. The contractor shall prepare design & working drawings for formwork & temporary support system for important structures and get them approved by the Engineer prior to commencement of actual work.

Materials used for the formwork inclusive of the supports and centering shall be capable of withstanding the working load and remain undistorted throughout the period it is left in service. All supports and scaffolds should be manufactured from structural or tubular steel except when specifically permitted otherwise by the Engineer.

The centering shall be true to vertical, rigid and thoroughly braced both horizontally and diagonally. Rakers are to be used where forms are to support inclined members. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as a liquid as well as the working load, in case the Contractor wishes to adopt any other design criteria, he has to convince the Engineer about its acceptability before adopting it. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of slurry or mortar.

To achieve the desired rigidity, tie bolts, spacer blocks, tie wires and clamps as approved by the Engineer shall be used but they must in no way impair the strength of concrete or cause stains or marks on the finished surface. Where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Alternatively, except in case of water retaining structures through rods and the tie bolts shall be sleeved with PVC conduits to allow retraction of the ties on removal of the shutters. Where required, the annulus of the conduits will be filled with expanding mortar to seal the void. Bolts passing completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork shall not be used.

The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of the Engineer immediately and rectified free of charge as directed by him.

For exposed interior and exterior concrete surfaces of beams, columns and wall, plywood or other approved form shall be thoroughly cleaned and tied together with approved corrosion- resistant devices. Rigid care shall be exercised in ensuring that all column forms are plumb and true and thoroughly cross braced to keep them so. All floor and beam centering shall be crowned not less than 8 mm in all directions for every 5 metres span. Unless specifically described on

the drawings or elsewhere to the contrary, bevelled forms 25 mm by 25 mm shall be fixed in the form-work at all corners to provide chamfering of the finished concrete edges without any extra charge. The formwork should lap and be secured sufficiently at the lift joints to prevent bulges and offsets.

Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base of vertical forms and at other places, where they are necessary and as may be directed by the Engineer. The temporary openings shall be so formed that they can be conveniently closed when required, during pouring operations without leaving any mark on the concrete.

### 3.20.02 **Cleaning and Treatment of Forms**

All parts of the forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish, loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before concrete is poured. Compressed air jet and/or water jet along with wire brushes, brooms etc. shall be used for cleaning. The inside surface of the formwork shall be treated with approved non-staining oil based shutter release agent like "Separol/Sika form oil/ Siparol Concentrate" or approved equivalent before it is placed in position. Care shall be taken that oil or other compound does not come in contact with reinforcing steel or construction joint surfaces. They shall not be allowed to accumulate at the bottom of the formwork. The oiling of the formwork will be inspected just prior to placement of concrete and redone wherever necessary.

### 3.20.03 **Design**

The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns and walls are independent of the soffits of beams and can be removed without any strain to the concrete already placed or affecting the remaining formwork. Removing any props or repropping shall not be done except with the specific approval of the Engineer. If formwork for column is erected for the full height of the column, one side shall be left open and built up in sections, as placing of concrete progress. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment and alignment of the formwork and to allow it to be removed gradually without jarring the concrete.

The design of formwork shall take into account all vertical and lateral loads that the forms will carry or be subjected to during the construction process. Besides weight and pressures of reinforced concrete and weight of the forms themselves, the design shall consider loading due to unsymmetrical placement of concrete; impact from dumping of concrete; movement of men and construction equipment; wind action and any other imposed load during construction. The contractor shall assess the magnitude of vertical live load to be taken for design of formwork duly considering his method, sequence and rate of pour of concrete. However, minimum design vertical live load to be considered shall be 750 kg/sqm excluding weight of concrete.



### 3.20.04 Inspection of Forms

Casting of Concrete shall start only after the formwork has been inspected and approved by the Engineer. The concreting shall start as early as possible within 3 (three) days after the approval of the formwork and during this period the formwork shall be kept under constant vigilance against any interference. In case of delay beyond three days, a fresh approval from the Engineer shall be obtained.

### 3.20.05 Removal of Forms

Before removing any formwork, the Contractor must notify the Engineer well in advance to enable him to inspect the concrete if he so desires.

The Contractor shall record on the drawing or in any other approved manner, the date on which concrete is placed in each part of the work and the date on which the formwork is removed therefrom and have this record checked and countersigned by the Engineer regularly. The Contractor shall be responsible for the safe removal of the formwork and any work showing signs of damage through premature removal of formwork or loading shall be rejected and entirely reconstructed by him without any extra cost to the Owner. The Engineer may, however, instruct to postpone the removal of formwork if he considers it necessary.

Forms for various types of structural components shall not be removed before the minimum periods specified herein and the removal after the minimum periods shall also be subject to the approval of the Engineer in each case.

**TABLE-VI**  
**SCHEDULE OF REMOVAL OF FORM**

Part of Structure	Ordinary Portland Cement Concrete				Rapid Hardening Portland Cement Concrete			
	Temperature Deg.C				Temperature Deg.C			
	Above 40°	40° to 20°	20° to 5°	Below 5°	Above 40°	40° to 20°	20° to 5°	Below 5°
	Days	Days	Days	Days	Days	Days	Days	Days
a) Columns & Walls	2	1	1	Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength	1	1	1	Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength
b) Beam sides	3	2	3		2	1	1	
c) Slabs, 125mm	10	7	8		7	4	5	

Part of Structure	Ordinary Portland Cement Concrete				Rapid Hardening Portland Cement Concrete			
	Temperature Deg.C				Temperature Deg.C			
	Above 40°	40° to 20°	20° to 5°	Below 5°	Above 40°	40° to 20°	20° to 5°	Below 5°
	Days	Days	Days	Days	Days	Days	Days	Days
d) Slabs over 120mm thk and soffit of minor beams	18	14	16		12	6	5	
e) Soffit of main beams	24	21	22		14	10	12	

Wherever exposed surfaces of concrete can be effectively sealed to prevent loss of water, the periods specified for temperature above 40 Deg.C can be reduced to those of the temperature range of 20 Deg.C to 40 Deg.C subject to approval of the Engineer.

Construction joints in beams, if required to be provided, will be located within the middle third of span according to clause 3.13.1(b) of this specification. In such cases, however, entire span of beam shall have to be kept supported by formwork till its removal for the portion of beam, cast at a later date, is due and so approved by the Engineer.

If any type of cement other than ordinary portland cement and Rapid hardening portland cement is used the time of removal or forms shall be revised as approved by the Engineer such that the strength of this cement at the time of removal of forms match with strength of portland cement at the time of removal of form as mentioned above. This has to be supported by regular tests.

### 3.20.06 Tolerance

The formwork shall be so made as to produce a finished concrete, true to shape, lines, levels, plumb and dimensions as shown on the drawings subject to the following tolerances unless otherwise specified in this Specification or drawings or directed by the Engineer :-

- |       |    |                     |   |  |
|-------|----|---------------------|---|--|
| For - | a) | Sectional dimension | - | 5 mm                                       |
|       | b) | Plumb               | - | 1 in 1000 of height                        |
|       | c) | Levels              | - | 3 mm before any deflection has taken place |

The tolerance given above are specified for local aberrations in the finished concrete surface and should not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Any error, within the above tolerance limits or any other as may be specially set up by the Engineer, if noticed in any lift of the structure after stripping of forms, shall be

corrected in the subsequent work to bring back the surface of the structure to its true alignment.

3.20.07 **Re-use of Forms**

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

3.20.08 **Classification**

Generally, the 'ordinary' class formwork shall be used unless otherwise directed by the Engineer :-

a) Ordinary :

These shall be used in places where ordinary surface finish is required and shall be composed of steel and/or approved good quality partially seasoned timber.

b) Plywood :

These shall be used in exposed surfaces, where a specially good finish is required and shall be made of approved brand of heavy quality plywood to produce a perfectly uniform and smooth surface conforming to the shape described in the drawing with required grain texture on the concrete. Re-use may only be permitted after special inspection and approval by the Engineer. He may also permit utilisation of used plywood for the 'ordinary' class, if it is still in good condition.

c) Ornamental:

These shall be used where ornamental and curved surface are required and shall be made of selected best quality well seasoned timbers or of plywood, which can be shaped correctly.

3.21.00 **Opening, Chases, Grooves, Rebates, Blockouts etc.**

The Contractor shall leave all openings, grooves, chases, etc. in concrete work as shown on the drawings or as specified by the Engineer.

3.22.00 **Anchor Bolts, Anchors, Sleeves, Inserts, Hangers/  
Conduits/Pipe and Other misc. Embedded Fixtures**

The Contractor shall build into concrete work all the items noted below and shall embed them partly or fully as directed and secure the same as may be required. The materials, if required to be supplied by the Contractor, shall be as specified and be of best quality available according to relevant Indian Standards of approved manufacture and to the satisfaction of the Engineer. Exposed surfaces of embedded materials are to be painted with one coat of approved anti- corrosive paint and/or bituminous paint without any extra cost to the Owner. If welding is to be done subsequently on the exposed surface of

embedded material the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, jigs, fixtures, supports etc. shall be used as may be required or directed by the Engineer, free of cost to the Owner.

Items to be embedded

- a) Inserts, hangers, anchors, frames around openings, manhole covers, frames, floor clips, sleeves conduits and pipes.
- b) Anchor bolts and plates for machinery, equipment and for structural steel work.
- c) Steel structurals to be left embedded for future extension, special connection etc.
- d) Lugs or plugs for door and window frames occurring in concrete work.
- e) Flashing and jointing in concrete work.
- f) Any misc. embedments and fixture as may be required.

Correct location and alignment, as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Contractor.

### 3.23.00 **Expansion and Isolation Joints**

#### 3.23.01 **General**

Expansion and isolation joints in concrete structures shall be provided at specific places as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the Engineer. All materials are to be procured from reliable manufacturers and must have the approval of the Engineer. Where it is the responsibility of the Contractor to supply the material, the Engineer may demand test certificates for the materials and/or instruct the Contractor to get them tested in an approved laboratory free of cost to the Owner. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the Engineer before starting path work.

#### 3.23.02 **Bitumen Board/Expanded Polystyrene Board**

- a) Bitumen Board

Bitumen impregnated fibre board of approved manufacturer as per IS:1838 may be used as fillers for expansion joints. It must be durable and waterproof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size

smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

b) Expanded Polystyrene Boards

If required, commercial quality of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Engineer. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of Bitumen paint may have to be applied on the board against which concrete will be placed.

3.23.03 **Joint Sealing Strips**

Joint sealing strips may be provided at the construction, expansion and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure. The sealing strips will be non-metallic like rubber or P.V.C.

Sealing strips will not have any longitudinal joint and will be procured and installed in largest practicable lengths having a minimum number of transverse joints. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of joint strips of similar make and shape for other jobs. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Engineer. The Contractor is to supply all labour and material for installation including the material and tools required for jointing, testing, protection, etc. If desired by the Engineer, joints in rubber seals may have to be vulcanised.

Non-metallic sealing strips will be normally in Rubber or P.V.C. Rubber or P.V.C. joint seals can be of shape having any combination of the following features :-

- i) Plain
- ii) Central bulb
- iii) Dumb-bell or flattened ends
- iv) Ribbed and Corrugated Wings
- v) V shaped

As these types of seals can be easily handled in very large lengths, transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Engineer.

The method of forming these joints, laps etc. shall be as specified by the Manufacturer and/or as approved by the Engineer taking particular care to match the central bulbs and the edges accurately.

a) Rubber Sealing Strips

The minimum thickness of Rubber sealing strips shall be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings/schedule of items and/or as directed by the Engineer. The material will be natural rubber and be resistant to corrosion, abrasion and tear and also to attacks from the acids, alkalis and chemicals normally encountered in service. The physical properties will be generally as follows. The actual requirements may be slightly different as decided by the Engineer:

Specific Gravity	:	1.1 to 1.15
Shore Hardness	:	65A to 75A
Tensile Strength	:	25 - 30 N/Sq.mm
Maximum Safe Continuous Temperature	:	75 Deg.C
Ultimate Elongation	:	Not less than 350%

b) P.V.C. Sealing Strips

The minimum thickness of P.V.C. sealing strips will be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings/schedule of items and/or as directed by the Engineer. The material should be of good quality Polyvinyl Chloride highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows. The actual requirements, which will be directed by the Engineer, may vary slightly :-

Specific Gravity	:	1.3 to 1.35
Shore Hardness	:	60A to 80A
Tensile Strength	:	10 - 15 N/Sq.mm
Maximum Safe Continuous Temperature	:	70 Deg.C
Ultimate Elongation	:	Not less than 275%

3.23.04 **Joint Sealing Compound**

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS:1834.

Alternatively, when directed, the expansion Joints may be filled with joint sealing compound like "Sikalastic" or approved equivalent and shall be applied as per manufacturer's specification.

3.23.05      **Isolation Joints**

Strong and tough alkathene or PVC sheet or equivalent, about 1 mm in thickness and as approved by the Engineer shall be used in isolation joints. It shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

3.23.06      **Rubber Pad**

Hard foundation quality rubber pads of required thickness and shapes shall be put below machine or other foundations as shown on the drawings or as directed by the Engineer. The rubber shall have a unit weight of 1500 Kg/Cu.m, a shore hardness - 65A to 70A and be of best quality of approved manufacture, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

3.24.00      **Grouting under Machinery or Structural Steel Bases**

If required, grouting under base plates of machines or structural steel etc. shall be carried out by the Contractor. In general, the mix shall be 1 (one) part cement and 1 (one) part sand and just enough water to make it flow as required. The areas to be grouted shall be cleaned thoroughly with compressed air jet and/or with water in locations where accumulated surplus water can be removed. Where directed by the Engineer, 6 mm down stone chips may have to be used in the mix. Surface to be grouted shall be kept moist for at least 24 hours in advance. The grout shall be placed under expert supervision, so that there is no locked up air. Edges shall be finished properly. If desired by the Engineer, admixtures like Aluminium powder, 'Ironite' etc. may have to be added with the grout in proportions to be decided by the Engineer. Admixture, if directed to be added, will be measured and paid separately.

Alternatively non-shrink, free flow, cementitious grout like "Sikagrout 214/ Ankor NSG" or approved equivalent specifically selected for the type of equipment to be located (vibrating, static etc.) may also be used for grouting as per manufacturer's specification with necessary approval of the Engineer.

3.25.00      **Precast Concrete**

The Specification for precast concrete will be similar as for the cast-in-place concrete described herein and as supplemented in this section. All precast work shall be carried out in a yard made for the purpose.

This yard shall be dry, properly levelled and having a hard and even as well as well drained surface to prevent excessive uneven settlement due to softening of soil during casting & curing. If the ground is to be used as a soffit former of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Engineer, casting will have to be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 10 (Ten) days of curing and can be removed for erection after 28 (twenty eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal and must be rigid enough to prevent distortion during placing and compaction of the concrete.

Other than normal curing by applying water through spray nozzles or perforated hose curing by high pressure steam, steam vapour or other accepted processes may also be employed to accelerate the hardening of the concrete and to reduce the curing time.

Lifting hooks, where necessary or as directed by the Engineer, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection.

All members shall be indelibly marked with a unique identification mark on a surface which will not be permanently exposed to show on which production line they were manufactured, their type, the class of concrete, the data of casting and if they are of a symmetrical section the face which will be uppermost when the member is in its correct position after erection.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Engineer. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Engineer. The Contractor shall render all help with instruments, materials and men to the Engineer for checking the proper erection of the precast units.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the Engineer. If centerings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before 14 (fourteen) days. The joint between precast roof planks shall be pointed with 1:2 cement : sand mortar where called for in the drawings.

### 3.26.00 **Waterproofing of Concrete Structure**

#### 3.26.01 **General**

Waterproofing of concrete structures shall be done by either suitable extraneous treatments like applying waterproofing paints like "Sikatop Seal" or approved equivalent, fixing bitumen felts etc. or internally by suitable design of the concrete mix, addition of suitable admixtures conforming to IS:2645 and equivalent American or British codes in the concrete or mortar at the time of mixing and/or installing water bars at the joints.



The design, material and workmanship shall conform to the relevant I.S. Codes where applicable. The Engineer's approval of the materials shall be obtained by the Contractor before procurement. If desired by the Engineer, test certificates for the materials and samples shall be submitted by the Contractor free of charge. The materials shall be of best quality available endogenously, fresh clean and suitable for the duties called upon.

### 3.26.02 **Water Bar/Seal/Special Treatment of Construction Joint**

Water bearing structures and underground structures may have water bar/seals installed at the joints. They may be rubber or P.V.C. The materials and installation will be as described under Clause 3.23.3. Construction joint should be provided as per clause 3.13.1 with or without water bar/Seal as shown on the drawing. In case of water bars being used at the construction Joint, fixing of the same has to be done carefully so that the water bar is not disturbed during concreting. The construction joint shall also be treated by any one of the following methods :

**Method 1 :** A surface retarder in the form of a thixotropic gel shall be applied on the joint surface of the previous pour in case of joint on the wall and in case of floor the same shall be applied on the formwork against which previous pour of concreting shall be done. The retarder may be liquid or paste form depending on the type of formwork. The formwork shall be removed within 24 hours after concreting. Within 2 hours of striking of the formwork the retarder shall be washed off with strong water jet to make surface rough and clean. Then a rich cement mortar using cement, sand and aggregates (maximum size 8 mm) along with synthetic rubber emulsion type water resistant bonding agent shall be applied for a depth of 50 mm just before pouring the next stage of concreting in case of walls. The above bonding agent will be mixed with water which will be used for making the cement mortar. The proportion of mixing of this bonding agent with water shall be as per manufacturer's specification. In case of floor joint, however, after washing of retarder a solvent free two component epoxy resin bonding agent will be used at the joint before the next pour of concrete. The above bonding agent shall have the following properties after 28 days:

Compressive strength	-	55 to 60 N/Sq. mm
Flexural Strength	-	25 to 30 N/Sq. mm.
Tensile strength	-	15 N Sq. mm (approx)
Bonding strength to concrete	-	3 N/Sq. mm (approx)
Bonding strength to steel	-	20 N/Sq. mm (approx)

The whole operation shall be done as per manufacturer's specification. The contractor shall provide manufacturer's supervision at no extra cost to the owner.

**Method 2 :** One row of threaded nozzles at regular intervals not exceeding 1.5 m centre to centre shall be placed in concrete along the construction joint during casting. Injection of cement water together with a suitable waterproof expanding grouting admixture of approved quality shall be done through the nozzles after the construction joint in walls and slabs. The injection shall be done under pressure of approximately 2 to 4 Kg/Sq cm. The nozzles shall be sealed off with suitable admixture after the injection is over. The whole operation shall be carried out as per manufacturer's specification and supervision. The cost of such manufacturer's supervision shall be borne by the contractor.

### 3.26.03 **Waterproofing Admixtures**

The waterproofing admixture for concrete and cement mortar/plaster shall conform to relevant IS code. The admixture shall not cause decrease of strength of concrete/plaster at any stage and it is free from chlorides and sulphates. the admixture shall not affect the setting time by more than 5%.

The maximum permissible dosage of admixture will be 3 % (three percent) by weight of cement but a lower dosage will always be preferred.

The product shall be stored in strong moisture proof packings.

However, in case of important structures where M25 or higher grade concrete is specified, the use of melamine based, high range water resistant concrete admixture shall be used to provide a waterproof concrete around 410 Kg/Cm.m a melamine based super plasticizer will be preferable.

#### a) In concrete :

The approved admixture shall be based on modified ligno-sulphonate like "Plastocrete - N/Super" or approved equivalent. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Engineer. The Contractor shall have the services of the manufacturer's supervisor at no extra cost to the Owner to supervise the work, if desired by the Engineer.

#### b) In Plaster :

The concrete surface, to be plastered, shall be hacked to Engineer's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture like "Noleek CP/Sika Latex" or approved equivalent and laid in appropriate thickness and in layers not exceeding 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by the Engineer. If desired by the Engineer, the Contractor shall have the work supervised by the manufacturer's supervisor at no extra cost to the Owner. On completion, the plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

### 3.26.04 **Bituminous or Tar Coating on External Surface**

The surface to be waterproofed shall be rendered absolutely dry, clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacturer and quality as per IS:216 (not heated above 375 Deg.F) using not less than 2 Kg. per Sq.M. or with hot asphalt i.e., bitumen according to IS:73 (not heated above 400 Deg.F) using not less than 1.5 kg. per Sq.M. When the first coat has completely dried up and approved by the Engineer, the second coat shall be applied in the same manner using not less than 1.25 Kg. per Sq.M. in case of coal tar and 1 Kg. per Sq.M. in case of asphalt. Immediately after application of the second coat and before it is dried up, sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand before backfilling is done in order to allow the final coat to dry up completely. In place of hot application by coal tar/asphalt the coating of the outside surfaces of walls may be carried out using a ready to use liquid, bituminous emulsion/rubber protective coating of approved manufacturer.

**3.26.05 Protective Coating on Inside Surface**

Two coats of cement based to components polymer modified flexible protective and waterproofing slurry having 1 mm thick for each coat shall be applied on the walls/floor after proper surface preparation as mentioned above. The slurry shall be applied by brush.

**3.26.06 Bitumen Felt : Application for Tanking**

This specification shall cover laying the waterproof course on the outside and inside of the walls and bases of structures.

The materials shall conform to IS:1322, and the workmanship to IS:1609. The bitumen felt shall be hessian base and/or fibre base as specified in Drawing/Schedule of Items. If required by the Engineer, tests as specified in relevant IS Codes shall be arranged by the Contractor without charging any extra to the Owner.

The Contractor shall execute this work in direct collaboration with one of the well known specialised firm approved by the Engineer.

Cleaning the surface, keeping it dry, providing necessary corner fillets and cement rendering and cutting chases, etc. shall be included in the rate for this item. If any protective brickwork on/against concrete sub-bases or walls are required, these will be paid extra under suitable items in the contract. A 20 (twenty) years' guarantee for satisfactory performances shall be given by the Contractor as well as his specialist sub-contractor jointly and severally, for this item of work. Free rectification of any defects noted in the work within this guarantee period will be carried out by the Contractor even if it is beyond the specified maintenance period of the contract as a whole.

### 3.26.07 Polyethylene Films

Application in Walls or base of Structures

Waterproof treatment shall be applied as outlined and as per sequence given hereunder:

- i) The concrete surface shall be made smooth with 12 mm cement plaster 1:6
- ii) Apply hot bitumen 80/100 grade (IS:73-1961) at the rate of 1.0 Kg/Sq.m minimum.
- iii) Lay black polyethylene film 250 micron (IS:2508-1977) with cut back bitumen adhesive in overlaps over hot bitumen surface, gently pressed, taking care not to puncture the film.

Alternatively, the overlaps shall be heat sealed by an electric iron having three parallel sealing bars. A long piece of plywood is to be placed below the polyethylene film to be heat sealed. On the plywood a rubber gasket is to be laid to provide a cushion for better welding of the film. On the rubber padding, a cellophane tape is to be spread and on this the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another cellophane tape is to be placed to prevent the heat sealer from sticking to the LDPE film. After this, the electric iron is to be pressed on the overlap joint for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of joints. After heat sealing, the cellophane tape is to be removed and the joints are to be tested for leaks.

- iv) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen.
- v) Lay hot bitumen 80/100 grade (IS:73-1961) at 1.0 Kg/Sq.m minimum.
- vi) Lay 250 micron polyethylene film as second layer similar to (iii) above.
- vii) Lay second layer of 100 gm. brown craft paper laminated similar to (iv) above.
- viii) Apply hot bitumen (straight run grade) to IS:73-1961 at 1.0 Kg/Sq.m dusted with fine sand.
- ix) Protecting with a layer of 75 mm plain cement concrete M-100, or a layer of brick laid in cement mortar 1:6. In case of wall apply a 12 mm thick plaster as shown on the drawing or a protective brick wall in 1:6 cement mortar as shown on the drawing.

3.27.00 **Protective coating on Concrete Surface**

3.27.01 **On Foundation**

The outside faces of foundation of important structures will be protected from adverse effect of soil/underground water, if shown on drawing or instructed by the Engineer, by using rubber/bitumen emulsion protective coating of approved manufacturer.

3.28.00 **Waterproofing by Pressure/Chemical Grouting**

Where required, waterproofing for underground concrete structure shall be done by injecting high polymer based non-shrink waterproof grouting compound through nozzle under pressure as per manufacturer's recommendation. The pressure during injection shall not be less than 2.5 kg/Sq.cum and the thickness of epoxy resinous emulsion waterproof paint (to be applied on the external surface of walls/slabs) shall not be less than 700 microns.

4.00.00 **SAMPLING AND TESTING**

4.01.00 **General**

The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in this specification. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

4.02.00 **Cement**

Representative samples will be taken from each consignment of cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths. Soundness Tests may also be required to be carried out if required by the Engineer. The tests shall be carried out free of charge by the Owner if cement is supplied by him. In case the Contractor is directed to arrange for the supply of cement as per the terms and conditions of the Contract the tests shall be carried out by him without any expense to the owner. In case due to any circumstances, the agency of supply is changed in the middle of the Contract, the party who bore the original contractual obligation will carry on with the test, free of charge to the other, till the end of the job. No cement from a particular consignment/batch will be used on the works unless satisfactory 3 (three) days and 7 (seven) days test results for compressive strength are known. The Owner, Engineer and Contractor will jointly associate themselves with the tests irrespective of whether they are carried out by the Owner or the Contractor. These tests are of great importance as their results will have a bearing on the acceptance of concrete or otherwise as per the terms and conditions of the Contract.

4.03.00      **Aggregates**

The Contractor shall carry out any or all the tests aggregates as may be required by the Engineer in accordance with IS:2386 PARTS-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

4.04.00      **Water**

Sampling and Testing of water being used for concrete works as per IS:3550 will be carried out by the Contractor at regular intervals and whenever directed by the Engineer. The final acceptance criteria in case of doubt will be as per IS:3025 & IS:456.

4.05.00      **Admixture**

4.05.01      **Air Entraining Agents (A.E.A)**

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cube crushing strength vis-a-vis quantity of A.E.A. used for all types of concrete will be established by the Contractor free of charge by carrying out sufficiently large number of tests. After than, at regular intervals and whenever directed by the Engineer, the Contractor will check up free of charge, the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results.

4.05.02      **Other Admixtures**

Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the Contractor free of charge to the Owner.

4.06.00      **Concrete**

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS:516 and IS:1199 the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed but under special circumstances the Engineer may require other tests to be performed in accordance with IS:516.

Sampling procedure, frequency of sampling and test specimen shall conform to Clause 14 of IS:456.

To control the consistency of concrete from every mixing plant, slump tests and/or compacting factor tests in accordance with IS:1199 and as mentioned in Clause 3.6 of this Specification shall be carried out by the Contractor every two hours or as directed by the Engineer. Slumps corresponding to the test specimens shall be recorded for reference.

The acceptance criteria of concrete shall be in accordance with Clause 15 of IS:456.

Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant formwork and reinforcement, embedded fixtures, etc. wasted in the dismantled portion shall be made. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Engineer.

5.00.00      **ACCEPTANCE CRITERIA**

5.01.00      **Standard Deviation**

Standard deviation shall be based on test results and determination of Standard deviation shall conform to clause 14.5 of IS:456.

5.02.00      **Acceptance Criteria**

The strength requirements and acceptance criteria shall conform to Clause 15 of IS:456.

5.03.00      **Inspection and Core Tests**

Inspection of concrete work immediately after stripping the formwork and core test of structures shall conform to Clause 16 of IS:456.

5.04.00      **Load Test**

Load tests of structural members may be required by the Engineer, when the strength of test specimen results fall below the required strength, as per 'Load Test on Parts of Structures', Clause 16.5 of IS:456. If load testing is decided by the Engineer, the member under consideration shall be subjected to a test load equal to 1.25 (one and a quarter) times the specified live load used for design and this load shall be maintained for a period of 24 (twenty four) hours before removal. The detailed procedure of the test is to be decided by the Engineer. Load tests shall not be made until the structure is at least 56 days old.

If the member shows evident failure, such changes as are necessary to make the structure adequately strong shall be made by the Contractor free of cost to the Owner. Alternatively, if permitted under Statutory Regulations and at the discretion of the Engineer, the structure under test or a portion thereof may be retained as such without any modification by derating its load bearing capacity, provided the design criteria allows such derating.

A reinforced concrete beam, floor or roof shall be deemed to have passed the test if the maximum deflection at the end of 24 hours does not exceed the deflection given in Clause 16.5 of IS:456.

The entire cost of load testing shall be borne by the Contractor. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification. The entire cost of dismantling and replacement and restoration of the site being borne by the Contractor.

If, in the course of dismantling, any damage is done to the embedded items

and or other adjacent structures, the same will be made good, free of charge by the Contractor to the satisfaction of the Engineer.

6.00.00      **RATES**

The rate for any item in the schedule, unless specifically excluded in the contract, shall be deemed to include the cost of all materials consumed or used in the work or incidental to it as well as labour, tools, plants, equipment, templates, supports, scaffolds, approaches, security & safety measures, power, fuel, lubricants, storage, handling, transport, testing, insurances, taxes, royalties and other revenue expenses, accommodation, services, supervision, overheads, profits etc. The various items of work which are to be provided are mentioned under Clause 2.1 and elsewhere in this specification. If no separate item is provided for any such work in the schedule of items, it is implied that the contractor shall not claim for any of the connected items of the schedule viz., detailed drawings and drawing of formwork in the item of formwork or concrete etc.

7.00.00      **METHOD OF MEASUREMENT**

7.01.00      **Concrete**

- a) Actual volume of work as executed or as per drawings issued, whichever is less, shall be measured in Cu.M. Deductions for openings, conduits, pipes, ducts, pockets, chases etc. shall be made, provided they are larger than 0.1 Sq.M. in area each.

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

- b) Precast concrete work shall be measured in the same way as specified in foregoing paragraph. No separate payment shall be made for formwork. Lifting hook where required in the design, shall be treated as reinforcement steel and paid accordingly. Payment shall be due only after erection, grouting and curing of the precast units in proper position unless otherwise provided for in the contract. All breakages and damages of the precast units will be to the Contractor's account and shall be replaced free of charge to the Owner.

7.02.00      **Admixture**

Admixture will be measured on the basis of theoretical requirement or actual consumption, whichever is less.

7.03.00      **Reinforcement**

- a) Bar or any other type of reinforcement used like Hard drawn steel wire fabric etc. for reinforced concrete shall be measured by weight in Tonnes. The weight will be arrived at by multiplying the actual or theoretical length, whichever is less, by the sectional weights. In case the Owner issues the reinforcing steel, the sectional weights will be the same as were applied at the time of issue. In case the steel is to be supplied by the Contractor, the sectional weight to be adopted will be



the I.S. Sectional Weight or as per actuals which will be arrived at by accurately measuring representative samples as directed by the Engineer, whichever is less.

- b) Standard hooks, cranks, bends, authorised laps etc. shall be measured.
- c) Lap welding or butt welding if permitted will be measured diameter wise per joint. The actual length of steel in lap will be measured separately in case of lap welding. The rate quoted for the smaller size bar will be applied in case of joint between two bars of different diameters.
- d) Separator pieces between two or more layers of steel shall be measured.
- e) No payment shall be made for binding wires, spacer block, supports, chairs, hangers, etc. of height 300 mm and less, required for keeping the steel in position unless otherwise specified in the contract. For supporting horizontal reinforcement at heights larger than 300 mm support drawings will be prepared by the Contractor and payment will be made for the supports as approved by the Engineer, or as actually placed, whichever is less, at the same rate as for reinforcement.
- f) No extra will be paid for modification of already embedded reinforcement, if required due to faulty fabrication or placement.
- g) Dowels neither shown on the drawings nor instructed by the Engineer, but required for construction facilities and/or sequence, shall not be measured.

7.04.00 **Formwork**

- a) Formwork shall be measured as the actual surface in contact with the concrete and paid in Sq.M. unless included in the rate for concrete.
- b) Formwork shall not be measured separately for precast concrete work, which shall be included in the concrete rates.
- c) No payment for formwork or any other requirements in construction joints shall be made.
- d) Openings upto 0.1 Sq.M. shall be neglected as if non- existent for the purpose of formwork measurement.
- e) No extra measurement or payment shall be made for making the formwork waterproof or for supports, scaffolding, centering, approaches, etc.
- f) No measurement shall be taken for the formwork in pockets, openings, chases etc. in concrete if the cross-sectional area is less than or equal to 0.1 Sq.M. in each case. If the cross-sectional area of any opening exceeds 0.1 Sq.M. the formwork shall be measured under appropriate classification.
- g) Fixing and removing pockets and openings of sectional area less than

0.1 Sq.M. shall be measured on number basis and paid separately.

7.05.00      **Anchor Bolts, Anchor Sleeves, Inserts, Hangers, Conduit Pipes and Other Miscellaneous Embedded Fixtures**

- a) These will be measured on theoretical weight basis of the complete insert handled by the Contractor irrespective of the amount of insertion. Where theoretical weight cannot be assessed satisfactorily, the actual weight shall be allowed under certification of the Engineer.
- b) No extra shall to be paid for templates and other arrangements required to secure these in position. The protection of these materials with proper anticorrosive paints/grease and covering with gunny bags against any damages till the structure is handed over, shall be the responsibility of the Contractor at no extra cost.
- c) Any 'boxing' left for inserts, etc. during construction, for facility of the Contractor's work, and later on filled in by the same Contractor after placing the insert shall be considered for measurement purpose, as if the inserts, etc. were placed before concreting.
- d) No extra payment shall be made for cleaning of the inserts, etc. required for bond with the concrete.

7.06.00      **Expansion and Isolation Joints**

- a) Expansion and isolation joints will be measured and paid on area basis. The drawings and or schedule of items will describe the thickness, painting, filling material, sealing strips, metal fixtures, inserts, etc. to be used in the joint.
- b) Formwork for the 'leading side' of the joint will be measured and paid under the relevant item. No payment for the formwork for the 'following side' will be made even if the Contractor is required to use formwork for constructional facilities.
- c) Any other fixtures and inserts installed as per drawing, riding plates etc. will be measured and paid if under the respective items of the Schedule of Items.
- d) All other work like installing Bitumen coating, Bitumen boards, Expanded Polystyrene Boards, Alkathene sheets, Bitumen filler etc. and trimming the top, repairs, finishes and other connected items will be deemed to be included in the unit rate for Expansion/Isolation Joints.

7.07.00      **Joint Seals : Rubber or P.V.C.**

All seals, whether used as water bars or in Expansion or Isolation joints shall be measured as Joint seals and on area basis. In case of Rubber and P.V.C. seals developed area will be measured but the central bulb, corrugation ribs etc. will be neglected. In all cases laps will not be measured.

7.08.00      **Rubber Pad**

Rubber pads below foundations will be measured on area basis. The theoretical or actual area, whichever is less, will be recorded.

**7.09.00 Grouting under Base Plates etc.**

Grouting shall be measured on theoretical volume basis neglecting the volume of embedded items. The cost shall include the cost of hacking the old concrete plus necessary formwork if any. Edges of the grouting shall be measured square even if chamfered. Necessary curing shall also be included. Admixtures, if added, will be measured and paid separately under the relevant items.

**7.10.00 Waterproof Plaster**

The measurement will be on finished square area basis. The thickness, method of applications, waterproofing additive to be used etc. will be specified in the specification/drawings/schedule of items.

The waterproofing additive will be measured and paid separately under admixtures (Clause 7.2). No deduction will be made for opening less than 0.1 Sq.M. in area each.

**7.11.00 Bitumen Coating/Tar coating/Bituminous or Rubber Protective Coating**

These shall be measured on net useful area, neglecting openings upto 0.1 Sq.M. in area each.

**7.12.00 Bitumen Felt**

Bitumen felt waterproofing shall be measured net on area of structure covered, neglecting openings upto 0.1 Sq.M. in area each, measuring only once for the completed work and not once for each layer.

**7.13.00 Polyethylene Film**

Polyethylene Film waterproofing shall be measured net on area of structure covered, neglecting openings upto 0.1 Sq.m in area each, measuring only once for the completed work and not once for each layer.

**7.14.00 Tests**

- a) Tests on concrete specimens shall be included in the rates for concrete and no separate payment shall be made for the specimens and testing
- b) No payment shall be made for tests carried out for approval of samples of different materials in accordance with the specification.
- c) Load Test, if required to be made as per terms and conditions of the contract, shall not be paid.

**8.00.00 LIST OF IS : CODES AND STANDARDS FOR REFERENCE**

All work under this specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not specifically covered by Indian Standard Specifications, any other standard practice, as may be specified by the Engineer, shall be followed :-

- |           |   |  |
|-----------|---|--|
| IS : 73   | - | Indian Standard Specification for Paving Bitumen   |
| IS : 216  | - | Indian Standard Specification for Coal Tar Pitch   |
| IS : 269  | - | Indian Standard Specification for 33 grade Ordinary Portland Cement  |
| IS : 383  | - | Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete   |
| IS : 432  | - | Indian Standard Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete Reinforcement - Part 1 & 2 |
| IS : 455  | - | Indian Standard Specification for Portland Slag Cement   |
| IS : 456  | - | Indian Standard Code of Practice for Plain and Reinforced Concrete   |
| IS: 457   | - | Indian Standard Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and other Massive Structures             |
| IS : 516  | - | Indian Standard Specification for Methods of Test for Strength of Concrete   |
| IS : 737  | - | Indian standard specification for wrought Aluminium and Aluminium Alloy sheet and strip for general Engineering purpose.                     |
| IS : 1199 | - | Indian Standard Specification for Methods of Sampling and Analysis of Concrete   |
| IS : 1200 | - | Indian Standard Specification for Method of (Part-II) Measurement Cement Concrete Works.   |
| IS : 1200 | - | Indian Standard Specification for Method of (Part-V) Measurement of Formwork   |
| IS : 1322 | - | Indian Standard Specification for Bitumen Felts for Waterproofing and Damp-proofing  |
| IS : 1489 | - | Indian Standard Specification for Portland - Pozzolona Cement - Part 1 & 2   |
| IS : 1566 | - | Indian Standard Specification for hard drawn steel wire fabric for concrete reinforcement.   |

IS : 1609	-	Code of Practice for Laying Damp-proof Treatment using Bitumen Felts.
IS : 1786	-	Indian Standard Specification for high strength deformed Bars & wires for Concrete Reinforcement.
IS : 1791	-	Indian Standard Specification for Batch Type Concrete Mixers.
IS : 1834	-	Indian standard specification for hot applied sealing compound for joint in concrete.
IS : 2062	-	Steel for general structural purpose.
IS : 2185	-	Indian Standard Specification for Hollow and solid/ solid light wt. Cement Concrete Blocks - Part-1&2.
IS : 2210	-	Indian Standard Specification for Design of Reinforced Concrete Shell Structures and Folded Plates
IS : 2386	-	Indian Standard Specification for Methods of Test for Aggregates for Concrete - Part-I to VIII
IS : 2430	-	Indian standard specification for method of sampling of Aggregate for concrete.
IS : 2502	-	Indian Standard Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement
IS : 2505	-	Indian Standard Specification for Concrete Vibrators Immersion Type
IS : 2506	-	Indian Standard Specification for Screed Board Concrete Vibrators
IS : 2514	-	Indian Standard Specification for Concrete Vibrating Tables
IS : 2645	-	Integral Cement water proofing compound
IS : 2722	-	Indian Standard Specification for Portable Swing Weigh Batchers for Concrete (Single and Double Bucket type)
IS : 2751	-	Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction
IS : 2770	-	Indian Standard Specification for Method of Testing Bond in Reinforced Concrete. Part - 1 : Pull out Test
IS : 3025	-	Indian Standard Specification for Methods of Sampling and Test (Physical and Chemical) for Water & waste

water - part-1 to 37

IS : 3201	-	Indian Standard Specification for Design and Construction of Precast Concrete Trusses and purlins.
IS : 3370	-	Indian Standard Specification for Code of Practice for Concrete Structures for Storage of Liquids Part 1 to 4
IS : 3384	-	Indian standard specification for/Bitumen primer for use in waterproofing and Damp proofing
IS : 3414	-	Code of practice for Design and Installation of joints in Buildings
IS : 3550	-	Indian Standard Specification for Method of Test for Routine Control for Water used in Industry
IS : 3558	-	Code of Practice for use of Immersion Vibrators for Consolidating Concrete
IS : 3696	-	Safety Code for Part-1 : Scaffolding and Part 2: Ladders
IS : 3812	-	Indian Standard Specification for Fly Ash for Use as Pozzolona & Admixture
IS : 4031	-	Indian Standard Specification for Method of Tests for Hydraulic Cement - Part - 1 to 14
IS : 4082	-	Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site
IS : 4090	-	Indian Standard Specification for Design of Reinforced Concrete Arches
IS : 4634	-	Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixers
IS : 4656	-	Indian Standard Specification for Form Vibrators for Concrete
IS : 4925	-	Indian Standard Specification for Concrete Batching and Mixing Plant
IS : 4926	-	Indian Standard Specification for Ready Mixed Concrete
IS : 4990	-	Indian Standard Specification for Plywood for Concrete Shuttering work
IS : 4991	-	Indian Standard Specification for Blast Resistant Design of Structure for Explosion above ground
IS : 4995	-	Indian Standard Specification for Design (Part-I&II)of Reinforced Concrete Bins for the Storage of Granular and

Powdery Materials

IS : 4998	-	Indian Standard Specification for Design of (Part-I) Reinforced Concrete Chimneys
IS : 5512	-	Indian Standard Specification for Flow Table for use in Tests of Hydraulic Cement and Pozzolanic Materials
IS : 5513	-	Indian Standard Specification for Vicat Apparatus
IS : 5515	-	Indian Standard Specification for Compaction Factor Apparatus
IS : 5751	-	Indian Standard Specification for Precast Concrete Coping Blocks
IS : 5816	-	Indian Standard Specification for Method of Test for Splitting Tensile Strength of Concrete Cylinders
IS : 5891	-	Indian Standard Specification for Hand Operated Concrete Mixers
IS : 6452	-	Indian Standard Specification for High Alumina Cement for Structural Use
IS:6909	-	Indian Standard Specification for Supersulphated Cement
IS : 6923	-	Indian Standard Specification for Method of Test for performance of Screed Board Concrete Vibrators
IS : 6925	-	Indian Standard Specification for Method of Test for Determination of Water Soluble Chloride in Concrete Admixtures
IS : 7242	-	Indian Standard Specification for Concrete Spreaders
IS : 7246	-	Indian Standard Specification for Table Vibrators for Consolidating Concrete
IS : 7251	-	Indian Standard Specification for Concrete Finishers
IS : 7320	-	Indian Standard Specification for Concrete Slump Test Apparatus
IS : 7861	-	Indian Standard Specification for (Part-I&II) Recommended Practice for hot and cold Weather Concreting
IS : 7969	-	Safety Code for Storage and Handling of Building Materials
IS : 8041	-	Indian Standard Specification for Rapid Hardening Portland cement

IS : 8043	-	Indian standard specification for hydrophobic cement
IS : 8112	-	Indian Standard Specification for 43 grade Ordinary Portland Cement
IS : 8142	-	Indian Standard Specification for Determining Setting time of Concrete by Penetration Resistance
IS : 8989	-	Safety Code for Erection of Concrete Framed Structures
IS:9013	-	Indian Standard Specification for Method of Making, Curing and Determining Compressive Strength of Accelerated - cured Concrete Test Specimens
IS : 9077	-	Code of Practice for Corrosion Protection of Steel Rails in RB and RCC Construction
IS : 9103	-	Indian Standard Specification for Admixtures for Concrete.
IS: 9417	-	Recommendation for welding cold worked bars for reinforced concrete construction
IS : 10262	-	Recommended Guideline for concrete Mix Design
IS : 12269	-	Indian standard specification for 53 grade ordinary portland cement
IS : 12330	-	Indian standard specification for sulphate resisting portland cement
IS : 12600	-	Indian standard specification for low heat portland cement



**SPECIFICATION NO. C-6**

**FOR**

**DRIVEN PRECAST CONCRETE PILE**

**SPECIFICATION NO. C-6  
FOR  
DRIVEN PRECAST CONCRETE PILE**

**C O N T E N T S**

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**SPECIFICATION NO. C-6  
FOR  
DRIVEN PRECAST CONCRETE PILE**

**1.00.00 SCOPE**

This Specification deals with the requirements regarding materials, workmanship, casting, curing, handling, transportation and driving of precast concrete piles (both vertical and raker) and all related items of work like surveying, layout of piles, sand filling in holes (considering driving of precast piles into the ground using follower) after driving of the piles, lengthening of the piles, redriving of the piles, jetting, and load testing of the piles, etc.

IS:2911 (Part I/Sec.3) shall form a part of this Specification and shall be complied with unless they are at variance with the Specification where the latter will prevail.

**2.00.00 GENERAL**

**2.01.00 Work to be Provided by the Contractor**

Work to be provided for by the Contractor, unless otherwise specified, shall include but not be limited to the following :

- a) Furnish all labour, supervision, services, materials, forms, templates, supports, approaches, aids, construction equipment, tools and plants, transportations, etc. required for the work.
- b) Prepare and submit for approval detailed drawings and bar bending schedules for reinforcement bars showing the positions and details of spacers, supports, etc.
- c) Submit for approval detailed scheme of all operations required for executing the work e.g. Material handling, casting, curing, handling, transporting, driving, testing, services, approaches, sand filling of holes etc.
- d) Design and submit for approval concrete mix designs required to be adopted for the job.
- e) Furnish samples and submit for approval results of tests for various properties e.g. various ingredients of concrete, concrete cubes etc.
- f) Supply & install the pile shoes made of chilled cast iron of approved design.
- g) Supply and paint Bitumen coating, if required, on the outer surfaces of the piles prior to their driving, as per schedule of items.
- h) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings, specifications and schedule of items.

2.02.00      **Work to be Provided by Others**

No work under this specification shall be provided by any agency other than the Contractor, unless specifically mentioned otherwise elsewhere in the contract.

2.03.00      **Codes and Standards**

All work under this Specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of Practices.

IS-269	:	I.S. Specification for ordinary, and Low Heat Portland Cement.
IS-383	:	I.S. Specification for Coarse and Fine Aggregates from Natural Source for concrete.
IS-432	:	I.S. Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement.
IS-456	:	I.S. Code of Practice for Plain and Reinforced Concrete.
IS-516	:	I.S. Specification for Methods of Test for Strength of Concrete.
IS-1199	:	I.S. Specification for Methods of Sampling and Analysis of Concrete
IS-1786	:	I.S. Specification for Cold-twisted Steel Bars for Concrete reinforcement.
IS-2386	:	I.S. Specification for Methods of Test for Aggregates for Concrete - Part - I to VIII.
IS-2502	:	Codes of Practice for Bending and Fixing of Bars for concrete Reinforcement.
IS-2751	:	Code of practice for welding of mild steel bars used for Reinforced concrete construction.
IS-2911 (Part-I/ Sec.3)	:	Code of practice for Design and Construction of Pile Foundations. Driven Precast Concrete Piles.
IS:2911 (Part-IV)	:	Code of Practice for Design and Construction of Pile Foundations - Load Test of Piles.
IS:3558	:	Code of Practice for use of immersion Vibrators for Consolidating Concrete.
IS-6999	:	I.S. Specifications for super-sulphated cement.

IS-8112 : I.S. Specification for high strength Ordinary Portland Cement.

2.04.00 **Conformity with Design**

The Contractor will prepare check lists in approved proforma which will be called "Pile Installation Cards". At each important stage of the work as decided by the Engineer, the work will be checked and approved by the Engineer for Correctness and conformity with the design, Specifications and drawings, before allowing the next phase of the work to commence. The intermediate checks and approval by the Engineer will not, however, absolve the Contractor from his total responsibility to execute the work as per the specification and drawings and remove and/or rectify all work which is defective or inaccurate.

2.05.00 **Materials**

2.05.01 **Cement**

Cement used shall conform to IS:269 (or Portland Cement), IS:455 (Slag cement), IS:6909 (Supper-sulphated cement) or any other I.S. Specification as indicated in the schedule of items.

2.05.02 **Aggregates**

Aggregates both fine and coarse shall comply with requirements of IS:383. Size of coarse aggregates shall be selected considering the size of section. Generally 20 mm down coarse aggregate shall be used.

2.05.03 **Steel**

Reinforcement Steel shall conform to IS:432 (Part-I) and IS:1786.

2.05.04 **Concrete**

Controlled concrete grade M30 shall be used for the piles, unless specified otherwise in the schedule of items. Water/cement ratio including water contained in aggregates shall not be more than 0.45. However, minimum cement content and corresponding W/c ratio shall be determined by trial mix design and as approved by the Engineer. Materials and methods of manufacture of concrete shall be in accordance with IS:456. In addition, the materials shall have special resistance against sulphate attack where subsoil conditions warrant it.

2.05.05 **Water**

Clear water, free from acids and other impurities, shall be used for the manufacture of concrete. Normally potable water is found to be suitable.

2.06.00      **Storage of Materials**

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Engineer shall not be used, failing which, the Engineer shall be at liberty to get the materials removed and the cost increased thereof shall be realised from the Contractor's dues.

2.07.00      **Quality Control**

The Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same. The requirements will include but not be limited to the following :

- a)      Casting of piles
- b)      Inspections of piles
- c)      Location and Plumb : Control survey for accuracy in plan and check for verticality.
- d)      Driving : Correlation of weight of hammer, length of stroke, number of strokes per minute and rate of penetrations.
- e)      Load tests.

3.00.00      **INSTALLATION**

All installation requirements shall be in accordance with IS:2911 (Part-I/ Sec. 3) latest edition and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification might not have covered all this aspects to the full satisfaction of the Engineer.

3.01.00      **General**

The tenderer shall furnish complete information about the type of piles offered, method of driving of piles, details and availabilities of driving equipment, formula or data curve on which the tenderer bases the load carrying capacity of piles as well as the criteria for determining suitable and sufficient` founding'of individual piles and any other relevant details.

The Contractor shall acquaint himself fully about the nature of the soil encountered from bore hole logs or any other data as available with the owner. All piles will have to be driven to the required set and/or based on load tests, as decided by the Engineer. In case the Contractor is required to drive piles to greater or shallower depths than that is envisaged the rates will be adjusted as per relevant items in Schedule of Items and no other extra claims will be entertained. The tenderer should, in his own interest, investigate the site thoroughly and take additional bore holes if he feels it necessary to assess the type of equipment to be used and the depths to which the piles may have to be driven finally.

### 3.02.00 Casting and Curing

Precast concrete piles shall be square with chamfered edges. (25mm x 25mm) and conical bottom. The top edges of all piles shall also be chamfered (25mm x 25mm).

Before placing in moulds, the steel skeletons shall be accurately fabricated and assembled away from the moulds, complete with metal shoe if specified, accurately fitted so that the point is truly on the axis of the pile.

Care shall be taken to ensure that the binders are perfectly tight and main reinforcements straight and true. Spacer fork of approved design are to be inserted throughout and spacing shall not be more than 1.5 m apart.

Longitudinal bars shall be in one length. In cases where laps in reinforcement bars cannot be avoided, the bars shall be staggered. Welded joints in reinforcement may be used with prior approval of the Engineer. Welding of reinforcements shall be done in accordance with the recommendations of relevant IS Code of practice. The cages shall be rigidly fixed straight and parallel to the moulds and held correctly as to maintain cover by spacer blocks. Care shall be taken to ensure correct and uniform cover throughout.

Formwork to be used for casting of the piles must be strong and level so that the outer faces of the piles are smooth and free from undulations. The prefabricated steel formwork with proper fasteners shall be used. Deformed and out of alignment formwork will be rejected.

The Casting Yard shall be so located that the piles can be lifted directly from their beds and transported to the piling frame with a minimum of handling. The casting yard should have a well drained surface to prevent excessive uneven settlement due to softening of soil during manufacturing and curing. The contractor shall submit layout drawing of the casting yard to the Engineer for approval prior to its construction.

Each pile shall be cast in continuous operation from end to end. The concrete shall be thoroughly compacted against the forms and around the reinforcement by means of immersion and/or shutter vibrators. Care shall be taken to ensure that the heads of the piles are formed plane and square to the axis. Particular attention must be paid to compaction at head and toe having regard to the more closely spaced reinforcement and the need for the densest possible concrete.

Immediately on completion of the casting the top surface shall be finished level without excess trowelling. Care shall be taken to ensure that vibration from adjacent work does not affect the previously placed concrete for piles during the setting period.

Side shutters shall be stripped off only after 24 hours of concreting. The piles shall be kept continuously wet for at least 7 days and protected from rapid drying by sheltering them from the wind and direct sunlight by covering the stacks.

### 3.03.00      **Storing and Handling**

Storage area shall be of firm ground free from liability to unequal subsidence or settlement under weight of the stack of piles. The piles shall be placed on timber supports which are truly level and spaced so as to avoid undue bending in the piles. The supports shall be vertically one above the other. Space shall be left round the piles to enable them to be lifted without difficulty. The order of stacking shall be such that the older piles can be withdrawn for driving without disturbing the new piles.

Great care shall be taken at all stages of transporting, lifting and handling of the piles that they are not damaged and cracked. Piles shall be lifted only by means of bolts or shackles inserted through the lifting holes provided and in no other way. Any pile damaged in handling shall be replaced free of charge by the Contractor.

All lifting and toggle holes shall be formed by casting in pieces of steel pipe for the full length of the concrete section. In places where lifting holes have not been provided in the piles, the points of lifting shall be clearly marked on the surface of the pile over at least half the perimeter. If the piles are put down temporarily after being lifted, they shall be placed on trestles or blocks located at lifting points. Lifting shall be by two points i.e. at 1/5th length of pile from either end so as to keep the handling stress minimum. Single point lifting is not permitted.

Piles must not be taken for driving before 28 days have passed after casting.

### 3.04.00      **Driving**

The proposed arrangement for driving, the equipment and accessories shall be to the approval of the Engineer.

The equipment and accessories are to be selected considering the hardness of driving, the capacity suitable for the size and weight of the pile to be handled. Piles may be driven with any type of hammer provided they penetrate to the prescribed depth or attain the specific resistance without being damaged. A hammer may be 'single acting' or 'double acting'. The hammer, dolly, helmet and the pile should be co-axial and sit squarely one upon the other. For a single acting or drop hammer, the fall should be limited to 1.2m, preferably 1m.

The head of precast concrete piles shall be protected with packing of resilient material, evenly spread and held securely in place. A helmet should be placed over the packing and provided with dolly of hardwood or equivalent not thicker than the width of pile.

Any sudden change in rate of penetration which cannot be explained due to normal change of nature of the ground should be noted and the cause ascertained before driving is continued.



Jetting may be used in case of sand, gravel and fine grained soils provided percentage of clay is small, after approval of the Engineer, as a means of minimizing the to resistance and skin resistance along the pile shaft. Jetting shall not be used in case of clay soils. The pressure of jetting should be from 6 Kg./Sq.cm. to 10 Kg./Sq.cm. Proper arrangement shall be made for taking away water that emerge at the ground so that the stability of the piling equipment is not endangered by softening of the ground. Special care should be taken to ensure that pile penetrates vertically.

Jetting shall be stopped prior to completing the driving which should always be made by ordinary methods. Jetting shall also be stopped if there is any tendency of the pile tip to be drawn towards the piles already driven owing to disturbance of the ground.

Piles should be installed as accurately as possible as per the drawings. As a guide, for vertical piles a deviation 1.5% and for raker piles a deviation of 4% shall not be exceeded. Piles shall not deviate more than 75 mm from their designed position. Spacing of the piles shall be as per the drawings.

In case of piles deviating beyond these limits, the piles shall be replaced or, supplemented by one or more piles as instructed by the Engineer at no extra cost to the owner.

In a group the sequence of installation shall be from the centre to the periphery of the group or from one side to the other, such that the carrying capacity of previously installed pile is not reduced. The driving shall not cause appreciable upheaval of the ground or cause unusual soil resistance to rest of the pile driving. It shall be ensured that soil is not flowing out literally during driving operation.

Set criteria shall be same as those used when the sets of test piles were obtained under identical driving conditions.

#### 3.05.00 **Stripping of Pile Heads**

If specified in the schedule of items the concrete shall be stripped to the cut-off levels shown on the drawings. Reinforcements shall be exposed for the full bond length appropriate to the diameter of the bar and projected in the pile cap. All concrete and cement shall be removed from the bars which shall also be wire brushed to remove any loose rust, dirt and scale. Any cracked or defective concrete shall be cut away and made good with new concrete properly bonded to the old concrete.

#### 3.06.00 **Lengthening of Piles**

Length of individual piece of precast pile is generally restricted from handling point of view. Considering the required total length of pile and the length of individual piece as mentioned above, the contractor shall develop standard splicing detail using studs, dowels, keys etc. at the spliced end of the piles and get it approved by the Engineer. The splice shall be as strong as the pile segments.

If due to unforeseen site conditions over and above the preplanned splicing mentioned above, further lengthening of pile is required during driving the longitudinal reinforcement shall be exposed by stripping of head and jointed properly either by welding or lapping as directed by the Engineer. The exposed surface of the concrete shall be hacked to form a key, brushed to remove loose material and covered with 25 mm thick cement mortar (1:2 mix) immediately before the new concrete is placed.

3.07.00 **Risen Piles**

In places where the piles may rise due to ground heaving, levels of the tops of the piles should be measured at interval while nearby piles are being installed. Piles which have risen as a result of driving adjacent piles should be redriven to the original depth as per the direction of the Engineer.

3.08.00 **Defective Piles**

Defective piles shall be removed or left in place without affecting performance of the adjacent piles as per direction of the Engineer. Additional piles shall be provided by the Contractor free of charge.

3.09.00 **Idle Period**

The phasing of construction and movement of plant shall be done as desired by the Engineer. The phasing may involve some extra movement of the plant or some idle period, but the Contractor will not be entitled for any claim due to this reason.

During the actual testing of the piles, the Contractor's plant and personnel may remain temporarily idle. Again, during the period of redesign, if any, (based on the pile test results), the plant personnel of the contractor may remain idle for any reason whatsoever.

For such idle periods mentioned above, the Contractor will not be entitled to any claim and rates quoted by him shall include the same. However, during the testing of piles and other hold ups, pile driving operation may be allowed on other piles wherever possible, if decided by the engineer with a view to minimise idle times.

If due to change in loading, elevations or any other alteration, some amendments become necessary in the design of foundations, the Contractor shall not be entitled to any claim whatsoever for such amendments in the pile layout during the progress of work including claims for any idle labour or tools and plant on this account.

3.10.00 **Test Pile**

The Contractor may have to construct test piles, if desired by the Engineer, before he starts systematic piling operation at locations indicated. For this purpose, the pile construction process shall be the same as in usual piling process to be followed on this job. Load test on such piles shall be as per the provisions under "Procedure for Initial Load Test" in IS:2911.

#### 4.00.00 **TESTING AND ACCEPTANCE CRITERIA**

##### 4.01.00 **General**

The Contractor shall carry out all sampling and testing for the components of reinforced concrete in accordance with the relevant Indian Standards at his own cost unless otherwise specified in the Contract. Whenever directed, the Contractor shall get the specimens tested in a laboratory approved by the engineer and submit to the Engineer the test results in triplicate within three (3) days of completion of the test.

Initial tests and/or routine tests as indicated in the Schedule of Items or as directed by the Engineer shall be carried out on single pile or pile groups to ascertain the capacities of the piles and their behaviour.

Any or all of the following tests shall be carried out as indicated in the Schedule of Items and as directed by the Engineer.

- a) Vertical load test on pile (Compression)
- b) Lateral load test on pile
- c) Pull out test on pile

All the above tests are to be performed as per requirements of IS:2911 (Part-IV) - latest revision and as supplemented herein.

##### 4.02.00 **Static Load Test on Working Piles**

In order to determine the carrying capacity of piles, static load tests shall be undertaken by the Contractor on single pile or pile groups, as indicated on drawings. Before any load test is made, the proposed arrangement of the structure, dead load to be used in making the load test, and method of application of load to the pile shall have to be approved by the Engineer. All load tests shall be made under the supervision of the Engineer. All responsibilities for conducting the test safely and properly lie with the Contractor.

The test load to be applied on pile or piles shall be one and a half times the proposed load value of the pile or piles as claimed by the Contractor. The test load shall be applied in 6 increments equal to one fourth, half, three fourth, one, one and one fourth and one and one half times the proposed working load. Readings of settlements and rebounds shall be referred to a constant elevation bench mark and shall be recorded with the help of three dial gauges of 0.02 mm sensitivity each positioned at equal distance around the pile. Each stage of loading, except the final test load of one and one half times the working load, shall be maintained till the rate of movement of the pile top is not more than 0.02 mm per hour. The final test load shall be maintained for 24 hours and hourly readings of settlements are to be recorded. The total test load shall be removed in decrements not exceeding 1/5 of the total test load with intervals of not less than one hour. The rebounds shall be recorded after each decrement is effected and the final rebound shall be recorded 24 hours after the entire test load has been removed. A complete record in triplicate shall be filed with the Engineer on the loads and readings obtained duly verified and countersigned by the Engineer.

The tested piles shall be used as usual foundation piles if they satisfy the acceptance criteria and no extra payment shall be made except for load tests on the piles.

If so desired by the Engineer, special test caps may have to be cast and subsequently dismantled at no extra cost.

4.03.00      **Acceptance Criteria**

The piles shall be accepted as satisfactory only when the work has been executed in order with this Specification to the satisfaction of the engineer and satisfy the following requirements :

- a)      Deviations shall be within the prescribed limit of tolerance specified in this specification.
- b)      Results of the load tests satisfy the specification and IS Code requirements.

4.04.00      **Recording Data**

The Contractor shall maintain a separate register, signed jointly by him and the Engineer, giving the following information during installation of the piles:

- a)      The sequence of installation of piles in each group with dates of starting and completion
- b)      The dimensions of the pile including the reinforcement details of the piles
- c)      The depth driven
- d)      The final set for the last ten blows or as may be specified by the Engineer
- e)      Cut-off levels
- f)      The type and size of hammer and its stroke, or with double acting hammers, the number of blows per minute
- g)      The type and condition of the packing on the pile head and the dolly in the helmet; and
- h)      Any other important observation

5.00.00      **INFORMATION TO BE SUBMITTED**

5.01.00      **With Tender**

The tenderer shall submit the following information along with his tender.

5.01.01      **Programme of Construction**

The tenderer will submit the details of the method of construction and the construction equipment that he will employ. A proposed construction programme, matching with the capacity of the equipment and taking into consideration the various idle and non production periods on account of shifting of equipment, testing and possible delays due to modifications of design should be drawn up and submitted along with the tender, keeping in view the completion dates stipulated in the tender.

5.02.00      **After Award**

After award of the contract, the successful tenderer is to submit the following details.

5.02.01      **Execution Plan**

Within 15 days of the receiving the Letter of Intent the Contractor will submit 6 (six) copies of drawings showing the sequence of driving. The drawings will be prepared on the basis of a master plan giving identification number of the piles, which will be furnished by the Engineer.

5.02.02      **Detailed Construction Programme**

Within 30 (thirty) days of the award of contract, a detailed construction programme for completion of the work is to be submitted. This master programme will be reviewed and updated every month or at more frequent intervals as directed by the Engineer, incorporating the various factors which have caused or are likely to cause changes in the programme.

5.02.03      **Requirement of Materials, Tools and Plants and Equipment**

In accordance with the master programme, a detailed material, tools and plants and equipment requirement schedule, particularly for those items which the Owner is to supply or is to help in procurement as per the terms and conditions of the Contract, is to be submitted within 30 (thirty) days of the contract.

5.02.04      **Test Results**

The test data and result for the various ingredients of R.C.C., concrete cubes and cylinders, driving of the pile, static load test on single piles and group will be submitted regularly and as and when directed by the Engineer.

**SPECIFICATION NO. C-7**

**FOR**

**DRIVEN CAST-IN-SITU CONCRETE PILE**

**SPECIFICATION NO. C-7  
FOR  
DRIVEN CAST-IN-SITU CONCRETE PILE**

**C O N T E N T S**

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**SPECIFICATION NO. C-7  
FOR  
DRIVEN CAST-IN-SITU CONCRETE PILES**

**1.00.00 SCOPE**

This specification covers driven reinforced cement concrete cast in situ piles including movement of pile driving equipment as per drawings as made available from time to time, and all related items of work like sand filling in the holes left after casting the piles, testing the load bearing capacity of individual piles and group of piles, etc. The relevant clauses of the "Technical Specification for Cement Concrete (Plain or Reinforced)" appearing in this document elsewhere, fall within the Scope of this Specification.

IS : 2911 (Part-I/Sec-2) shall form a part of this specification and shall be complied with unless they are at variance with the specification where the latter will prevail.

Other items of work like, excavation, casting pile caps, beams etc. which in most cases, will be required to be executed in connection with piling, will fall under the Scope of other relevant sections of the Technical Specifications which appear separately in this document.

**2.00.00 GENERAL**

**2.01.00 Work to be provided by the Contractor**

The work to be provided for by the Contractor, unless otherwise specified, shall include but not be limited to the following :

- a) Furnish all labour, supervision, services, materials, equipment, tools, plants, transportation etc. required for the supply and installation of piles of desired capacity.
- b) Mark the proposed sequence of driving on six (6) copies of identification plan. The identification plan will be prepared by the Contractor as per the basic plan furnished by the Engineer, if so desired by him.
- c) Furnish detailed drawings in six (6) copies of the pile driving equipment giving all salient dimensions and loads.
- d) Submit detailed daily report of pile driving incorporating information as required by the Engineer.
- e) Carry out load tests to the satisfaction of the Engineer including casting and dismantling of test caps if necessary and submit the test results in approved proforma.
- f) Make necessary earthwork and approaches for movement of the pile driving rig.



- g) Provide all necessary work mentioned under the "Technical Specification for Cement Concrete (Plain or Reinforced)", as may be applicable.

2.02.00 **Work to be provided by others**

No work under this Specification will be provided by any agency other than the Contractor unless specifically mentioned otherwise elsewhere in the Contract.

2.03.00 **Codes and Standard**

All work under this Specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standards Specifications and codes of Practice. In case any particular aspect of work is not specifically covered by Indian Standard Specifications, any other Standard Practice as may be specified by the Engineer shall be followed :

IS : 269	Indian standard Specifications for 33 Grade ordinary Portland Cement.
IS : 383	Indian Standard Specifications for Coarse and fine Aggregates from Natural sources for concrete.
IS : 432	I.S. specification for Mild Steel and Medium (Part-I) Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement : Part I Mild Steel and Medium Tensile Steel Bars.
IS : 455	Indian Standard Specification for Portland Slag Cement.
IS : 456	Code of Practice for Plain and Reinforced concrete.
IS : 516	Indian Standard Specification for Methods of test for Strength of concrete.
IS:1199	Indian Standard Specification for Method of sampling and Analysis of Concrete.
IS:1786	Indian standard Specification for Cold worked steel High strength Deformed Steel Bars and Wires for Concrete Reinforcement.
IS : 2502	Code of practice for bending & Fixing of Bars for Concrete Reinforcement.
IS: 2722	Indian Standard Specification for Portable Swing Weight Batches for Concrete (Single and Double Bucket Type).
IS : 2751	Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction.
IS :2911	Code of Practice for Design and (Part-I/Construction of Pile Foundations - Driven Sec-2)Cast-in-situ Concrete Piles.

IS : 2911      Code of Practice for Design and Construction (Part-IV) of Pile Foundations - Load Test on Piles.

IS : 4926      Indian Standards Specification for Ready Mixed Concrete.

IS : 5121      Safety Code for Piling and other Deep Foundations.

#### 2.04.00      **Conformity with Design**

The Contractor will prepare check lists in approved proforma which will be called "Pile Installation Cards". At each important stage of the work as decided by the Engineer, the work will be checked and approved by the Engineer for correctness and conformity with the design, specifications and drawings, before allowing the next phase of the work to commence. The intermediate checks and approvals by the Engineer will not, however, absolve the Contractor from his total responsibility to execute the work as per the specification and drawings and to remove and/or rectify all work which is defective or inaccurate.

#### 2.05.00      **Materials**

##### 2.05.01      **General**

All materials whether incorporated in the works or used temporarily as aids or for executing enabling works will be of best approved quality conforming to the latest Indian Standard Specification.

##### 2.05.02      **Pile Shoes and Shells**

Piles shoes, where used, should be manufactured out of best quality cast Iron or Steel with proper treatment, the composition and thickness of the materials being of special importance where they are likely to be in contact with harmful chemicals and organic materials causing deterioration in service. The shell tubes which are to be left in place should also receive similar consideration in selection.

##### 2.05.03      **Cement**

Cement used shall conform to IS : 269, IS : 8112 or IS : 12269 (Portland Cement), IS : 6909 (Super-sulphated cement), IS : 12330 (Sulphate resisting Portland Cement) or any other I.S. specification as indicated in the schedule of items.

##### 2.05.04      **Aggregates**

Aggregates both fine and coarse shall comply with the requirements of IS : 383. Size of coarse aggregates shall be selected considering the size of the section. Generally, 20 mm down coarse aggregates shall be used.

##### 2.05.05      **Steel**

Reinforcement steel shall conform to IS : 432 (Part - I) (Mild Steel plain bars) or IS : 1786 (High yield strength deformed bars).

2.06.00      **Storage of Materials**

2.06.01      **General**

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Engineer shall not be used, failing which, the Engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the Contractor's dues. The relevant clauses pertaining to storage of material under "Technical Specification for Cement Concrete (Plain & Reinforced)" will apply.

2.06.02      **Cast Iron or Steel Shoes and Shells**

All cast iron or steel shoes and shells will be painted with two coats of anticorrosive paint or smeared with protective layer of grease and kept stored in weatherproof sheds, off the ground, on sturdy racks in such a manner as to enable quick and easy inspection.

2.07.00      **Quality Control**

The Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same. The Quality Control requirements stipulated under the "Technical Specifications for Cement Concrete (Plain and Reinforced)" will apply wherever relevant. In addition, the requirements will include but not be limited to the following :

- a)      Location and Plumb : Control survey for accuracy in planned check for verticality.
- b)      Driving : Correlation of wt. of hammer, length of stroke, number of strokes per minute and rate of penetration.
- c)      Casting of Piles : Check inside casing, reinforcement cage, concrete mix, placing, consolidation and curing.
- d)      Inspection of Pile
- e)      Load Tests

2.07.01      **Non-conformance**

Any work which fails to conform to the specification will be subject to the issue of a non-conformance report in line with the quality control procedures to be implemented at site. Corrective or remedial action, design modification or product rejection will be reviewed in accordance with site quality plan.

3.00.00 **INSTALLATION**

All installation requirements shall be in accordance with IS:2911 (Part I) and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification might not have covered all the aspects to the full satisfaction of the Engineer.

3.01.00 **General**

The Tenderer shall furnish complete information about the type of piles offered with sketches of pile sections showing reinforcement, method of driving the piles, details and availability of driving equipment, formula or data curve on which the Tenderer bases the load carrying capacity of piles as well as the criteria for determining suitable and sufficient 'founding' of individual piles and any other relevant details.

The Tenderer will be supplied with bore hole logs or any other data indicating the nature of the soil expected to be encountered. The information furnished to the Contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the Contract. All piles will have to be driven to the required set and/or based on load tests, as decided by the Engineer. In case the Contractor is required to drive piles to greater or shallower depths than that is envisaged the rates will be adjusted as per relevant items in the Schedule of Items and no other extra claims will be entertained. The tenderer should, in his own interest, investigate the site thoroughly and take additional bore holes if he feels it necessary to assess the type of equipment to be used and the depths to which the piles may have to be driven finally.

3.02.00 **Type of Pile**

All piles shall be adequately reinforced cast in situ concrete piles driven as specified on the drawing/s. The reinforcement and diameters of piles should be exactly as indicated in the drawing and specification. Only cast in situ piles with complete reinforcement for the total length and casing driven to total depth required for pouring controlled concrete mixture shall be accepted.

In spite of different methods of driving, concreting, etc. of different types of cast in situ piles, the allowable vertical load carrying capacity of piles shall be as follows:

Nominal diameter of pile		Max. allowable load carrying capacity of single pile
450 mm	:	60 M.T.
550 mm	:	100 M.T.

3.03.00 **Identification of Piles**

A plan, in triplicate, showing clearly the designation of all piles by an identifying system shall be filed with the Engineer before installation of piles is started if so desired by the Engineer.

### 3.04.00      **Sequence of Construction**

The piles shall be installed in such a sequence that the carrying capacity of previously installed pile is not reduced. The driving shall not cause appreciable upheaval of the ground or cause unusual soil resistance to rest of the pile driving. It shall be ensured that the soil is not flowing out laterally during driving operation. The Engineer shall decide on the sequence of the groups of piles and the Contractor shall have to follow this sequence.

### 3.05.00      **Driving of Piles**

Piles shall be installed with due consideration to the adjacent structures and by a method which leaves their strength unimpaired and which develops and retains the required bearing resistance. Equipment and the method of driving the pile shall be such that the pile is installed in its proper position and alignment. The pile shall not be out of plumb by more than 2% of the pile length. If any pile goes out of plumb by more than 2% of the pile length, the design of the foundation shall have to be modified in a manner approved by the Engineer to support the resulting vertical and lateral forces properly. The cost of modification, however, has to be borne by the Contractor at no extra cost to the Owner. A maximum positional deviation of 7.5 cm at the cut off level from the designed location of pile may be permitted, beyond which modification in the design shall become necessary.

Jetting shall not be done except when permitted in writing by the Engineer. The driving shall start from the existing ground level. After completion of driving, concrete shall be placed and compacted to fill up the hole left by the driving up to 300 mm above the cut of level. The balance depth between the G.L. and the top of concrete shall be filled up with sand so that the next pile does not move out of place during construction. To construct the pile cap, the ground will be excavated to expose the top portion of the piles, which will be dismantled neatly upto the cut off level removing all cracked, loose and unsound concrete. the top surface of the piles will be kept rough to ensure bond with the pile cap in which they will be ultimately embedded. The reinforcement rods of the pile should project out of the top by at least the value of bond length for the bar depending on its diameter and grade of concrete in pile cap. This length of bar will be later on bent and embedded in the pile cap concrete.

During the process of driving, should an obstruction be encountered, through which piling tube can not penetrate, the Contractor shall be compensated for the cost of removal of such obstruction at actual cost plus 20%.

Liquefaction of soil or localised compaction of soil due to driving of piles, if occurring, may create conditions when determination of load bearing capacity by the usual method of 'set' sometimes gives erroneous results. The pile, in such cases, shall be driven to the set desired or the desired strata based on the experience gained on the various load tests as desired by the Engineer.

The Contractor shall ensure that any green concrete in the nearby piles or any pile loaded in testing operation is not disturbed by driving the tube adjacent to it.

### 3.06.00      **Concrete in Pile**

This shall conform to the requirements of "Technical Specification for Cement Concrete (plain and reinforced)" enclosed herewith, to the extent it has been referred to or as applicable to this Specification. The concrete shall be of controlled grade and approved quality preferably M 20 and M 25 but in no case shall it be less than M 15 grade. The stipulation laid down in IS:2911 (Part I), regarding selection of mix shall be generally followed unless otherwise specified by the Engineer.

Concreting shall start as soon as possible after the hole is completed. Concrete shall be so placed as to fill the entire volume of the hole without segregate and formation of voids caused by faulty consolidation or entrapped air. The volume of concrete placed shall be observed in the initially cast piles and the average figure obtained shall be used to check whether there is undue deviation in concrete consumption for the subsequent piles.

Where the concrete is cast in place in a tube, its consistency shall be suitable to the method of compaction employed in the formation of piles. If necessary, concrete shall be as dry as possible to minimise shrinkage and to minimise the possibility of cement being washed down by flow of subsoil water while casing is withdrawn. Care shall be taken against segregation of concrete while passing the reinforcement cage, and against inflow of soil and water during withdrawal of the tube by maintaining sufficient head of concrete inside the tube. The extraction of casing shall not cause any shearing or necking of the poured concrete thereby reducing the capacity of piles.

The method of concreting shall strictly conform to the above specification and no deviation shall be allowed.

As mentioned in Section 3.5, concreting of the pile shall have to be done at least 300 mm above the cut off level of the pile. The remaining part of the hollow formed by the withdrawal of driving tube from ground down to the top of the concreted pile shall be filled up with sand.

#### 3.06.01 **Trimming of Pile Heads**

Completed piles shall be trimmed to the cut-off levels shown on the drawings or until sound concrete is found. In the event of trimming being carried below the cut-off level, the pile shall be made up to the correct cut-off level, with concrete of the same quality as used in the piles at the contractor's expense. A 'non-conformance' will be raised in such circumstances. Reinforcement shall be exposed for the full bond length appropriate to the diameter of the bar and projected in the pile cap as per drawing. All concrete and cement shall be removed from the bars, which shall also be wire-brushed to remove any loose rust, dirt and scale.

#### 3.06.02 **Lengthening of Piles**

Where it is necessary to increase the length of any pile after it has been installed, the head of the pile shall be cut-off to expose the reinforcement for a full bond length of the bars to lap with the new bars. The exposed surface of the concrete shall be chiselled to form a key brushed to remove loose material and covered with 25 mm thick cement mortar (1 : 2 mix) immediately before

the new concrete is placed.

#### 3.07.00      **Reinforcement in Piles**

Steel Reinforcement conforming to IS:432, IS:1139 or IS:1786 grade suitable for reinforced cement concrete for general building work shall be applicable for the specification to the extent it has been referred to or applicable.

Pile has to be reinforced throughout its length. In spite of different methods of driving, concreting, etc. of different types of cast-in-situ driven piles, the minimum area of longitudinal reinforcement within the pile shaft shall be 0.4 percent of the sectional area calculated on the basis of outside diameter of the casing of the shaft when mild steel plain bars conforming to IS : 432 Grade I are used. For other grades of steel noted above, the area of reinforcement may be adjusted suitably, but in no case shall the number of vertical reinforcing bars be less than six and the bar diameter less than 16 mm. The minimum diameter of the links or spirals shall be 6 mm and their spacing shall not be less than 150mm. In addition to the binders/links, spacer bars of 8 mm diameter shall be welded at the inside face of the cage of suitable intervals.

Reinforcement used in cast in situ piles shall be made up into cages sufficiently well wired or spot welded to withstand handling without damage. The bars shall be so spaced as not to impede the placing of the concrete. Care shall be taken to preserve correct cover and alignment of reinforcement throughout the whole operation of placing the concrete by means of concrete rollers or by any other means approved by the Engineer. Any distortion or displacement of reinforcement, during the compaction of concrete or while extracting the tube, shall be avoided. The reinforcement in the pile shall be exposed for a minimum length of the anchor length in tension above cut off level to permit it to be adequately bonded into the pile cap. All reinforcement in piles including the dowels projecting above the piles, shall be measured and paid separately.

#### 3.08.00      **Dowels**

The Contractor shall provide necessary dowels as directed by the Engineer. In case of inadequate length of dowels, the same shall be extended by welding or by mechanical devices, if necessary as per direction of the Engineer. The expenditure on this account shall be borne by the Contractor. The extra reinforcement thus required shall be taken into consideration during reconciliation if the same is supplied by the Owner.

#### 3.09.00      **Inspection**

Before placing the reinforcement and concrete in the driven pile, the same shall be inspected by lowering a battery or flash lamp or by any other method approved by the Engineer to ensure water tightness of the tube. In case of water in any bore or damage to any cast iron shoe, the tube shall be extracted and redriven after earthfilling of the hole, with a fresh shoe at the cost of the Contractor.

### 3.10.00 **Record for driving of Piles**

A joint record of the entire penetration shall be maintained by the Contractor in a proforma approved by the Engineer for every pile for the behaviour of such pile during its entire process of construction. Such records shall be submitted to the Engineer regularly as the job progresses. Any sudden change in the rate of penetration which can not be ascribed to the nature of the ground or any deviation from the designed location, alignment or load carrying capacity of any pile or any upheaval or subsidence noticed on any pile driven under this Contract shall be promptly reported to the Engineer and adequate corrective measures shall be taken free of any charge as decided by the Engineer.

Upon completion of the pile driving, all records together with the records of such additional borings or other subsurface information that were obtained during the process of driving shall also be filled with the Engineer in triplicate.

### 3.11.00 **Defective Piles**

Piles that are defective or piles with deviation in alignment of the tube or position of the base more than that permissible under this specification shall be pulled out or left in place as per the direction of the engineer. Additional piles shall be driven to replace them and/or the pile cap shall be redesigned in consultation with the engineer. All the additional costs associated with the corrective action shall be borne by the Contractor. However, the extra reinforcement and cement that will be required for such work shall be taken into consideration during reconciliation of Owner's material, if the same are supplied by the Owner.

### 3.12.00 **Idle Period**

The phasing of construction and movement of plant shall be done as desired by the Engineer. The phasing may involve some extra movement of the plant or some idle period, but the Contractor will not be entitled for any claim due to this reason.

During the actual testing of the piles, the contractor's plant and personnel may remain temporarily idle. Again, during the period of redesign, if any, (based on the pile test results), the plant personnel of the contractor may remain idle for any reason whatsoever.

For such idle periods mentioned above, the Contractor will not be entitled to any claim and rates quoted by him shall include the same. However, during the testing of piles and other hold ups, pile driving operation may be allowed on other piles wherever possible, if decided by the engineer with a view to minimise idle times.

If due to change in loading, elevations or any other alteration, some amendments become necessary in the design of foundations, the Contractor shall not be entitled to any claim whatsoever for such amendments in the pile layout during the progress of work including claims for any idle labour or tools and plant on this account.



In case of extra rolling of rig arising out of a decision taken by the Engineer due to non-availability of drawings or site, or priority consideration, the same shall be paid under the relevant item in the schedule of items.

3.13.00      **Test Pile**

The Contractor may have to construct test piles, if desired by the Engineer, before he starts systematic piling operation at locations indicated. For this purpose, the pile construction process shall be the same as in usual piling process to be followed on this job. Initial test shall be carried out on such piles as per the relevant provision in IS : 2911 (Part-IV).

4.00.00      **TESTING AND ACCEPTANCE CRITERIA**

4.01.00      **General**

The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in the Contract. Whenever directed, the Contractor shall get the specimens tested in a laboratory approved by the engineer and submit to the Engineer the test results in triplicate within three (3) days of completion of the test.

4.02.00      **Components of R.C.C**

The testing and acceptance criteria for the components of Reinforced Cement concrete shall be as stipulated in the relevant clauses of the Technical Specification for Cement concrete (Plain and Reinforced) appearing in the document elsewhere.

4.03.00      **Static Load Test on Working Piles**

In order to determine the carrying capacity of piles, static load tests shall be undertaken by the Contractor on single pile or pile groups, as indicated on drawings. Piles to be tested shall be cast at least 30 days before loading unless otherwise directed by the Engineer. Before any load test is made, the proposed arrangement of the structure, dead load to be used in making the load test, and method of application of load to the pile shall have to be approved by the Engineer. All load tests shall be made under the supervision of the Engineer. All responsibilities for conducting the test safely and properly lie with the Contractor.

The test load to be applied on pile or piles shall be one and a half times the proposed load value of the pile or piles as claimed by the Contractor. The test load shall be applied in 6 increments equal to one fourth, half, three fourth, one, one and one fourth and one and one half times the proposed working load. Readings of settlements and rebounds shall be referred to a constant elevation bench mark and shall be recorded with the help of minimum two dial gauges of 0.02 mm sensitivity and resting on diametrically opposite sides. Each stage of loading, except the final test load of one and one half times the working load, shall be maintained till the rate of movement of the pile top is not more than 0.02 mm per hour. The final test load shall be maintained for 24 hours and hourly readings of settlements are to be recorded. The total test load

shall be removed in decrements not exceeding 1/5 of the total test load with intervals of not less than one hour. The rebounds shall be recorded after each decrement is effected and the final rebound shall be recorded 24 hours after the entire test load has been removed. A complete record in triplicate shall be filed with the Engineer on the loads and readings obtained duly verified and countersigned by the Engineer.

The tested piles shall be used as usual foundation piles if they satisfy the acceptance criteria, and no extra payment shall be made except for load tests on the piles.

If so desired by the Engineer, special test caps may have to be cast and subsequently dismantled at no extra cost.

#### 4.03.01 **Acceptance Criteria**

The pile or piles tested shall be accepted to carry the proposed working load provided that the total settlement of the pile top under the load does not exceed 12 mm.

#### 4.04.00 **Lateral Load Tests/Pull out Tests**

If desired by the Engineer lateral load tests on piles will be carried out by the Contractor as per IS:2911. Pull out tests will be carried out in special cases if required by either cantilever or fulcrum loading as may be approved by the Engineer. The quantum and nature of test loading will be as approved by the Engineer.

#### 4.05.00 **Non-destructive Dynamic Testing on Working Piles**

In addition to the above load tests, the Contractor may also have to carry out testing of piles by non-destructive dynamic testing methods before or during piling work as desired by the engineer.

#### 4.05.01 **"Low Strain" Method for Integrity Investigation of Concrete Piles**

The method of testing shall conform to ASTM D4945. All equipment including small impact device, 16 lbs nylon tipped hand held hammer accelerometer pile integrity tester and pile driving analyser shall be arranged by the Contractor. Analysis shall be carried out by exponential amplification of the signal with line and the average velocity curve obtained by numerically integrating the acceleration record to be submitted. From analysis of the results any defect like necking, honey-combing, segregation or weakness in concrete, when detected shall be reported in detail.

#### 4.05.02 **"High Strain" Method for Determination of Pile Capacity**

The method of testing shall conform to ASTM D 4945. All equipment including piezoelectric transducers, strain gauges, pile driving analyser, two track oscilloscope for displaying data and contractor for every hammer below the analyser shall determined the following data :

- a) Pile bearing capacity

- b) Transferred energy
- c) Maximum compression force
- d) Maximum tension force
- e) Maximum impact velocity
- f) Maximum acceleration
- g) Maximum displacement

which are to be properly recorded and analysed and submitted in detailed report form.

#### 4.06.00 **Lateral Dynamic Load Test on Piles**

Two types of tests, namely, free and forced vibration lateral tests shall be carried out to observe response of soil-pile system under horizontal dynamic loads and for the evaluation of soil pile stiffness, soil modulus, natural frequency, time period and damping characteristics of soil- pile system.

A minimum of three representative piles of same type in almost similar soil conditions shall be tested. Two adjacent piles shall be subjected first to free vibrations and then to forced vibrations, the third pile shall only be tested under forced vibrations.

The equipment and accessories for the test, setting up and test procedure and recording of observations shall be as described in relevant sections IS : 9716 (Guide for Lateral Dynamic Load Test on Piles).

The tests shall normally be carried out without sustained vertical load other than that of the oscillator assembly. However, sustained weight can be used to increase dynamic force to obtain resonance or nearly resonance condition.

From analysis of test data, the following parameters shall be determined:

- i) Frequency of vibrations
- ii) Amplitude of vibrations
- iii) Imparted dynamic force
- iv) Natural frequency
- v) Damping coefficient
- vi) Soil-pile stiffness
- vii) Coefficient of horizontal soil modulus variation

5.00.00      **INFORMATION TO BE SUBMITTED**

5.01.00      **With Tender**

The Tenderer should submit the following information alongwith his tender :

5.01.01      **Design Data**

The Contractor will submit full details of method of construction, design data and drawings for the type of piles he wishes to adopt.

5.01.02      **Programme of Construction**

The Contractor will also submit the details of the construction equipment that he will employ. A proposed construction programme, matching with the capacity of the equipment and taking into consideration the various idle and non production periods on account of shifting of equipment, testing and possible delays due to modifications of design should be drawn up and submitted along with the tender, keeping in view the completion dates stipulated in the tender.

5.02.00      **After Award**

After award of the contract, the successful tenderer is to submit the following details.

5.02.01      **Execution Plan**

Within 15 days of receiving the letter of Intent the Contractor will submit 6 (six) copies of drawings showing the sequence of driving. The drawings will be prepared on the basis of a master plan giving identification number of the piles, which will be furnished by the Engineer.

5.02.02      **Detailed Construction Programme**

Within 30 (thirty) days of the award of contract, a detailed construction programme for completion of the work is to be submitted. This master programme will be reviewed and updated every month or at more frequent intervals as directed by the Engineer, incorporating the various factors which have caused or are likely to cause changes in the programme.

5.02.03      **Requirement of Materials, Tools and Plants and Equipment**

In accordance with the master programme, a detailed material, tools and plants and equipment requirement schedule, particularly for those items which the Owner is to supply or is to help in procurement as per the terms and conditions of the Contract, is to be submitted within 30 (thirty) days of the contract.

5.02.04      **Test Results**

The test data and result for the various ingredients of R.C.C., concrete cubes and cylinders, driving of the shell, static load test on single piles and group and non-destructive dynamic test on working piles will be submitted regularly and as and when directed by the Engineer. For testing the ingredients of R.C.C. the relevant clauses of the "Technical Specification for Cement Concrete (Plain and Reinforced)" will apply.

6.00.00      **RATES**

The rate for the item of installation of piles shall include the cost of all materials consumed in the work or incidental to it as well as testing of materials, the cost of plants and equipment, labour, supervision, transport, taxes, insurances, royalties and revenue expenses, securities and safety measures, approaches, power, fuel, lubricants, services, preliminary and enabling works, camps, stores, etc. and overheads and profits complete. The rate shall include the entire cost of driving, supplying and installing concrete including the cost of providing extra concrete above cut off level and subsequent dismantling and removing the same. Rate for providing reinforcement including cutting, bending, binding and placing in position shall be quoted separately. The work to be provided for by the Contractor for installing cast in situ piles is given under clause 2.1 and elsewhere in this specification. In case no specific items is provided in the schedule to cover any particular item of work, it is implied that the Contractor will include the cost of executing such work in the rates quoted for connected items in the schedule.

7.00.00      **METHODS OF MEASUREMENT**

7.01.00      **Installation of Piles**

- a)      Measurement of length for payment will be done by letting down a tape with a heavy weight attached at the end, through the hole left by driving, before the reinforcement cage is lowered and concreting commences. The additional depth driven and covered with the shoe or any other materials like aggregates or concrete will not be considered for payment.
- b)      Unless specified otherwise in the schedule of items, piles of specific size and length will be measured in numbers. For any addition or reduction over the above specified lengths, the extra/rebate for specific sizes will be measured in length. Reinforcement in piles shall be measured in weight.

7.02.00      **Sand Filling**

The theoretical volume of sand required to fill the hole left by driving and casting the pile, upto the original ground level or the actual volume of sand used whichever is less, will be measured for payment.

7.03.00      **Load Test**

Measurement will be taken for static/dynamic, lateral load or pull out tests on single pile or groups as per specification and schedule of items on each occasion of test.

7.04.00      **Other Items**

The mode of measurement of the other connected item of work like excavation, casting pile caps and beams etc. will be governed by the relevant clauses of the Technical Specification for earthwork, concrete etc.

**SPECIFICATION NO. C-8**

**FOR**

**BORED CAST-IN-SITU CONCRETE PILE**

**SPECIFICATION NO. C-8  
FOR  
BORED CAST-IN-SITU CONCRETE PILE**

**C O N T E N T S**

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**SPECIFICATION NO. C-8  
FOR  
BORED CAST IN SITU CONCRETE PILE**

**1.00.00 SCOPE**

This specification deals with the requirements regarding materials, workmanship and installation of bored cast-in-situ reinforced concrete piles and all related items of work like sand filling in the holes after casting the piles, testing the load bearing capacity of individual piles and group of piles, etc. The relevant clauses of the "Technical Specification for Concrete Work", appearing elsewhere in this document, fall within the scope of this specification.

IS:2911 (Part-I/Sec-2) shall form a part of this specification and shall be complied with unless they are at variance with the specification where the latter shall prevail.

**2.00.00 GENERAL**

**2.01.00 Work to be provided by the Contractor**

The work to be provided for by the contractor, unless otherwise specified, shall include but not be limited to the following :

- a) Furnish all labour, supervision, services, materials, equipment and accessories, tools, plants transportation including consumables and temporary works required for the supply and installation of piles of desired capacity.
- b) Mark the proposed sequence of installation on six (6) copies of identification plan. The identification plan will be prepared by the contractor as per the basic plan furnished by the Engineer, if so desired by him.
- c) Furnish full details of the proposed piling equipment, accessories, temporary works and method of pile construction for approval of the engineer.
- d) Submit detailed daily report of boring and pile casting incorporating information as required by the Engineer.
- e) Carryout load tests to the satisfaction of the engineer including casting and dismantling of test caps if necessary and submit the test results in approved proforma.
- f) Make necessary earthwork and approaches for movement of pile installation equipment.
- g) Provide all necessary work mentioned under "Technical Specification for Cement Concrete (Plain and Reinforced)", as may be applicable.

2.02.00      **Work to be provided by others**

No work under this specification will be provided by any agency other than the contractor unless specified elsewhere in the Contract.

2.03.00      **Codes and Standards**

All work under this specification shall, unless specified otherwise, conform to the latest revisions and/or replacements/amendments of the following or any other Indian Standard Specifications and Code of Practice.

IS : 269      Indian Standard Specifications for 33 Grade Ordinary Portland Cement.

IS : 383      Indian Standard Specifications for Natural Sources for Concrete.

IS : 432      Indian Standard Specification for (Part - I)Mild Steel & Medium Tensile Steel Bars and Hard drawn Steel Wire for Concrete Reinforcement : Part I Mild Steel and Medium Tensile Steel Bars.

IS : 455      Indian Standard Specifications for Portland Slag Cement.

IS : 456      Indian Standard Code of Practice for Plain and Reinforced Concrete.

IS : 516      Indian Standard Specifications for Methods of Test for Strength of Concrete.

IS : 1199      Indian Standard Specifications for Methods of Sampling and Analysis of Concrete.

IS : 1786      Indian Standard Specifications for high strength deformed steel bars and wires for concrete reinforcement.

IS : 2062      Steel for General Structural Purposes

IS : 2386      Indian Standard Specification for Methods of Test for Aggregates for Concrete Part - I to VIII.

IS : 2502      Code of Practice for Bending & Fixing of Bars for Concrete Reinforcement.

IS : 2722      Indian Standard Specifications for Portable Swing Weight Batches for Concrete (Single and Double Bucket Type).

IS : 2751      Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction.

IS : 2911      Code of Practice for Design and Construction of Pile Foundations - Bored Cast-in-situ piles.

IS : 2911      Code of Practice for Design and (Part - IV)Construction of Pile Foundations - Load Test on Piles.

IS : 4926 Indian Standard Specifications for Ready Mixed Concrete.

IS : 9716 Guide for Lateral Dynamic Load Test on Piles.

#### 2.04.00 **Conformity with Design**

The contractor will prepare check lists in approved proforma which will be called "Pile Installation Cards". At each important stage of the work as decided by the engineer, the work will be checked and approved by the engineer for correctness and conformity with the design, specification and drawings, before allowing the next phase of work to commence. The intermediate checks and approvals by the engineer will not, however, absolve the contractor from his total responsibility to execute the work as per the specification and drawings and to remove and/or rectify all work which is defective or inaccurate.

#### 2.05.00 **Materials**

##### 2.05.01 **General**

All materials whether incorporated in the works or used temporarily as aids or for executing enabling works will be of best approved quality conforming to the latest Indian Standard specification.

##### 2.05.02 **Casing**

Casing in boreholes where used, should be manufactured out of best quality mild steel with proper treatment, the composition and thickness of the materials being of special importance where they are likely to be in contact with harmful chemicals and organic materials causing deterioration in service. Casing to be left in place like in offshore piling should also receive similar consideration in selection. They shall have sufficient strength and rigidity to permit their being driven and not to be distorted by soil pressure or driving of adjacent tubes. They shall be sufficiently water-tight to exclude water during placing of concrete.

##### 2.05.03 **Concrete**

Concrete type M-15/M-20 grade shall be used for piles as indicated in drawings. Materials and method of manufacture for cement concrete shall in general be in accordance with IS : 456. The concrete cube strength on 15 cm. cubes at 28 days shall satisfy the acceptance criteria as per IS : 456. Concrete cubes will be cast as per instruction of the Engineer. These will be cast and cured by the Contractor at site for testing. The concrete shall be of such consistency as to give a slump of 100 to 150 mm. Cement used for the concrete shall be Portland Blast Furnace Slag or 33 Grade ordinary Portland cement conforming to IS:455 & IS:269 respectively. The minimum cement content should be 350 kg/m<sup>3</sup> and 385 kg/m<sup>3</sup> for M-15 & M-20 grade concrete respectively based on subsoil condition requirement besides that required from strength and other considerations.

2.05.04      **Reinforcement**

Reinforcement shall be mild steel bars conforming to IS: 432. If instead of mild steel, Tor steel bars are used, they shall conform to IS : 1786.

2.06.00      **Storage of Materials**

2.06.01      **General**

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the engineer shall not be used, failing which, the engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the contractor's dues. The relevant clauses pertaining to storage of material under "Technical Specification for Cement Concrete (Plain and Reinforced)" will apply.

2.06.02      **Casing**

Mild steel casing will be painted outside with two coats of anticorrosive paint or smeared with protective layer of grease and kept stored in weather proof sheds, off the ground, on sturdy racks in such a manner as to enable quick and easy in spectrum. Epoxy painting on outside surface shall be provided if so specified in the drawing.

2.07.00      **Quality Control**

The contractor shall establish and maintain quality control for different items of work and materials as may be directed by the engineer to assure compliance with contract requirements and maintain and submit to the engineer records of the same. The quality control requirements stipulated under the "Technical Specification for Cement Concrete (Plain and Reinforced)" will apply wherever relevant. In addition, the requirement will include but not be limited to the following.

- a)      Location and plumb : Control survey for accuracy in plan and check for verticality.
- b)      Driving of casing : Correction of weight of hammer, length of fall, number of strokes per minute and rate of penetration.
- c)      Boring : Boring method to suit soil profile.
- d)      Casting of piles : Check inside casing, reinforcement cage, concrete mix, placing, consolidation and curing.
- e)      Inspection of pile
- f)      Load tests

2.07.01 Any work which fails to conform to the specification will be subject to the issue of a 'non-conformance report' in line with the quality control procedures to be implemented at site. Corrective or remedial action, design modification or product rejection will be reviewed in accordance with site quality plan.

3.00.00 **INSTALLATION**

All installation requirements shall be in accordance with IS:2911 (Part-I/ Sec.2) and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification might not have covered all the aspects to the full satisfaction of the engineer.

3.01.00 **General**

The tenderer shall furnish complete information about the type of piles offered with sketches of pile sections showing reinforcement, method of boring, details and availability of equipment and accessories formula or data curve on which the tenderer bases the load carrying capacity of piles as well as the criteria for determining suitable and sufficient founding of individual piles and any other relevant details.

The tenderer will be supplied with bore hole logs or any other data indicating the nature of the soil expected to be encountered. The information furnished to the contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the contract. Piles should be founded on suitable continuous hard strata. In case the contractor is required to drive piles to greater or shallower depths than that is envisaged, the rates will be adjusted as per relevant items in the schedule of items and no other extra claims will be entertained. The tenderer should, in his own interest, investigate the site thoroughly and take additional bores if he feels it necessary to assess the type of boring equipment to be used and the depth to suitable founding strata.

3.02.00 **Design of Pile**

The contractor shall satisfy the engineer as to the boring procedure and equipment which he proposes to use for the particular conditions of the site. If the engineer desires, sufficient test piles shall be installed to prove the adequacy of the pile, at the places indicated by the engineer and a load test shall be performed on each pile.

The Contractor shall satisfy the Engineer as to the boring procedure and equipment which he proposes to use for the particular conditions of the site. If the Engineer desires, sufficient test piles shall be driven to prove the adequacy of the pile, at the places indicated by the Engineer, and a load test shall be performed on each pile.

Piles have to be reinforced throughout their length. Main longitudinal reinforcement in the length of the piles as well as links or spirals shall be provided as shown in the drawings. Longitudinal bars shall preferably be in one length. Reinforced cage shall be handled and installed carefully without damaging its shape. All other requirements of reinforcement bars i.e., quality, workmanship, etc. shall be as specified for reinforced concrete work in Technical Specification for Concrete work.

The average basic length of the piles shown in the drawing/schedule of items is tentative and is to be assumed from cut-off level to the tip of the pile, but the final length will be decided by the Contractor with approval of the Engineer on the basis of boring resistance actually observed at site at the particular location. It will be the responsibility of the Contractor to prove by subsequent load tests/pull-out tests that the adopted length of the pile shall carry the safe loads, in compression and tension with the resulting deflections being within permissible limits. To ensure this, the length of the pile actually installed will be subject to change if considered necessary from the above mentioned basic length and payment shall be made to the Contractor on the basis of the actual lengths of pile installed at the rates quoted by the Contractor for deviation in length above or below the stipulated basic length.

If the load test is satisfactory and the Engineer accepts the type of the pile as suitable, payment shall be made for the pile. If the piles by reasons of defective workmanship or failure of one or more load tests, are found to be unsatisfactory, the cost of the test piles shall be borne by the Contractor.

3.03.00      **Identification of Piles**

A plan in triplicate, showing clearly the designation of all piles by an identifying system shall be filed with the engineer before installation of piles is started if so desired by the engineer.

3.04.00      **Sequence of Piling**

Individual piles and pile groups shall be constructed in such a sequence that the adjacent piles already installed are not disturbed, nor their carrying capacity reduced by subsequent boring/driving operation. The Contractor shall submit the sequence order and programme chart to the Engineer and get his confirmation before starting the work.

3.05.00      **Boring**

3.05.01      **With Casing**

Boring equipment and accessories shall generally conform to IS:2911 - relevant section. Boring may be done by either rotary or percussion equipment or grabbing equipment using reversed or direct mud circulation method. In case of unstable soils the boring tools used should be such that suction effects are minimised. Stabilisation of the sides of bore hole shall be done by use of casing. The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm.

The casing should be used from the ground level and shall be kept ahead of boring in case where there is danger of caving-in due to subsoil water entering into the bore hole or where the soil is loose. While boring below subsoil water level, precaution shall be taken so that no boiling of the bottom of the hole occurs due to difference in hydrostatic head.

Boring shall proceed by alternatively driving the casing and extracting the bored material with the boring tools. While boring in soft material liable to cavitation boring tools shall not be operated at a level below the toe of the casing. Care shall be taken to ensure that the volume of water added to the bore shall be not more than the minimum necessary for the operation of the boring tools. The casing shall be driven down through the soft material to penetrate a hard stratum not subjected to cavitation and shall be sealed in this material as far as possible. Thereafter the boring shall be continued by means of the boring tools until the approved bearing layer is reached.

Criteria for approval of the bearing layer will be agreed between the Engineer and the Contractor based on visual inspection of recognisable samples, recovered from the pile bore in the upper levels of the compact layer. The approved samples shall consist of sound material shall be consistent in quality for a depth of 300 mm in the pile bore. A sample of this material shall be supplied by the Contractor to the Engineer duly labelled for maintaining records of the founding strata.

The piles shall be installed with due consideration for safety of adjacent structures by a method which leaves their strength unimpaired and which develops and retains the required bearing resistance.

Where the soil is such that driving of a pile causes previously installed piles to heave, load test shall be conducted at the expense of the Contractor on such proportion of the heaved piles which shall be ordered by the Engineer.

#### 3.05.02 **With Drilling Fluid**

Alternate to the boring with casing, stabilisation of the sides of bore hole can be effected by the use of drilling fluids.

In such cases the drilling fluid must be used at least from the level of subsoil water, as the hole, should then be always kept almost full with the fluid. The density and composition of the fluid shall be such as to suit the requirements of ground conditions and to maintain the fine materials from the boring in suspension. At the last stage of boring or in intermediate hard layers chisel or a chopper may be used. The rate for piling work should be inclusive of any chiselling, chopping of hard strata, clearing of bottom of pile borehole etc. complete as per specifications and necessary penetration test as may be required to prove the soundness of the founding strata. A five per cent bentonite suspension would be generally suitable and its quality shall conform to specification given in Appendix 'A' of IS : 2911 (Part-I/Sec.2).

#### 3.06.00 **Spacing of Piles**

In general, all piles shall have a minimum spacing on centres of 3 d (where 'd' is the diameter of the pile) unless shown otherwise in the drawings.

#### 3.07.00 **Placing of Reinforcement**

Reinforcement as required shall be made into stiff cages sufficiently wired or welded to withstand handling without any damage or distortion. Reinforcement shall be placed immediately after cleaning and inspection of the bottom of bore

holes. The reinforcement should be supported away from the sides of the shaft by means of suitable space block to ensure concentric alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the piles without any distortion.

Nominal lap between reinforcement cages shall be 60 cm and the main reinforcing steel shall project for a length sufficient to develop bond (45 times the diameter of reinforcing bar) above the level of the underside of the pile cap.

The concrete cover to main reinforcement shall not be less than 5 cm and suitable spacer blocks shall be provided at intervals not exceeding 2 metres and wired to the main reinforcement.

### 3.08.00 **Concreting**

Immediately before concreting the bottom of the hole shall be cleaned very carefully. The cleaning of the hole shall be ensured by careful operation by air lifting process unless otherwise allowed by the Engineer. To lift the spoil at founding level before concreting, borehole shall be agitated by jetting with fresh drilling mud with relatively higher pressure than that used during boring or air through tremie pipe. While boring by use of drilling mud, the specific gravity of the mud suspension in the vicinity of the bottom of the borehole shall be determined by suitable slurry sampler in a first few piles and at suitable interval of the piles and recorded. Consistency of the drilled mud suspension shall be controlled throughout the boring as well as concreting operation in order to keep the hole stabilised and to avoid concrete mixed up with the thicker suspension of the mud.

Concreting of boreholes shall start as soon as possible after the completion of boring. If a borehole, be left unconcreted for more than two hours, it shall be cleaned thoroughly as directed by the Engineer before concreting. Concrete shall be so placed as to fill the entire volume of the tube or bore without the formation of voids caused by faulty consolidation or entrapped air. Great care shall be taken to ensure that the fluid alluvial soil does not penetrate between batches of the concrete. Concreting under water shall be done in one operation. Concrete shall be placed by means of a tremie pipe. It shall, however, be ensured that concrete entering the tremie pipe does not get mixed up with the slurry and 1/4 kg of granulated vermiculite shall be poured in the tremie pipe before pouring concrete as directed by the Engineer.

### 3.08.01 **Tremie Method of Concreting**

The tremie pipes and funnel shall be filled and lifted just 15 cm above bottom before releasing the concrete column to facilitate flushing out the bottom. The concrete levels in the tremie shall be checked every few centimeters in order to note the difference, if any, between the theoretical quantity that should have been placed and actual quantity that has gone in. This is to locate the position of over cut during boring.

In addition to the normal precautions to be taken in tremie concreting as per relevant section of IS:2911 the following specifications shall be particularly applicable for the use of tremie concrete in pipes :



- a) The concrete shall be coherent, rich in cement (not less than 400 kg/m<sup>3</sup>) and of slump not less than 100 mm.
- b) The hopper and tremie shall be closed system embedded in the placed concrete, through which water cannot pass.
- c) The tremie shall be large enough with due regard to the size of the aggregate. For 20 mm aggregate the tremie pipe shall be of diameter not less than 200 mm, aggregates more than 20 mm shall not be used.
- d) The first charge of concrete shall be placed with a sliding plug pushed down the tube ahead of it or with a steel plate of adequate charge to prevent mixing to concrete and water. However, the plug shall not be left in the concrete as a lump.
- e) The tremie pipe shall always penetrate well into the concrete with an adequate margin if safety against withdrawal of the pipe is required while discharging the concrete.
- f) The pile shall be concreted wholly by tremie and the method of deposition shall not be changed part way up the pile, to prevent the laitance from being entrapped within the pile.
- g) All tremie tubes shall be scrupulously cleaned after use.

Normally concreting of the piles shall be uninterrupted. In exceptional cases interruption of concreting may be allowed but it will be resumed within 1 or 2 hours. The tremie shall not be taken out of the concrete, instead it shall be raised and lowered slowly, from time to time to prevent the concrete around the tremie from setting. Concreting should be resumed by introducing a little richer concrete with a higher slump for taking care of the partly set concrete in the bore.

If the concreting cannot be resumed before final setting of concrete already placed, the pile so cast may be rejected.

In case of withdrawal of tremie out of the concrete, either accidentally or to remove a choke in the tremie, the tremie may be reintroduced in the following manner to prevent impregnation of laitance or scum lying on the top of the concrete already deposited in the bore.

The tremie shall be gently lowered on to the old concrete with very little penetration initially. A vermiculite plug shall be introduced in the tremie. Fresh concrete of slump between 150 mm and 175 mm shall be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing laitance/scum. The tremie will be pushed further in steps making fresh concrete sweep away laitance/scum in its way. When tremie is buried by about 60 to 100 cm, concreting may be resumed.

### 3.08.02      **Concreting in Cased Holes**

In case of cased holes, after the required founding level is encountered, the bottom shall be sealed with concrete and the reinforcement cage shall be lowered. If the borehole is dry, concrete shall be deposited by direct pour from the top followed by gradual withdrawal of casings. If water is present in the borehole, it shall be bailed out by bailer.

If it is difficult to dewater by the bailer, concrete shall be placed under water by means of a placer. After the head of water has been neutralised by the head of the concrete, excess water shall be bailed out and concrete shall then be deposited by direct pouring from the top, as is done, if the borehole is dry.

Extraction of casing shall be done in such a way that no necking or shearing of the concrete in the shaft takes place.

During the extraction of casing, slumping of concrete shall be observed and when required, additional quantity of concrete shall be poured so that the pile is formed above the cut-off level as per the requirements indicated below.

### 3.08.03      **Cut-off Level**

The top of concrete in a pile shall be brought above the cut-off level to permit removal of all laitance and weak concrete before capping and to ensure good concrete at the cut-off level for proper embedment into the pile cap.

Where cut-off level is less than 1.5 m below the working level concrete shall be cast to a minimum of 500 mm above cut-off level. For each additional 0.3 m increase in cut-off level below the working level additional coverage of 50 mm minimum shall be allowed. Higher allowance may be necessary depending on the length of the pile as directed by the Engineer. When concrete is placed by tremie method, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection or to a minimum of one metre above cut-off level. In the circumstances where cut-off level is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above cut-off level shall be determined and allowed in Works.

### 3.09.00      **Steel Pipe or Casing Tube**

This item shall be fabricated with mild steel plates conforming to IS : 2062 and/or steel tubes for structural purpose conforming to IS : 1161 & IS : 1239 as shown on drawings and/or described in the schedule of items.

Fabrication work and welding of steel shall be done in accordance with IS : 800 and IS : 9595. Welding of pipes shall be done by experienced and good welder who have been qualified by tests in accordance with IS : 817.

### 3.10.00      **Trimming of Pile Heads**

Completed piles shall be trimmed to the cut-off levels shown on the drawings or until sound concrete is found to the satisfaction of the Engineer. In the event of trimming being carried below the cut-off level, the pile shall be made upto the

correct cut-off level, with concrete of the same quality as used in the piles at the Contractor's expense. Reinforcement shall be exposed for the full bond length appropriate to the diameter of the bar and projected in the pile cap. The minimum distance of keying of pile into pile cap shall be 75 mm unless noted otherwise. All concrete and cement shall be removed from the bars, which shall also be wire-brushed to remove any loose, rust, dirt and scale.

Manual chipping shall be permitted after three (3) days of pile casting. Pneumatic chipping, if permitted by the Engineer, shall not be started before seven (7) days. In case Portland Pozzolana cement is used, chipping shall only be started as directed by the Engineer.

#### 3.11.00 **Lengthening of Piles**

Where it is necessary to increase the length of any pile after it has been driven, the head of the pile shall be cut-off to expose the reinforcement for a full bond length of the bars to lap with the new bars. The exposed surface of the concrete shall be hacked to form a key, brushed to remove loose material and covered with 25 mm thick cement mortar (1:2 mix) immediately before the new concrete is placed.

#### 3.12.00 **Removal of Spoil**

The Contractor shall be responsible for the prompt removal from the site of all spoil due to the boring to places indicated by the Engineer. The cost of such disposal shall be deemed to have been included in the cost of piling.

#### 3.13.00 **Back-Filling of Abandoned Borings**

The Contractor shall backfill all the abandoned borings between the concrete pile and the surface level after setting of concrete of the piles, by sand or by other materials as directed by the Engineer.

All permanently abandoned boreholes generally shall be backfilled with selected materials and for a depth of 5 M below cut-off level with plain concrete of mix 1:4:8 so that resistance to lateral forces on neighboring piles are developed.

#### 3.14.00 **Record for Installation of Piles**

The Engineer and the Contractor shall maintain separate registers, signed jointly by both the parties, giving the following information for each pile or any other proforma as agreed between Engineer and Contractor. These data shall be submitted to the Engineer, in triplicate, on completion of installation of each pile.

- a) Date of completion, pile number & sequence of installation of piles in a group.
- b) Bored depth, concreted depth, empty boring and nature of stratum at founding level.
- c) Pile diameter, details of reinforcement and details of mild steel liner where provided along with stiffener.

- d) Volume of concrete poured, time taken, cement bag consumption, slump of concrete and RL of top of concrete.
- e) Time taken for penetration of every 15 cm during last 2 M depth before founding level.
- f) Method of cleaning bottom of hole at founding level before concreting.
- g) Records of additional borings or other subsurface information obtained during the process of boring.
- h) Any other relevant important information.

Any sudden change in the rate of boring which cannot be ascribed to the nature of the ground or any deviation from the designed location, alignment or load carrying capacity of any pile or any upheaval or subsidence noticed on any pile shall be promptly reported to the engineer and adequate corrective measures shall be taken free of any charge as decided by the engineer.

The data for pile load test (load, displacement, time, etc.) are to be recorded sequentially for the test under consideration in a suitable proforma as agreed between Engineer and Contractor. These data along with the load displacement curve shall be submitted to the Engineer, in triplicate, on completion of each load test.

#### 3.15.00 **Defective Piles**

Any pile which is shown to be defective under load test shall not be accepted and the Engineer will relate such failure to the acceptance of other piles in the area.

If an individual pile should fail to meet the requirements specified in Clause 16.00.00 above such piles may be deemed to be defective and the Engineer may order such investigation to be made as he considers appropriate.

When any pile is found defective, the Contractor shall perform at his own expense one or more of the following remedial measures as directed by the Engineer.

- i) Replacement of defective piles.
- ii) Providing additional piles.
- iii) Alteration in design of pile caps.

#### 3.16.00 **Idle Period**

The phasing of construction and movement of plant shall be done as desired by the engineer. The phasing may involve some extra movement of the plant or some idle period, but the contractor will not be entitled to any claim due to this reason.

3.17.00      **Test Pile**

The contractor may have to construct test piles, if desired by the engineer, before he starts systematic piling operation at locations indicated. For this purpose, the pile construction process shall be the same as in usual piling process to be followed on this job. Load test on such piles shall be as per the provisions under "Procedure for Initial Load Test" in IS : 2911 (Part-IV) or as directed by the engineer.

3.18.00      **Offshore Piles**

Offshore piles, subjected to high horizontal forces and having large unsupported height above the bed level are to be installed under structures to be constructed on river/sea bed. Installation shall be done with the help of floating rig/crane from the river or by cantilever method from land using moving gantry or similar other equipment. Temporary filling of the area for movement of the piling rig will, however, be allowed to the extent that such filling does not encroach on the flow of the river and also no hindrance is caused to adjoining work. The cost of building such temporary gangway/filling, embedment and removal of the same shall be included in the cost for relevant items related to installation of offshore Piles in the schedule of items.

The piles adopted are in general large diameter bored piles with mild steel liner retained for a height as indicated in the related drawings. The liner shall be of 6 mm mild steel plates fabricated to true shape and be provided with protective surface treatment. The concreting shall be done by tremie method as described earlier and according to the other stipulation as described in the Technical Specification.

4.00.00      **TESTING AND ACCEPTANCE CRITERIA**

4.01.00      **General**

The contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in the contract. Whenever directed, the contractor shall get the specimens tested in a laboratory approved by the engineer and submit to the engineer test results in triplicate within three (3) days of completion of the test.

4.02.00      **Components of RCC**

The testing and acceptance criteria for components of reinforced cement concrete shall be as stipulated in the relevant clauses of the Technical Specification for Cement Concrete (Plain and Reinforced).

4.03.00      **Components of Steel**

Testing and acceptance criteria for the component of steel pipe material and fabrication work shall be as stipulated in relevant clauses of IS : 800 and IS : 9595.

4.04.00      **Load Tests**

4.04.01      **General**

Initial tests and/or routine tests as indicated in the schedule of items or as directed by the engineer shall be carried out on single pile or pile groups to ascertain the capacities of the piles and their behaviour.

Any or all of the tests described below shall be carried out as indicated in the schedule of items and as directed by the engineer. The tests shall be performed as per requirements of the relevant Indian Standards and as supplemented herein.

4.04.02      **Vertical Load Test [as per IS : 2911 (Part-IV)]**

Load tests shall be carried out on single piles to check the bearing capacity or the quality of piles in the manner specified below :

From among the completed piles the Engineer at his discretion shall select piles for the purpose of testing.

At least 1% of the piles driven shall be tested to an overload of 50% above the working load of the pile and 0.1% of the piles driven shall be tested to an overload of 100% above the working load of the pile.

Load shall be applied in increments of about one-fifth of the design load till the design load is reached and thereafter in increment of 10 tonnes till the test load is reached.

Each increment of load shall be maintained for minimum of half an hour upto design load and thereafter for one hour till the test load is reached. Test load shall be maintained for 24 hours.

For each increment of load, readings of settlement at every ten minutes shall be taken. The next increment of load shall be applied only when the difference in settlement of readings between the last two readings does not exceed 0.02 mm. On application of test load, readings shall be taken at every hour.

Unloading will be done in following decrements of load :

- i)      Test load to design load
- ii)     Design load to 50% of design load
- iii)    50% of design load to 25% of design load
- iv)    25% of design load to complete unloading

Each decreased load shall be kept for a minimum of half an hour and readings of rebound taken every ten minutes. The next decrement shall be applied only when the difference in readings between the last two readings is less than 0.02 mm.

The observation and recording of settlement and rebound shall be done simultaneously by the Contractor and the Engineer's representative. Three copies of all the readings for the test shall be supplied by the Contractor to the Engineer-in-charge. Actual proforma for recording the results shall be proposed by the Contractor and approved by the Engineer-in-charge before the start of the load test.

The pile shall be deemed to be acceptable if the gross settlement at the test load of one and a half times the designed load does not exceed 0.01" per tonne of test load or 1/2" (12 mm) whichever is less.

In case a pile fails under or during the load test, the Engineer shall select two additional piles in lieu of each of such piles failed and the Contractor shall carry out load tests on these piles in the same way as the load tests on the original piles at his own cost. This procedure will be repeated in the case of each failure of pile under/during load test.

The Contractor shall arrange at his own expense sufficient amount of knowledge for loading well in advance of the commencement of the load test.

Detailed proposal together with a sketch for the load test arrangement shall be furnished by the Contractor to the Engineer-in-charge for checking and approval.

The pile head shall be chipped off to natural horizontal plane till sound concrete is met. The projecting reinforcement shall be cut-off or bent suitably and the top finished smooth and level. A bearing plate with a hole at the centre shall be placed on the head of the pile for the jacks to rest.

Jacks used in any particular load test should be of the same capacity and their number shall be limited to two only. They should preferably be connected and operated by one pump. The Contractor shall submit certificates certifying the correctness of the calibrations of the pressure gauges and jacks before use. All jacks should be fitted with locking devices. Settlement and rebound shall be recorded by minimum two (2) deflectometers of 0.01 mm sensitivity and also by other independent means of direct measurement. Deflectometers shall be supported independently and in such a way as to be not affected by the settlement of the piles.

#### 4.04.03 **Lateral Load Test**

The test shall be carried out by introducing hydraulic jack with gauge between two piles under test or the reaction shall be suitably obtained otherwise. When the test is conducted by jack located between two piles, the full load imposed by the jack shall be taken as the lateral resistance of each pile.

Load shall be applied in increments of about one-fifth of the design load. The next increment shall be applied after the rate of displacement is nearer to 0.1 mm per 30 minutes. Displacement shall be read by using at least two (2) deflectometer of 0.01 mm sensitivity spaced by 30 cm and kept horizontally one above the other or by any means as per IS-2911 (Part-4) or as approved by the Engineer. The safe lateral load on pile shall be taken as the least of the followings :

- a) Fifty percent (50%) of the final load at which displacement increases to 12 mm.
- b) Final load at which the total displacement corresponds to 5 mm.

#### 4.04.04 **Pull-out Test**

The test shall be carried out to an overload of fifty percent (50%) of the estimated safe load or a displacement of 12mm total whichever is earlier.

Uplift force may preferably be applied by means of hydraulic jack(s) with gauge using a suitable pull-out set up as per IS-2911 (Part-4) or as approved by the Engineer.

The pull-out load increments and consequent displacement readings shall be same as in the case of Vertical Load Test.

The safe load shall be taken as the least of the followings :

- a) Two-thirds of the total load at which the displacement is 12mm.
- b) Half the load at which the load-displacement curve shows a clear break (downward trend).

#### 4.05.00 **Non-destructive Dynamic Test on Working Piles**

##### 4.05.01 **"Low Strain" Method for Integrity Investigation of Concrete Piles**

The method of testing shall conform to ASTM D 4945.

All equipments e.g., small impact device 16 lbs. nylon tipped hand held hammer, accelerometer, pile integrity tester & pile driving analyser shall be arranged by the Contractor. Analysis shall be carried out by exponential amplification of the signal with time and the average velocity curve obtained by numerically integrating the acceleration record to be submitted. From analysis of the results any defect like necking, honey-combing, segregation or weakness in concrete, when detected shall be reported in detail.

##### 4.05.02 **"High Strain" Method for Determining of Pile Capacity**

The method of testing shall conform to ASTM D 4945. All equipment including piezoelectric transducers, strain gauges, pile driving analyser, two track oscilloscope for displaying data and analog tape recorders for recording data shall be arranged by the contractor. For every hammer blow, the analyser shall determine the following data :

- i) Pile bearing capacity
- ii) Transferred energy
- iii) Maximum compression force
- iv) Maximum tension force
- v) Maximum impact velocity



- vi) Maximum acceleration
- vii) Maximum displacement

which are to be properly recorded and analysed and submitted in a detailed report form.

#### 4.06.00 **Acceptance Criteria**

The piles shall be accepted as satisfactory only when the work has been executed in accordance with this specification to the satisfaction of the Engineer and the standards stated hereinafter.

- a) The head of the pile shall be within 75 mm of the specified position on the drawings.
- b) The pile shall not be out of plumb by more than two percent.
- c) The toe of the pile shall be at the approved bearing level in each case.
- d) The total volume of concrete shall not be less than 20% and not more than 50% greater than the calculated volume. The calculated volume for this purpose shall be the cross-sectional area inside the casing multiplied by the length of the shaft. The concrete shall show the specified strength as indicated by the cube test results.
- e) The results of the load tests including non destructive dynamic test carried out in accordance with the contract and with the specifications shall be satisfactory.
- f) In case of single pile the positional tolerance shall not be more than 50mm.

#### 4.07.00 **Lateral Dynamic Load Test on Piles**

Two types of tests, namely, free and forced vibration lateral tests shall be carried out to observe response of soil-pile system under horizontal dynamic loads and for the evaluation of soil-pile stiffness, soil modulus, natural frequency, time period and damping characteristics of soil-pile system.

A minimum of three representative piles of same type in almost similar soil conditions shall be tested. Two adjacent piles shall be subjected first to free vibrations and then to forced vibrations, the third pile shall only be tested under forced vibrations.

The equipment and accessories for the test, setting up and test procedure and recording of observations shall be as described in relevant sections of IS : 9716 (Guide for Lateral Dynamic Load Test on Piles). The tests shall normally be carried out without sustained vertical load other than that of the oscillator assembly. However, sustained weight can be used to increase dynamic force to obtain resonance or nearly resonance condition.

From analysis of test data, the following parameters shall be determined:

- i) Frequency of vibrations
- ii) Amplitude of vibrations
- iii) Imparted dynamic force
- iv) Natural frequency
- v) Damping coefficient
- vi) Soil-pile stiffness
- vii) Coefficient of horizontal soil modulus variation

5.00.00 **INFORMATION TO BE SUBMITTED**

5.01.00 **With Tender**

The tenderer should submit the following information along with his tender.

5.01.01 **Design Data**

The contractor will submit full details of the method of construction, design data and drawings for the type of piles he wishes to adopt.

5.01.02 **Programme of Construction**

The contractor will also submit the details of the construction equipment that he will employ. A proposed construction programme, matching with the capacity of the equipment and taking into consideration the various idle and non production periods on account of shifting of equipment, testing and possible delays due to modifications of design should be drawn up and submitted along with the tender, keeping in view the completion dates stipulated in the tender.

5.02.00 **After Award**

After award of the contract, the successful tenderer is to submit the following details :

5.02.01 **Execution Plan**

Within 15 days of receiving the letter of intent the contractor will submit six (6) copies of drawings showing the sequence of piling. The drawings will be prepared on the basis of a master plan giving identification number of the piles, which will be furnished by the engineer.

5.02.02      **Detailed Construction Programme**

Within thirty (30) days of award of the contract, a detailed construction programme for completion of the work is to be submitted. This master programme will be reviewed and updated every month or at more frequent intervals as directed by the engineer, incorporating the various factors that have caused or are likely to cause changes in the programme.

5.02.03      **Requirement of Materials, Tools and Plants and Equipment**

In accordance with the master programme, a detailed material, tools and plants and equipment requirement schedule, particularly for those items which the owner is to supply or is to help in procurement as per the terms and conditions of contract is to be submitted within thirty (30) days of award of the contract.

5.02.04      **Test Results**

The test data and results for the various items like welding of pipes, ingredients of RCC, concrete cubes and cylinders, driving of the shell, static load tests on single piles and pile groups and dynamic tests on working pile will be submitted regularly and as and when directed by the engineer.

6.00.00      **RATES**

The rates for the items of installation of cast-in-situ bored piles shall include the cost of materials consumed in this work or incidental to it as well as testing of materials, the cost of plants and equipment, labour, supervision, transport, taxes, insurance, royalties and revenue expenses, security and safety measures, approaches, power, fuel, lubricants, services, preliminary and enabling works, camps, stores, etc. and overheads & profits complete. The rate shall include the entire cost of boring, supplying and installing concrete including the cost of extra concrete above cut-off level and subsequently dismantling and removing the same and providing steel casing wherever required. In case no specific item is provided in the schedule to cover any particular item of work, it is implied that the contractor will include the cost of executing such work in the rates quoted for connected items in the schedule.

7.00.00      **METHOD OF MEASUREMENT**

7.01.00      **Piles**

Unless specified otherwise in the schedule of items piles shall be measured in number and payment shall be done for the number of piles of a specific size and with a specified length measured from the toe of piles upto the pile cut-off level.

For any addition or reduction over the above specified lengths, the extra/rebate in rates for specific sizes shall be measured in length units.

7.02.00      **Permanent Steel Casing**

The weight of M.S.plate for use as casing shall be measured for payment.

7.03.00      **Reinforcement**

Length of reinforcing steel measured or calculated from drawings, whichever is less, including laps will be multiplied by standard unit weights to arrive at the quantity to be paid for.

7.04.00      **Filling in Boreholes**

The theoretical volume of the selected material required to fill the borehole between the concrete pile and surface level or the actual quantity of such material provided, whichever is less, shall be measured for payment.

7.05.00      **Load Tests**

For load tests, measurement shall be taken for vertical, lateral load or pull-out tests on single piles or pile group and dynamic test on working piles as per specification and schedule of items on each occasion of test.

**SPECIFICATION NO. C-9**

**FOR**

**FABRICATION OF STRUCTURAL  
STEELWORK**

**SPECIFICATION NO. C-9  
FOR  
FABRICATION OF STRUCTURAL STEELWORK**

**C O N T E N T S**

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**SPECIFICATION NO. C-9  
FOR  
FABRICATION OF STRUCTURAL STEELWORK**

**1.00.00 SCOPE**

This specification covers supply, fabrication, testing, painting and delivery to site of structural steelwork including supply of all consumable stores and bolts, nuts, washers, electrodes and other materials required for fabrication and field connections of all structural steelwork in general covered under the scope of the contract. However, for any special structures such as rail & road bridges, steel chimney, tanks, transmission towers, furnace structures, etc., the relevant Indian Standard or IRC specification and Codes of Practices shall be given due consideration over & above this specification.

**2.00.00 GENERAL**

**2.01.00 Work to be provided for by the Contractor**

The work to be provided for by the Contractor, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following:

- a) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on design drawings to be furnished by the Owner.
- b) To submit revised design with calculations and detailed fabrication drawings in case any substitution of the designed sections are to be made.
- c) To submit design calculations for joints and connections developed by the contractor along with detailed fabrication drawings.
- d) Furnish necessary test certificates of all raw steel materials supplied by the Contractor.
- e) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding electrodes for field connections. The field connection materials supplied by the contractor shall be to the extent of actual requirement plus 10% ( ten percent).
- f) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.
- g) Suitably mark, bundle and pack for transport all fabricated materials.
- h) Prepare and furnish detailed Bill of Materials, Drawing Office Despatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

- i) Insure, load and transport all fabricated steelwork field connection materials to site.

2.02.00 **Work by others**

No work under this specification will be provided for by any agency other than the contractor, unless specifically mentioned otherwise elsewhere in the contract.

2.03.00 **Codes and standards**

All work under this specification shall, unless otherwise specified in the contract, conform to the requirements of the latest revision and/or replacements of the following or any other relevant Indian Standard specifications and codes of practice. In case any particular aspect of the work is not specifically covered by any Indian Standard Specification, any other standard practice, as may be specified by the Engineer shall be followed:

- |          |   |   |
|----------|---|---|
| IS : 800 | - | Code of practice for general construction in steel.   |
| IS : 801 | - | Code of practice for use of cold formed light gauge steel structural members in general building construction.    |
| IS : 806 | - | Code of practice for use of steel tubes in general building construction.   |
| IS : 808 | - | Dimensions for rolled steel beams, channels and angle sections.   |
| IS : 812 | - | Glossary of terms relating to welding & cutting of metals.  |
| IS : 813 | - | Scheme of symbols for welding.  |
| IS : 814 | - | Covered electrodes for metal arc welding of carbon and carbon manganese steel.                                    |
| IS : 815 | - | Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel. |
| IS : 816 | - | Code of practice for use of metal arc welding for general construction in mild steel.                             |
| IS : 817 | - | Code of practice for training & testing metal arc welders.  |
| IS : 818 | - | Code of practice for safety and health requirements in electric and gas welding and cutting operations.           |
| IS : 819 | - | Code of practice for resistance spot welding for light assemblies in mild steel.                                  |
| IS : 822 | - | Code of practice for inspection of welds.   |
| IS : 919 | - | Recommendations for limits and fits for (Part-1&2)  |



		engineering.
IS : 1161	-	Steel Tubes for structural purposes.
IS : 1182	-	Recommended practice for Radiographic Examination of fusion welded butt joints in steel plates.
IS : 1200 (Part-8)	-	Method of measurement of steel work and iron work
IS : 1239 (Part-1&2)	-	Mild steel tubes, tubulars and other wrought steel fittings
IS : 1363 (Part-1 to 3)	-	Hexagon head bolts, screws and nuts of product grade C.
IS : 1364 (Part-1 to 5)	-	Hexagon head bolts, screws and nuts of product grade A & B.
IS : 1365	-	Slotted counter sunk head screws (dia. 1.6 to 20mm)
IS : 1367 (Part-1 to 18)	-	Technical supply conditions for threaded steel fasteners.
IS : 1608	-	Method for tensile testing of steel products.
IS : 1730	-	Dimensions for steel plate, sheet and strip for structural and general engineering purposes.
IS : 1852	-	Rolling and cutting tolerances for hot-rolled steel product.
IS : 1977	-	Structural steel (Ordinary quality)
IS : 2016	-	Plain washer
IS : 2062	-	Steel for general structural purposes.
IS : 2629	-	Recommended practice for hot-dip galvanising of iron and steel.
IS : 2633	-	Method for testing uniformity of coating on zinc coated articles.
IS : 3644	-	Code of practice for ultrasonic pulse echo testing by contact and immersion method.
IS : 3757	-	High Strength Structural Bolt
IS : 4000	-	High strength bolts in steel structure

- |                              |   |  |
|------------------------------|---|--|
| IS : 4759                    | - | Specifications for hot-dip zinc coatings on structural steel and other allied products.      |
| IS : 4923                    | - | Hollow steel sections for structural use.  |
| IS : 5334                    | - | Code of practice for magnetic particle flaw detection of weld.                               |
| IS : 5369                    | - | General requirements for plain washers and lock washer.                                      |
| IS : 6005                    | - | Code of practice for phosphating of iron and steel.  |
| IS : 6649                    | - | Specification for hardened and tempered washers for high strength structural bolts and nuts. |
| IS : 6623                    | - | Specification for high strength structural nuts.   |
| IS : 7215                    | - | Tolerances for fabrication of steel structures.  |
| IS : 7280                    | - | Bare wire electrode for submerged arc welding  |
| IS : 8500                    | - | Structural steel micro alloyed (medium & high strength quality).                             |
| IS : 8629<br>(Part-I to III) | - | Code of practice for protection of iron and steel structures from atmospheric corrosion.     |
| IS : 9595                    | - | Recommendation for metal arc welding of carbon manganese steels.                             |

#### **PAINTING**

- |                            |   |   |
|----------------------------|---|---|
| IS : 117                   | - | Specification for ready mixed paint, brushing, finishing, exterior, semi-gloss, for general purposes. |
| IS : 128                   | - | Specification for ready mixed paint, brushing, finishing, semi-gloss for general purposes, black.     |
| IS : 1477<br>(Part-I & II) | - | Code of practice for painting of ferrous metal in building.   |
| IS : 2074                  | - | Ready mixed paint, air-drying red-oxide zinc chrome priming.  |
| IS : 2339                  | - | Specification for aluminium paints for general purposes in dual container.                            |
| IS : 2932                  | - | Specification for enamel, synthetic exterior type-I.  |
| IS : 2933                  | - | Specification for enamel, synthetic exterior type-II.   |

## 2.04.00 **Conformity with Designs**

Except where the standard connection details are furnished, the contractor shall design all connections, supply and fabricate all steelwork and furnish all connection materials in accordance with the approved drawings and/or as instructed by the Engineer Keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and/or as approved by the Engineer. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

## 2.05.00 **Materials to be used**

### 2.05.01 **General**

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Engineer and/or Consultant.

If desired by the Engineer, Test Certificates of materials supplied by the contractor in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Engineer, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

The arc welding electrodes shall conform to the relevant Indian Standard Codes of Practice and Specifications and shall be of heavily coated type and the thickness of the coating shall be uniform and concentric. With each container of electrodes, the manufacturer shall furnish instructions giving recommended voltage and amperage (Polarity in case of D.C. supply) for which the electrodes are suitable.

### 2.05.02 **Steel**

All steel materials to be used in construction within the purview of this specification shall comply with any of the following Indian Standard Specifications as may be applicable : -

- |           |   |   |
|-----------|---|---|
| IS : 801  | - | Cold formed light gauge steel structural member.                  |
| IS : 806  | - | Steel tubes in general building construction.                     |
| IS : 1161 | - | Steel tubes for structural purpose.                               |
| IS : 1977 | - | Structural steel (Ordinary quality) St-42-0                       |
| IS : 2062 | - | Steel for general structural purpose                              |
| IS : 8500 | - | Structural steel-micro alloyed (Ordinary & high strength quality) |

In case of imported steel materials being used, these shall conform to specifications equivalent to any of the above as may be applicable.

#### 2.05.03 **Electrodes**

All electrodes to be used under the Contract shall comply with any of the following Indian Standard Specifications as may be applicable :

- IS : 814 - Covered electrodes for metal arc welding structural steel
- IS : 815 - Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.
- IS : 7280 - Base wire electrode for submerged arc welding.

#### 2.05.04 **Bolts and Nuts**

All bolts and nuts shall conform to the requirements of Indian Standard Specification IS:1367 - Technical Supply Conditions for Threaded Fasteners.

Materials for Bolts and nuts under the purview of this contract shall comply with any of the following Indian Standard Specifications as may be applicable.

- a) Mild Steel : All mild steel for bolts and nuts when tested in accordance with the following Indian Standard Specification shall have a tensile strength of not less than 44 Kg/mm<sup>2</sup> and a minimum elongation of 23 per cent on a gauge length of 5.6  $\sqrt{A}$ , where 'A' is the cross sectional area of the test specimen : -

IS:1367 - Technical supply conditions for threaded fasteners.

IS:1608 - Method for tensile testing of steel other than sheet, strip, wire and tube.

- b) High Tensile Steel : The material used for the manufacture of high tensile steel bolts and nuts shall have the mechanical properties appropriate to the particular class of steel as set out in IS:1367 or as approved by the Engineer.

#### 2.05.05 **Washers**

Washers shall be made of steel conforming to any of the following Indian Standard Specifications as may be applicable under the provisions of the Contract :

- IS : 1977 - Structural steel (Ordinary Quality) St-42-0
- IS : 2062 - Steel for general structural purpose
- IS : 8500 - Structural steel - micro alloyed (medium & high strength quality)
- IS : 6623 - High Strength Structural Nuts

IS : 6649 - Hardened and tampered washers for high strength structural bolts & nuts.

#### 2.05.06 **Paints**

Paints to be used for shop coat of fabricated steel under the purview of this contract shall conform to the Indian Standard Specification IS:2074 - Ready mixed Paint, Air Drying, Red Oxide - Zinc Chromate Priming.

In highly corrosive environment other type of primer such as epoxy resin based zinc rich primer (such as blast steel EZ1 of Shalimer Paints Ltd., or equivalent) may be necessary.

#### 2.06.00 **Storage of Material**

##### 2.06.01 **General**

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged shall be removed from the contractor's yard immediately, failing which, the Engineer shall be at liberty to get the material removed and the cost incurred thereof shall be realised from the Contractor. The Contractor shall maintain upto date accounts in respect of receipt, use and balance of all sizes and sections of steel and other materials. In case the fabrication is carried out in contractor's fabrication shop outside the plant site where other fabrication works are also carried out, all materials meant for use in this contract shall be stacked separately with easily identifiable marks.

##### 2.06.02 **Steel**

The steel to be used in fabrication and the resulting cut- pieces shall be stored in separate stacks off the ground sectionwise and lengthwise so that they can be easily inspected, measured and accounted for at any time. If required by the Engineer, the materials may have to be stored under cover and suitably painted for protection against weather.

##### 2.06.03 **Electrodes**

The electrodes for electric arc welding shall be stored in properly designed racks, separating different types of electrodes in distinctly marked compartments. The electrodes shall be kept in a dry and warm condition if necessary by resorting to heating.

##### 2.06.04 **Bolts, Nuts and Washers**

Bolts, nuts and washers and other fastening materials shall be stored on racks off the ground with a coating of suitable protective oil. These shall be stored in separate gunny bags or compartments according to diameter, length and quality.

2.06.05      **Paints**

Paints shall be stored under cover in air tight containers. Paints supplied in sealed containers shall be used up as soon as possible once the container is opened.

2.07.00      **Quality Control**

The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer or Engineer's representative. As far as possible, all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at Site or elsewhere. The Contractor shall co-operate with the Engineer or Engineer's representative in permitting access for inspection to all places where work is being done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Contractor.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work : -

- |    |              |   |  |
|----|--------------|---|--|
| 1) | Steel        | : | Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.   |
| 2) | Bolts, Nuts  | : | Manufacturer's certificate, dimension & Washers checks, material testing.  |
| 3) | Electrodes   | : | Manufacturer's certificate, thickness and quality of flux coating.   |
| 4) | Welders      | : | Qualifying Tests   |
| 5) | Welding sets | : | Performance Tests  |
| 6) | Welds        | : | Inspection, X-ray, Ultrasonic tests  |
| 7) | Paints       | : | Manufacturer's certificate, physical inspection reports  |
| 8) | Galvanizing  | : | Tests in accordance with IS : 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS : 4759 - Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products. |

2.08.00      **Standard Dimensions, Forms and Weights**

The dimensions, forms, weights and tolerances of all rolled shapes bolts, nuts, studs, washers etc. and other members used in the fabrication of any structure shall, wherever applicable, conform to the requirements of the latest relevant Indian Standards, wherever they exist, or, in the absence of Indian Standards, to other equivalent standards.

2.09.00      **Shop Drawings**

The contractor shall within thirty (30) days after the award of the Contract submit to the Engineer the Schedule of Fabrication and delivery of structural steelwork for approval. He shall, within forty five (45) days after the award of the contract start to submit progressively for approval, the shop drawings based on the Design Drawings furnished to him and, before proceeding with the fabrication work, shall get the said shop drawings approved in accordance with the contract.

The sequence of submission of shop drawings for approval shall match with the approved fabrication and delivery schedule. The approval for the shop drawings will be accorded only towards the general conformity with the design requirements as well as specification and will ensure the correctness of general arrangement for centreline dimensions and levels, Section sizes, and adequacy of connections including splice joints as to the no. of bolts, weld length, size of gusset/end plates. The correctness of all other details like cutting lengths, matching of holes, notch dimensions, match markings, bill of materials, bolt list etc. will be entirely the contractor's responsibility. The approval of the drawing however shall not relieve the contractor of his sole responsibility in carrying out the work correctly and fulfilling the complete requirements of contract documents.

The shop drawings shall include but not be limited to the following :

- a)      Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.
- b)      Dimensional drawings of base plates, foundation bolt location etc.
- c)      Details of all connections with supporting calculations.
- d)      Comparison sheets to show that the proposed alternative section, if any, are as strong as the original sections shown on the Design Drawings.
- e)      Complete Bill of Materials and detailed drawings of all sections as also their billing weights.
- f)      Any other drawings or calculations that may be required for the clarification of the works or substituted parts thereof.

The shop drawings shall give all the necessary information for the fabrication, erection and painting of the steelwork in accordance with the provisions of this Specification. Shop drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication

and erection. Shop drawings shall give complete information necessary for fabrication of various components of the steelwork, including the location, type, size and extent of welds. These shall also clearly distinguish between shop and field bolts and welds and specify the class of bolts and nuts. The drawings shall be drawn to a scale large enough to convey all the necessary information adequately. Notes on the shop drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence and technique of welding shall be carefully controlled to minimize the locked-up stresses and distortion. Welding symbols used shall be in accordance with the requirements of the Indian Standard Specification - IS:813 - Scheme of symbols for Welding, and shall be consistent throughout. Weld lengths called for on the drawings shall mean the net effective length.

The Contractor shall be responsible for and shall pay for any alterations of the work due to any discrepancies, errors or omissions on the drawings or other particulars supplied by him, whether such drawings or other particulars have been duly approved or not in accordance with the Contract.

3.00.00      **WORKMANSHIP**

3.01.00      **Fabrication**

3.01.01      **General**

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of the Indian Standard IS:800 - Code of Practice for use of Structural Steel in General Building Construction and other relevant Indian Standards or equivalent.

3.01.02      **Straightening Material**

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed by the Indian Standard Specification IS:1852 - Specification for rolling and cutting tolerance for hot-rolled steel products. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600 Deg. C.

3.01.03      **Cutting**

Cutting shall be effected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Engineer.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gouges not more than 4 mm deep will be



permitted. Gouges greater than 4 mm, that remain from cutting, shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

#### 3.01.04 **Planning of Edges**

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Engineer.

#### 3.01.05 **Clearances**

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end, but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

#### 3.02.00 **Bolted construction**

##### 3.02.01 **Holes**

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3mm subject to a maximum thickness of 16mm provided that the holes are punched 3mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for rivets or black bolts shall be not more than 1.5 mm or 2.0 mm (depending on whether the diameter of the bolt is less or more than or equal to 25 mm) larger in diameter than the nominal diameter of the black bolt passing through them.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS:919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

3.02.02      **Assembly**

Drifting to enlarge unmatching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted nor otherwise damaged, and shall be so prepared that the specified cambers, if any, are maintained.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Engineer.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or lock-nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

3.03.00      **Welded Construction**

3.03.01      **General**

Welding shall be in accordance with relevant Indian Standards and as supplemented in the Specification. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS:817.

3.03.02      **Preparation of Material**

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears. Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

3.03.03      **Assembling**

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees ( 2 Deg.).

The work shall be positioned for flat welding whenever practicable.

### 3.03.04      **Welding Sequence**

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Engineer, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Engineer.

### 3.03.05      **Welding technique**

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

### 3.03.06      **Temperature**

No welding shall normally be done on parent material at a temperature below (-) 5 Deg.C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 5 Deg. C and 0 Deg. C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is handwarm. When the parent material is

more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 20 Deg. C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

3.03.07      **Peening**

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

3.03.08      **Equipment**

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the engineer.

3.04.00      **Finish**

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-butt over the whole section with a clearance not exceeding 0.1 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 1.0 mm.

3.05.00      **Slab Bases and Caps**

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

To facilitate grouting, holes shall be provided, where necessary, in stanchion bases for the escape of air.

3.06.00      **Lacing bars**

The ends of lacing bars shall be neat and free from burrs.

3.07.00      **Separators**

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

3.08.00      **Bearing Plates**

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

3.09.00      **Architectural Clearances**

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

3.10.00      **Shop connections**

- a)      All shop connections shall be welded as specified on the Drawings.
- b)      Certain connections, specified to be shop connections, may be changed to field connections if desired by the Engineer for convenience of erection and the Contractor will have to make the desired changes at no extra cost to the Owner.

3.11.00      **Castings**

Steel castings shall be annealed

3.12.00      **Shop erection**

The steelwork shall be temporarily shop-erected complete or as directed by the Engineer so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchangeability.

3.13.00      **Shop painting**

3.13.01      **General**

Unless otherwise specified, steelwork which will be concealed by interior building finish need not be painted; steelwork to be encased in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given one coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned, in accordance with the following paragraph, by brush, spray, roller coating, flow- coating or dipping as may be approved by the Engineer.

After inspection and approval and before leaving the shop, all steelwork specified to be painted shall be cleaned by hand- wire brushing or by other mechanical cleaning methods to remove loose mill scale, loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by solvent. Steelwork specified to have no shop paint shall, after fabrication, be cleaned of oil or grease by solvent cleaners and be cleaned of dirt and other foreign material by through sweeping with a fibre brush.

After completion of the precleaning, the metal surface shall be immediately painted with red oxide zinc chromate primer conforming to IS : 2074.

In highly corrosive environment, all steelwork shall be given a coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned by sand blasting to SA 2/1/2 grade minimum. The shop paint shall be epoxy resin based zinc rich primer such as Blast Steel EZ1 of Shalimer Paint Limited or equivalent.

**3.13.02 Inaccessible Parts**

Surfaces not in contact, but inaccessible after assembly, shall receive two coats of shop paint, positively of different colours to prove application of two coats before assembly. This does not apply to the interior of sealed hollow sections.

**3.13.03 Contact Surfaces**

Contact surface shall be cleaned in accordance with Sub-clause 3.13.1 before assembly.

**3.13.04 Finished Surfaces**

Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

**3.13.05 Surfaces adjacent to Field Welds**

Unless otherwise provided for, surfaces within 50 mm of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

**3.14.00 Galvanizing**

**3.14.01 General**

Structural steelwork for switchyard or other structures as may be specified in the Contract shall be hot dip galvanized in accordance with the American Society for Testing and Materials Specification ASTM-A 123 or IS : 2629 - Recommended practice for Hot-Dip Galvanising of Iron and steel. Where the steel structures are required to be galvanized the field connection materials like bolts, nuts and washers shall also be galvanized.

**3.14.02 Surface Preparation**

All members to be galvanized shall be cleaned, by the process of pickling of rust, loose scale, dirt, oil, grease, slag and spatter of welded areas and other foreign substances prior to galvanizing. Pickling shall be carried out by immersing the steel in an acid bath containing either sulphuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and the temperature of the bath can be varied, provided that the pickling time is adjusted accordingly.

The pickling process shall be completed by thoroughly rinsing with water, which should preferably be warm, so as to remove the residual acid.

3.14.03      **Procedure**

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements when tested in accordance with IS:2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS:4759 - Specification for Hot-dip zinc coatings on Structural Steel & other allied products.

After finishing the threads of bolts, galvanizing shall be applied over the entire surface uniformly. The threads of bolts shall not be machined after galvanizing and shall not be clogged with zinc. The threads of nuts may be tapped after galvanizing but care shall be taken to use oil in the threads of nuts during erection.

The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized. Where members are of such lengths as to prevent complete dipping in one operation, great care shall be taken to prevent warping.

Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after having been dipped twice, it shall be rejected. Special care shall be taken not to injure the skin on galvanized surfaces during transport and handling. Damages, if occur, shall be made good in accordance with the provisions of this Specification or as directed by the Engineer.

4.00.00      **INSPECTION, TESTING, ACCEPTANCE  
CRITERIA AND DELIVERY**

4.01.00      **Inspection**

Unless specified otherwise, inspection to all work shall be made by the Engineer or Engineer's representative at the place of manufacture prior to delivery. The Engineer or his representative shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification.

The Contractor shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Engineer to carry out inspection and/or tests in accordance with the Contract.

The Contractor shall guarantee compliance with the provisions of this Specification.

#### 4.02.00 **Testing and Acceptance Criteria**

##### 4.02.01 **General**

The Contractor shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

##### 4.02.02 **Steel**

All steel supplied by the Contractor shall conform to the relevant Indian Standards. Except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Engineer, random samples of materials will be taken from each unidentified lot of 50 M.T or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be borne by the Contractor.

All material shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

##### 4.02.03 **Testing Criteria for checking Lamination in Raw Steel Plates**

All raw steel plate of thickness more than 20 mm supplied by the contractor shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Engineer.

- a) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.
- b) If the results of the tests in (a) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (a) or as directed by the Engineer.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Engineer requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Contractor. If the plates in the fabricated item is found to be laminated, the component will be rejected.

##### 4.02.04 **Welding**

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Engineer may



ask for at least 1 (one) test- destructive or non-destructive including X-ray, ultrasonic test or similar, the cost of which shall be borne by the Contractor. In the event of further tests as may be desired by the Engineer, the cost of such test shall be borne by the Contractor if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the Owner. In cases of the test results showing deficiency, the Engineer shall have option to reject or instruct any remedial measures to be taken free of charge to the Owner.

4.02.05      **Bolts, Nuts and Washers**

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Engineer and shall conform to the relevant Indian Standards. If desired by the Engineer, representative samples of these materials may have to be tested in an approved laboratory and in accordance with the procedures described in relevant Indian Standards. Cost of all such testing shall have to be borne by the Contractor.

4.02.06      **Shop Painting**

All paints and primers shall be of standard quality and procured from approved manufacturers and shall conform to the provisions of the relevant Indian Standards.

4.02.07      **Galvanizing**

All galvanizing shall be uniform and of standard quality when tested in accordance with IS:2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS:4759 - specification for Hot-Dip Zinc Coatings on Structural Steel & other allied products.

4.03.00      **Tolerance**

The tolerances on the dimensions of individual rolled steel components shall be as specified in IS:1852 - specification for rolling and Cutting Tolerances for Hot-rolled Steel Products. The tolerances on straightness, length etc. of various fabricated components (such as beams and girders, columns, crane gantry girder etc.) of the steel structures other than steel railway & road bridges, structures subjected to dynamic loading (like wind, seismic etc.) and thin walled construction (like box girders) shall be as specified in IS:7215 - Tolerances for Fabrication of Steel Structures.

4.04.00      **Acceptance**

Should any structure or part of a structure be found not to comply with any of the provisions of this Specification, the same shall be liable to rejection. No structure or part of the structure, once rejected, shall be offered again for test, except in cases where the Engineer considers the defects rectifiable. The Engineer may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved laboratory and should the items, so tested, be found to be unsatisfactory, the costs shall be borne by the contractor, and if satisfactory, the costs shall be borne by the Owner.

When all tests to be performed in the Contractor's shop under the terms of this contract have been successfully carried out, the steelwork will be accepted forthwith and the Engineer will issue an acceptance certificate, upon receipt of which, the items will be shop painted, packed and despatched. No item to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

4.05.00      **Delivery of materials**

4.05.01      **General**

The Contractor will deliver the fabricated structural steel materials to site with all necessary field connection materials in such sequence as will permit the most efficient and economical performance of the erection work. the Owner may prescribe or control the sequence of delivery of materials, at his own discretion.

4.05.02      **Marking**

Each separate piece of fabricated steelwork shall be distinctly marked on all surfaces before delivery in accordance with the markings shown on approved erection drawings and shall bear such other marks as will further facilitate identification and erection.

4.05.03      **Packing and Shipping**

All projecting plates or edges and all ends of members of joints shall be stiffened, all straight members and plates, shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all bolts, nuts, washers, and small loose parts shall be packed separately in order to prevent damage or distortion during shipping.

Shipping shall be strictly in accordance with the sequence stipulated in the agreed programme. Payment may be held up for items sent in advance of the sequence till they could be erected. The Contractor shall include and provide for in his rates, the freight and other charges for despatching the materials to the worksite and also for securely protecting and packing the materials to avoid loss or damage during transport by rail, road or water. All packings shall allow for easy removal and checking at site. Special precautions shall be taken against rusting, corrosion, breakage or damage otherwise of the materials. All parts shall be adequately braced to prevent damage in transit.

Each bundle, bale or package delivered under this contract shall be marked on as many sides as possible and such distinct marking (all previous irrelevant markings being carefully obliterated) shall show the following : -

- a)      Name and address of the consignee
- b)      Name and address of the consignor
- c)      Gross weight of the package in tonnes and its dimensions

- d) Identification marks and/or number of the package
- e) Custom registration number, if required

All markings shall be carried out with such materials as would ensure quick drying and indelibility.

Each component or part or piece of material when shipped, shall be indelibly marked and/or tagged with reference to assembly drawings and corresponding piece numbers.

Each packing case shall contain in duplicate in English a packing list pasted on to the inside of the cover in a water- proof envelope, quoting especially -

- a) Name of the Contractor
- b) Number and date of the Contract
- c) Name of the office placing the contract
- d) Nomenclature of stores
- e) A schedule of parts or pieces, giving the parts or piece number with reference to assembly drawings and the quantity of each.

The shipping dimensions of each package shall not exceed the maximum dimensions permissible for transport over the Indian Railways/Roads.

After delivery of the materials at site, all packing materials shall automatically become the property of the Owner without any extra payment.

Notwithstanding anything stated hereinbefore, any loss or damage resulting from inadequate packing shall be made good by the Contractor at no additional cost to the Owner. When facilities exist, all shipments shall be covered by approved Insurance Policy for transit at the cost of the Contractor.

The contractor shall ship the complete materials or part on board a vessel belonging to an agency approved by the Owner or on rail and/or road transport as directed. The Contractor shall take all reasonable steps to ensure correct appraisal of freight rates, weights and volumes and in no case will the Owner be liable to pay any warehouse, wharfage, demurrage and other charges.

If, however, the Owner has to make payment of any of the above mentioned charges, the amount paid will be deducted from the progressive bills of the Contractor.

Necessary advise regarding the shipment with relevant details shall reach the Engineer at least a week in advance.

5.00.00      **INFORMATION TO BE SUBMITTED**

5.01.00      **With Tender**

The following information are required to be submitted with the Tender:

a)      **Progress Schedule**

The Contractor shall quote in his Tender a detailed schedule of progress of work and total time of completion, itemizing the time required for each of the following aspects of work.

- 1)      Preparation and approval of shop drawings
- 2)      Procurement of materials
- 3)      Fabrication and shipping of all anchor bolts
- 4)      Fabrication and shipping of main steelwork
- 5)      Fabrication and shipping of steelwork for bunkers. Tanks and/or silos as applicable.
- 6)      Fabrication and shipping of all other remaining steel work including miscellaneous steelwork
- 7)      Final date of completion of all shipments

Time required for completion being one of the main criteria for selecting the successful bidder, it is desired that the bidder quotes the minimum time required by him for completing the work.

b)      **Shop**

Location of the Tenderer's fabrication workshop giving details of equipment, manpower, the total capacity and the capacity that will be available exclusively for this contract shall be submitted.

5.02.00      **After Award**

After award of the Contract the successful Tenderer is to submit the following :

- a)      Complete fabrication drawings, material lists, cutting lists, bolt lists, field welding schedules based on the design drawings furnished to him in accordance with the approved schedule.
- b)      Monthly Progress Report with necessary photographs in six (6) copies to reach the Engineer on or before the 7th day of each month, giving the upto date status of preparation of detailed shop drawings, bill of materials, procurement of materials, actual fabrication done, shipping and all other relevant information.

- c) Results of any test as and when conducted and as required by the Engineer.
- d) Manufacturer's mill test report in respect of steel materials, bolts, nuts and electrodes as may be applicable.

6.00.00 **RATES**

6.01.00 **General**

In general, even though it may not be specifically mentioned in the Schedule of Items, the rates for items mentioned in the Schedule of Items shall include cost of all materials consumed in the work or incidental to it, hire charges of tools and plants, cost of labour, insurance, all transport charges including transporting and delivery of finished fabricated materials back to sites, all taxes, royalties,, making approaches, security and safety arrangements, power, fuel, lubricant, preparation of all fabrication drawings, material lists, cutting lists, bolt lists, field welding schedule, services, supervision, overheads, profits etc. complete in all respects unless certain items specifically excluded by the terms and conditions of the Contract and as mentioned in the following sub-clauses.

6.02.00 **Fabrication**

The rates quoted for fabrication of various categories of steelwork shall specifically include supply of all raw steel materials, one shop coat of approved metal protection paint but exclude any transport of the fabricated materials. The rates for fabrication shall also include supply of all electrodes required for shop and field work including 10% extra for field work.

6.03.00 **Transport**

The rate quoted for transport shall include all C.I.F. from the Contractor's fabricating shop upto the Site and loading of the fabricated materials on railway wagons or trucks at the fabricating shop but shall generally exclude unloading at site(which is generally included in the rate for erection). But, in case the terms & conditions of the contract so desire, the cost of unloading of the fabricated material at site shall also be included in the quoted rates for transport.

6.04.00 **Bolts, nuts and washers**

The rates quoted for the supply of bolts, nuts and washers shall include the total cost of delivery of the materials at site.

7.00.00 **METHOD OF MEASUREMENT**

7.01.00 **Fabrication**

Measurement shall be in tonnes and based on the unit weights as per relevant Indian Standards and on the following considerations : -

- a) All members, except plate works paid under rates for bunkers, tanks,

etc., will be measured square.

- b) All plate works paid under rates for bunkers, tanks, etc. as applicable will be measured as actual.
- c) No deduction will be made for bolt and/or holes and/or holes upto 25 Sq.Cm.
- d) Unless otherwise specified no allowance shall be made for weld metals in case of welded steel structure.

**7.02.00 Supply of bolts, nuts and Washers**

The supply of bolts, nuts and washers will be measured on standard unit weight basis or actuals whichever is less.

**7.03.00 Transport**

The measurement for transport of fabricated steelwork will be for the net weight of the fabricated materials as measured under Sub-clause 7.1.0 excluding the weight of all packing and supporting materials necessary for transport.

**8.00.00 PAYMENT**

Unless mentioned otherwise in the tender / contract document, for fabricated materials delivered to Site, the Contractor shall be entitled to 90% of the value of the materials supplied and the balance 10% shall be paid only after the final erection, and aligning of the fabricated materials. In addition, the Security Money as stipulated in the Contract, shall be deducted from each payment.

**SPECIFICATION NO. C-10**

**FOR**

**ERECTION OF STRUCTURAL  
STEELWORK**

**SPECIFICATION NO. C-10  
FOR  
ERECTION OF STRUCTURAL STEELWORK**

**C O N T E N T S**

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**SPECIFICATION NO. C-10  
FOR  
ERECTION OF STRUCTURAL STEELWORK**

**1.00.00 SCOPE**

This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at Site, installing the same in position, painting and grouting the stanchion bases all complete as per Drawings, this Specification and other provision of the Contract.

**2.00.00 GENERAL**

**2.01.00 Work to be provided for by the Contractor**

The work to be provided for by the Contractor, unless otherwise specified in the Contract, shall include but not be limited to the following:-

- a) The Contractor shall provide all construction and transport equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- b) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Contractor shall pay all demurrage and/or wharfage charges etc. on account of default on his part.
- c) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer. If necessary suitable temporary approach roads to be built for transportation of fabricated steel structures.
- d) Checking center lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. any defect observed in the foundation shall be brought to the notice of the Engineer. The Contractor shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.
- e) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Engineer.
- f) Painting of the erected steel structures if required by the Contract.

- g) All minor modifications of the fabricated steel structures as directed by the Engineer including but not limited to the following:-
  - i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
  - ii) Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.
  - iii) Reaming of holes for use of higher size bolt if required.
  - iv) Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Engineer.
  - v) Refabrication of parts damaged beyond repair during transport and handling or Refabrication of parts which are incorrectly fabricated.
  - vi) Fabrication of parts omitted during fabrication by error, or subsequently found necessary.
  - vii) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
  - viii) Carry out tests in accordance with this Specification if directed.

2.02.00 **Work by others**

No work under this Specification will be provided for by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

2.03.00 **Codes and Standards**

All work under this Specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specification and codes of Practice of equivalent:-

- IS-800 : Code of Practice for general construction in steel
- IS-456 : Code of Practice for plain or reinforced concrete
- IS-7205 : Safety Code for erection of Structural Steel work
- IS-12843 : Tolerance for erection of Steel Structures

2.04.00 **Conformity with Designs**

The Contractor will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and/or other stated document. All work shall

conform to the provisions of the relevant Indian Standard Specifications and/or the instructions of the engineer. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and/or the instructions of the Engineer.

2.05.00      **Material**

2.05.01      **General**

All fabricated steel structures and connection materials shall be supplied by the Contractor for fabrication work. The Contractor for erection work will take delivery of all the materials from storage yard at Site. The Contractor may also have to take delivery directly from railway wagons or trucks at Site as per terms & condition of the contract, in which case he shall have to unload the materials and perform all formalities like checking of materials and attend to insurance matters in accordance with Sub-Clause 2.1.0 and as specified hereinbefore.

While taking delivery, the Contractor will check the quantity, quality and the sizes of the materials and verify the adequacy of the same in accordance with the Drawings and Specifications. In case the Contractor finds any material inadequate, he shall inform the Engineer immediately prior to taking delivery of the same. No claim whatsoever, in respect of bad quality, shortages or difference in size will be entertained once the delivery is taken and the Contractor shall make good any such deficiency, if detected later, either by repair or with fresh material as may be directed by the Engineer at the Contractor's Own cost.

Excepting all field connection materials like bolts, nuts, washers and electrodes, which will be supplied by the fabrication Contractor to the extent of 10% in excess of the estimated requirements as per Drawings, all other consumables like oxygen and acetylene gas, paints, fuels, lubricants, oil, grease, cement, sand, aggregates and any other material that may be required for the execution of the works in accordance with the contract will be supplied by the contractor for erection work and will be deemed to have been included in this rates.

2.05.02      **Materials to conform to Indian Standards**

All materials required to be supplied by the Contractor under this Contract shall conform to the relevant Indian Standard Specifications.

2.06.00      **Storage of Materials**

2.06.01      **General**

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site, failing which, the Engineer shall be at liberty to get the materials removed by agency and the cost incurred thereof shall be realised from the Contractor's dues.

2.06.02      **Yard**

The Contractor will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials. The yard shall have proper facilities like, drainage, lighting, suitable access for large cranes, trailers and other heavy equipments. The yard shall be fenced all around with security arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access for cranes, trailers and other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

The Tenderer should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. all of which shall be carried out by the Contractor at his own cost as directed by the Engineer.

**2.06.03 Covered Store**

All field connection materials, paints, cement etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Contractor.

**2.07.00 Quality Control for Erection**

The contractor shall establish and maintain quality control procedures for different items of work and materials as may be directed by the Engineer to assure compliance with the provisions of the Contract and shall submit the records of the same to the Engineer. The quality control operation shall include but not be limited to the following items of work:-

- 1) Erection : Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.
- 2) Grouting : Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency and strength of grout.
- 3) Painting : Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

**2.08.00 Taking Delivery**

The erection Contractor shall take delivery of fabricated structural steel and necessary connection materials supplied by the fabrication Contractor from railhead, trucks as may be necessary and as per terms & conditions of the contract or as directed by the Engineer. He shall check, unload, transport the materials to his stores for proper storing at his own cost. The erection Contractor shall submit claims to insurance or other authorities and pursue the same in case of loss or damage during transit and handling and all loss thereof shall be borne by him.

The erection contractor shall also take all precautions against damage of the materials in his custody after taking delivery and till the same are erected in place and accepted.

3.00.00      **WORKMANSHIP**

3.01.00      **Erection**

3.01.01      **Plant and Equipment**

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Engineer.

3.01.02      **Method and Sequence of Erection**

The method and sequence of erection shall have the prior approval of the Engineer. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

3.01.03      **Temporary Bracing**

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the Owner, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The responsibility of the Contractor in respect of temporary bracings and guys shall cease when the structural steel is once located, plumbed, levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Engineer.

The temporary guys, braces, false work and cribbing shall be removed immediately upon completion of the steel erection and shall return to the Owner's store in good condition if the materials are supplied by the Owner otherwise permission shall be given to Contractor to take out the materials from the project site. The Owner may remove and return the materials in good condition to the Contractor without any charge if they have been left in place under other agreed arrangement.

3.01.04      **Temporary Floors for Buildings**

It shall be the responsibility of the Contractor to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and/or by-laws of state, Municipal or other local authorities.

3.01.05      **Setting out**

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Engineer. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Contractor shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations. He shall remain responsible for correct positioning. For heavy columns, etc. the Contractor shall set proper screed bars if desired by the Engineer, to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

3.01.06      **Field Bolting**

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:-

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum bolt tension by any of the following methods.

a)      **Turn-of-Nut Method**

When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into good contact with each other. "snug tight" is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All

bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table-1 with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

**TABLE-I**

<b>Bolts length not exceeding 8xdia. or 200mm</b>	<b>Bolts length exceeding 8xdia. or 200mm</b>	<b>Remarks</b>
½ turn	_ turn	Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation - 30 over or under.

Bolts may be installed without hardened washers when tightening is done by the turn-of-nut method. However, normal washers shall be used.

Bolts tightened by the turn-of-nut method may have the outer face of the nut match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

**b) Torque Wrench tightening**

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in TABLE-II. Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

**TABLE-II**

<b>Nominal Bolt Diameter (mm)</b>	<b>Torque to be applied (Kg.M) for bolt class 8.8 of IS:1367</b>
20	59.94
22	81.63
103.73	

**NOTE :**

The above torque values are approximate for providing tensions of 14.7 MT for 20 mm dia., 18.2 MT for 22 mm dia., and 21.2 MT for 24 mm dia., bolts under moderately lubricated condition. The torque wrench shall be calibrated at least once daily to find out the actual torque required to produce the above required tension in the bolt by placing it in a tension indicating device. These torques shall be applied for tightening the bolts on that day with the particular torque wrench.

In either of the above two methods, if required, for bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches if used shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this sub clause.

#### 3.01.07 **Field Welding**

All field assembly and welding shall be carried out in accordance with the requirements of the specification for fabrication work applicable to the project, excepting such provisions therein which manifestly apply to shop conditions only. Where the fabricated structural steel members have been delivered painted, the paint shall be removed before field welding for a distance of at least 50 mm on either side of the joints.

#### 3.01.08 **Holes, Cutting and Fitting**

No cutting of sections, flanges, webs, cleats, bolts, welds etc. shall be done unless specifically approved and/or instructed by the Engineer.

The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract or directed by the Engineer. Wherever such work is specified the Contractor shall obtain complete information as to size, location and number of alterations prior to carrying out any work. The Contractor shall not be entitled for any payment on account of any such work.

#### 3.02.00 **Drifting**

Correction of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be called to the attention of the Engineer and approval of the method of correction obtained. The use of gas cutting torches at erection site is prohibited.

#### 3.03.00 **Grouting of stanchion bases and bearings of beams and girders on stone, brick or concrete (Plain or reinforced)**



Grouting shall be carried out with Ordinary Cement grout as described below :

The mix shall be one (1) part cement and one (1) part sand and just enough water to make it workable. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water and any accumulated water shall be removed. These shall be placed under expert supervision, taking care to avoid air-locks. Edges shall be finished properly. If the thickness of grout is 25 mm or more, two (2) parts of 6 mm down graded stone chips may be added to the above noted cement-sand grout mix, if required, by the Engineer or shown on the drawings.

Admixtures like aluminium powder, "ironite" or equivalent may be required to be added to the grout to enhance certain desirable properties of the grout.

Alternatively, the grouting may be done with non-shrink high strength free flow cementitious grout (ready mixed) like "Sika grout - 214", or "Anchor NSG" or approved equivalent.

No grouting shall be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, levelled and plumbed and sufficient floor beams are tied in position.

Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally levelled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall be thoroughly cleaned.

#### 3.04.00 **Painting after Erection**

Field painting, if required to be done by the erection Contractor, shall only be done after the structure is erected, levelled, plumbed, aligned and grouted in its final position, tested and accepted by the Engineer. However, touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the erection Contractor free of cost to the Owner. The materials and specification for such painting in the field shall be in accordance with the requirements of the specification for fabrication of structural steelwork applicable for the project.

Painting shall not be done in rainy or foggy weather or when humidity is such as to cause condensation on the surfaces to be painted. Before painting of steel, which is delivered unpainted, is commenced, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.

All field bolts, welds and abrasions to the shop coat shall be spot painted with the same paint used for the shop coat. Where specified, surfaces which will be in contact after site assembling shall receive a coat of paint (in addition to the shop coat, if any) and shall be brought together while the paint is still wet.

Surface which will be inaccessible after field assembly shall receive the full specified protective treatment before assembly. Bolts and fabricated steel members which are galvanized or otherwise treated and steel members to be encased in concrete shall not be painted.

The specification for paint and workmanship shall be in accordance with the requirements of the specification for fabrication of structural steelwork applicable to the project. The number of coats and the shades to be used shall be as specified or as directed by the Engineer.

**3.05.00 Stainless Steel Plate Lining in Bunker Hopper**

The hopper portion of the coal bunkers shall be lined with stainless steel plates of 3 mm thickness. The stainless steel shall be of AISI-316 quality. The work includes supply, fabrication, welding and fixing of stainless steel lining plate to bunker M.S. plate as per drawing & specification.

The stainless steel liner shall be fixed to the tanker hopper MS shall be plug welding using special electrodes (such as, Inox-CW coding AWS-310-16 ISMBOS-311 or Inox-D2 coding AWSE-309-16, ISMB 04-311 manufactured by Advani Oerlikon Ltd. or equivalent). Such plug welding shall be done by drilling 21.5 mm dia. holes at 300 mm centre to centre both ways as per drawings. The plug welding shall be ground flush with the lining plate.

**3.06.00 Final Cleaning up**

Upon completion of erection and before final acceptance of the work by the Engineer, the Contractor shall remove free of cost all false work, rubbish and all Temporary Works resulting in connection with the performance of his work.

**3.07.00 Safety Measures during Erection**

The safety measures to workmen and supervisors during all types of erection work (e.g., use of lifting appliances, slinging, welding, gas cutting, etc.) should be taken as per IS : 7205. When any statutory provisions exist, the same shall be complied with in addition to the provisions contained in the above code.

**4.00.00 TESTING AND ACCEPTANCE CRITERIA**

**4.01.00 General**

Loading tests shall be carried out on erected structures, if required by the Engineer, to check adequacy of fabrication and/or erection. Any structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract of either fabrication or erection of steelwork whoever is responsible for it and no payment towards the cost of the dismantled portion and any connected work shall be made to the Contractor, unless it is proved that the deficiency is due to reasons beyond the Contractor's scope. On the basis of the tests, the Engineer will decide whether the fabricator or the erector is responsible for the unacceptable member or structure and his decision will be final. In case it is established that the unacceptability of the member or structure is due to design deficiency, the cost of replacement and/or modifications will be borne by the Owner. In course of dismantling, if any damage is done to any other parts of the structure or to any fixtures, the same shall be made good free of cost by the Contractor responsible, to the satisfaction of the Engineer. The cost of the tests specified hereinafter shall be borne by the Owner. Any extra claim due to

loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable and appropriate time extensions will be allowed.

The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated in the following Sub-clauses 4.1.1, 4.1.2 and 4.1.3. The method of testing and application of loading shall be as approved by the Engineer.

#### 4.01.01 **Stiffness Test**

In this test, the structure or member shall be subjected, in addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 per cent of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this second test is not less than 90 per cent of the maximum increase in strain or deflection recorded during the second test.

#### 4.01.02 **Strength Test**

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified superimposed load, and this load shall be maintained for 24 hours.

In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

#### 4.01.03 **Structure of same Design**

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous Sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure.

When a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Engineer. This load shall be maintained for 24 hours, during which time, the

maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20% of the maximum strain or deflection recorded at similar load in the test on the prototype.

#### 4.01.04 **Repair for subsequent Test and use after Strength Tests**

An actual structure which has passed the "Strength Test" as specified in Sub-clause 4.1.2 hereinbefore and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' as specified in Sub-clause 4.1.1. hereinbefore.

#### 4.02.00 **Tolerances**

Some variation is to be expected in the finished dimensions of structural steel frames. Unless otherwise specified, such variations are deemed to be within the limits of good practice when they are not in excess of the cumulative effect of detailed erection clearances, fabricating tolerances for the finished parts and the rolling tolerances for the profile dimensions permitted under the Specifications for fabrication of structural steelwork applicable to this Project and as specified below :

##### I. **For Buildings Containing Cranes**

Component	Description	Variation Allowed
Main columns	a) Shift of column axis at foundation level with respect to building line	
	i) In longitudinal direction	i) 3.0mm
	ii) In lateral direction	ii) 3.0mm
	b) Deviation of both major column axis from vertical between foundation and other member connection levels	
	i) For a column upto and including 10M height	i) 3.5mm from true vertical
	ii) For a column greater than 10M but less than 40M height measured between connection levels, but not more than 7.0mm per 30m length	ii) 3.5mm from true vertical for any 10M length
	c) For adjacent pairs of columns across the width of the building prior to placing of truss	9mm on true span
	d) For any individual column deviation of any bearing or resting level from levels shown on drawings	3.0mm
	e) For adjacent pairs of columns either across the width of building or longitudinally level difference allowed between bearing or seating level supposed to be at the same level.	3mm

Component	Description	Variation Allowed
Trusses	a) Deviation at centre of span of upper chord member from vertical plane running through centre of bottom chord	1/1500 of the span or not greater than 10mm whichever is the least
	b) Lateral displacement of top chord at centre of span from vertical plane running through centre of supports	1/250 of depth of truss or 20mm whichever is the least.
Crane Girders & Tracks	a) Difference in levels of crane rail measured between adjacent columns	2.0mm
	b) Deviation to crane rail gauge	3.0mm
	c) Relative shifting of ends of adjacent crane rail in plan and elevation after thermic welding	1.0mm
	d) Deviation of crane rail axis from centre line of web	3.5mm
Setting of Expansion gaps	At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or below 30°C	
	The coefficient of expansion or contraction shall be taken as 0.000012 per °C per unit length.	

## II. For Building without Cranes

The maximum tolerances for line and level of the steel work shall be  $\pm 3.0$  mm on any part of the structure. The structure shall not be out of plumb more than 3.5 mm on each 10M section of height and not more than 7.0 mm per 30 M section.

These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.

### 4.03.00 Acceptance

Structures and members which have passed the tests and conform to all requirements specified in the foregoing Sub-clause 4.1.0, 4.1.1, 4.1.2, 4.1.3 and 4.1.4 and other applicable provisions of this Specification and are within the limits of tolerances specified in Sub-clause 4.2.0 and/or otherwise approved by the Engineer shall be treated as approved and accepted for the purpose of fulfillment of the provisions of this Contract.

### 5.00.00 INFORMATION TO BE SUBMITTED

#### 5.01.00 Before Tender

Along with the Tenders the Tenderers will be required to submit the following information :

5.01.01      **Tentative Programme**

The Tenderer shall submit a tentative programme based on the information available in the Tender Document and visit to Site indicating the structure-wise erection schedule proposed to be maintained by the Contractor to complete the job in time in accordance with the Contract.

5.01.02      **Constructional Plant and Equipment,  
Tools, Temporary Works & Manpower**

A detailed list of all Constructional Plant & Equipment like cranes, derricks, winches, welding sets, erection tools etc. along with their make, model, present condition and location available with the Tenderer which he will be able to employ on the job to maintain the progress of work in accordance with the Contract shall be submitted along with the Tender. The total number of each category of experienced personnel like fitters, welders, riggers etc. that he will be able to employ on the job shall also be indicated.

5.01.03      **Erection Yard**

A site plan showing the layout and location of the erection yard proposed to be established by the Tenderer shall be attached with the Tender indicating the storage space for fabricated steel materials, site-fabrication and repair shop, covered stores, offices, locations of erection equipments and other facilities. The Engineer shall have the right to modify the arrangement and location of the proposed yard to suit site conditions and the Contractor shall comply with the same without any claim whatsoever.

5.02.00      **After award of the Contract**

After award of the contract, the Contractor shall submit the following:-

5.02.01      **Detailed Programme**

The Contractor shall submit a detailed erection programme within a month of the award of the Contract for completion of the work in time in accordance with the Contract. This will show the target programme, with details of erection proposed to be carried out in each fortnight, details of major equipment required and an assessment of required strength of various categories of workers in a proforma approved by the Engineer.

5.02.02      **Fortnightly Progress Report**

The Contractor shall submit fortnightly progress reports in triplicate to the Engineer showing along with necessary photographs, 125 mm x 90 mm size, and all details of actual achievements against the target programme specified in Sub-clause 5.2.1 above. Any shortfall in the achievement in a particular fortnight must be made up within the next fortnight. Along with this report, the Contractor shall also furnish details of fabricated materials in hand at site and the strength of his workers.

6.00.00      **RATES**

Even though it may not be specifically mentioned in the Schedule of Items, the rates shall include all work to be provided by the Contractor in accordance with Sub-clause 2.1.0 of this Contract and cost of all materials and labour required to complete the work or incidental to it, hire charges of Constructional Plant and Equipment and erection tools, insurance, all necessary transport, taxes and royalties, making necessary arrangements for approaches, yard, security, safety and other facilities, power, fuel, lubricant, services, supervisions, overheads, profits etc. complete in all respects. It shall also include cost of all other work and supplies not specifically mentioned but reasonably implied as being necessary to complete the works in all respects in accordance with the Contract.

7.00.00      **METHOD OF MEASUREMENT**

7.01.00      **Erection**

All measurement shall be in tonnes and based on the theoretical unit weights as per Indian Standard and on the following considerations :

- i) All members, except plate work paid under rates for bunkers, tanks, etc. shall be measured square.
- ii) All plate work paid at rates for bunkers, tanks, etc. shall be measured as actual.
- iii) No deduction shall be made for bolt and/or holes for other purposes upto 25 Sq.Cm. in area.
- iv) Unless otherwise specified in the case of welded steel structure, no allowance shall be made for the weld metal.
- v) No separate payment shall be made for field connection materials such as permanent bolts, nuts, washers, erection bolts and nuts. No extra payment shall be made for site welding.

7.02.00      **Grouting**

The measurement of grouting the stanchion and other base plates shall be on the basis of theoretical volume of the voids to be filled in Cu.M. without any deduction for the volume of embedments. Edges of the grouting shall be measured square neglecting chamfers, if any.

7.03.00      **Painting**

The finish painting, other than touch up and other painting, if required to be done within the quoted rates as per this Specification, shall be measured on the basis of the tonnage of the structure erected and painted calculated on the basis of Sub-clause 7.1.0

8.00.00

**PAYMENT**

Unless mentioned otherwise in the tender/contract document for fabricated materials erected, aligned, plumbed, levelled and grouted, the Contractor shall be paid 95% (ninety five percent) of the value of erection. The balance 5% (five percent) shall be paid after acceptance of the structure withstanding necessary tests in accordance with the Contract. Necessary deductions towards Security Money shall be made from all bills of the Contractor in accordance with the Contract.



**SPECIFICATION NO. C-11**

**FOR**

**ROADS AND DRAINAGE**

**SPECIFICATION NO. C-11  
FOR  
ROADS AND DRAINAGE**

**C O N T E N T S**

<b>CLAUSE NO.</b>	<b>DESCRIPTION</b>	<b>PAGE NO.</b>
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**SPECIFICATION NO. C-11  
FOR  
ROADS AND DRAINAGE**

**1.00.00 SCOPE**

This specification covers all work required for the construction of road including embankment, shoulder, sub-base, water bound macadam, bituminous macadam, wearing course etc. and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work.

This specification also includes all work required for drainage including road side drain, R.C.C. culverts, pipe-culverts, drainage pipes, manholes etc. and all other incidental items.

**2.00.00 GENERAL**

**2.01.00 Work to be Provided for by the Contractor**

The work to be provided for by the Contractor, unless specified otherwise, shall include but not be limited to the following :

- a) To prepare layout and detailed drawings for roads and drains as per the provisions of the specification and submit to Consultant for approval along with relevant design calculations.
- b) Furnish all labour, supervision, services, materials, equipment, tools and plants, transportation etc. required for the work.
- c) Submit for approval detailed schemes of all operations required for executing the work e.g. material handling, placement, services, approaches etc.
- d) To carry out and submit to the Engineer results of tests whenever required by the Engineer to assess the quality of work.

**2.02.00 Work to be Provided for by Others**

No work under this specification will be provided for by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

**2.03.00 Codes and Standards**

All work under this specification, unless specified otherwise, shall conform to the latest revision and/or replacements of the following or any other relevant I.S. Specifications and Codes of Practice.

- a) Specification for road and bridge works of Ministry of shipping & Transport (Roads wing) Published by the IRC.

- b) IRC-19 Standard specifications and Code of Practice for Water Bound Macadam.
- c) IRC:SP-11 Hand Book of Quality Control for Construction of Roads and Runways.
- d) IS-456 Indian Standard Code of Practice for Plain and Reinforced Concrete.
- e) IS-2212 Code of Practice for Brickwork.
- f) IS-783 Code of Practice for Laying of Concrete Pipes.
- g) Other specifications mentioned elsewhere in this specification.

In case any particular aspect of work is not covered specifically by Indian Standard Specification, any other standard practice as may be specified by the Engineer shall be followed.

#### 2.04.00 **Conformity with Designs**

The contractor shall carryout the work as per the approved drawings and/or the Engineer's instructions.

#### 2.05.00 **Materials to be Used**

##### 2.05.01 **General**

All materials required for the work shall be of best commercial variety and as approved by the Engineer.

#### 2.06.00 **Quality Control**

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used.

All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer. Permitted tolerances for roadworks are described hereinafter.

##### a) **Horizontal Alignments**

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of  $\pm 25$  mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be  $\pm 40$  mm.

##### b) **Longitudinal Profile**

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as

directed by the Engineer, beyond tolerances mentioned below :

Sub-grade	±25 mm
Sub-base	±20 mm
Base course	±15 mm
Wearing course	±10 mm

Tolerance in wearing course shall not be permitted in conjunction with the positive tolerance for base course if the thickness of the former is thereby reduced by more than 6 mm.

c) **Surface Regularity of Subgrade and Pavement Courses**

The surface regularity of completed sub-bases, base courses and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table-I.

The longitudinal profile shall be checked with a 3 metre long straight edge, at the middle of each traffic lane along a line parallel to the centre of the road. The transverse profile shall be checked with a set of three camber boards at intervals of 10 metres.

- NOTES :**
- 1.\*\* For surface dressing in all other cases, the standards of surface evenness will be the same as those for the surface receiving the surface dressing.
  - 2.\*\*\* These are for machine laid surfaces. If laid manually due to unavoidable reasons, tolerance upto 50 percent above these values in this column may be permitted at the discretion of the Engineer. However, this relaxation does not apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the table.
  3. Surface evenness requirements in respect of both the longitudinal and cross profiles should be simultaneously satisfied.

3.00.00 **EXECUTION**

3.01.00 **Setting Out**

Within 15 days of award of contract, the contractor will prepare and submit to the Engineer, detailed drawings/schemes of embankment filling and excavation works as proposed to be executed by him showing the dimensions as per approved drawings and specification adding his proposals of drainage and dewatering of pits and watering and compacting the embankment fill etc. On receiving the approval from the Engineer with modifications and corrections, if necessary, the contractor will set out the work from the control points furnished by the Engineer and fix permanent points and markers for ease of future checking. These permanent points and markers will be checked by the Engineer and certified by him after which the contractor will proceed with the work. It should be noted that this checking by the Engineer prior to start of the work will in no way absolve the contractor of his responsibility of carrying out the work to

true lines and levels as per drawing and subsequent corrections, if necessary, free of cost to the Owner in case any errors are noticed in the Contractor's work at any stage. Profiles of the embankment made by Bamboos, earth or other convenient materials and strings shall be set up at suitable intervals for the guidance of the workmen.

3.02.00      **Clearing and Grubbing etc.**

Before commencement of earthwork, the surface area of ground to be occupied shall be cleared of all fences, trees, logs, stumps, bush, vegetation, rubbish, slush etc. Felling of trees shall include taking out roots upto 600 mm below ground level or 300 mm below excavated pit level. After the tree is cut and roots taken out the pot holes formed shall be filled with good earth in 250 mm layers and compacted unless directed by the Engineer otherwise. The trees shall be cut in suitable pieces as instructed by the Engineer.

Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be burnt or removed from the site to approved disposal areas as may be specified. Useful materials, saleable timbers, firewood, etc. shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Engineer.

3.03.00      **Filling in Embankment**

3.03.01      **General**

The material used for constructing the embankment by earth filling shall be earth, moorum, gravel, a mixture of these or any other material approved by the Engineer. The material shall be free from lumps & clods, boulders or rock pieces, roots and vegetations, harmful salts and chemicals, organic materials, loose silts, fine sands and expansive clays in order to provide a stable embankment.

The filling and compaction operation should be such that the best available materials are saved for the top portion and will result in an acceptable and uniform gradation of material to provide for impermeability and stability of the embankment when compacted.

The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm. However, the Engineer may at his discretion permit the use of material coarser than this also if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the Specification required.

Ordinarily, only the materials satisfying the density requirements as given below in Table-I shall be employed for embankment construction.

**Table-I**  
**Density Requirements Of Embankment Materials**

<b>Sl. No.</b>	<b>Type of Work</b>	<b>Maximum laboratory dry density when tested as per IS:2720 (Part-VII)</b>
1.	Embankment upto 3 metre height	Not less than 1.44 gm/cc.
2.	Embankments exceeding 3 metre height or embankments of any height subject to long periods of inundation	Not less than 1.52 gm/cc.
3.	Top 0.5 metres of the embankment below the subgrade level and shoulders (where earth shoulders are specified)	Not less than 1.65 gm/cc.

Expansive clays exhibiting marked swell and shrinkage properties shall not be permitted in the embankment filling.

The materials for embankment shall be obtained from approved sources with preference given to materials becoming available from nearby road excavation or any other excavation under the same contract.

#### 3.03.02 **Setting Out**

After the site has been cleaned, the work shall be set out true to lines, curves, slopes, grades and sections as shown on the approved drawings or as directed by the Engineer. The contractor shall provide all labour, survey instruments and materials such as strings, pigs, nails, bamboos, stones, lime, mortar, concrete, etc. required in connection with the setting out of the works and establishment of the bench marks. The limits of the embankment shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. To ensure their safety, the pegs should normally be fixed about 500mm back from the actual limits of the fill and to be painted in a distinctive colour. The centreline of the embankment shall be pegged at regular intervals of 25/30 metres and at all skewes/curves. The actual profile of the embankment shall be marked at every third centreline peg with bamboo posts and strings. Preferably prototype profiles, developed with wooden planks need to be fixed at every 200 metres and at the intersection points at curves. The profile shall be about 3 metres long.

#### 3.03.03 **Stripping and Storing of Top Soil**

The construction of the earthen embankment by filling shall conform to the dimensions, slopes and other details shown in the approved drawings. Before commencement of filling for building up the embankment section, the surface area of ground to be occupied, after clearing and grubbing, is to be stripped off upto a minimum depth of 150 mm or more as directed by the Engineer in order to remove all perishable material and any soil which may become unstable on saturation or may interfere with development of proper bond between the

foundation and embankment. It is not necessary to remove all the soil containing fine hair-like roots but only the rather heavy mat.

In localities where most of the available embankment materials are not conducive to plant growth, or when so directed by the Engineer the top soil existing over the embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired.

#### 3.03.04 **Compacting Original Ground**

In all cases, the original ground shall be compacted by rolling, as directed by the Engineer but with a maximum of six passes of 8-10 tonne roller.

Where the height of the proposed embankment is less than 0.5 metre and the original ground does not already have a relative compaction of at least 95 percent, the same shall be loosened to a depth of 0.5 metre, watered and compacted in layers not exceeding 250 mm in loose thickness to the maximum dry density of the material determined in accordance with IS-2720 (Pt.VII). However, before relaying and compacting the loosened material, the surface below this level shall be suitably compacted as directed by the Engineer but with a maximum of six passes of a 8-10 tonne roller.

Where so directed by the Engineer, any unsuitable materials occurring in the embankment foundation shall be removed and replaced by approved materials suitably compacted.

Embankment work shall not proceed until the foundations for embankment have been inspected by the Engineer for satisfactory condition and approved.

#### 3.03.05 **Filling**

The embankment material shall be spread uniformly over the entire width of the embankment in layers not exceeding 250 mm in loose thickness. Successive layers of embankment shall not be placed until the layer under construction has been thoroughly compacted to the requirements set down hereunder.

Moisture content of the material shall be checked at the source of supply and if found less than that specified for compaction, the same shall be made good either at the source or after spreading the soil in loose thickness for compaction. In the latter case, water shall be sprinkled directly from a hose line or from a truck-mounted water tank, and flooding shall not be permitted under any circumstances.

If the material delivered to the road bed is too wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, work on compaction shall be suspended.



Moisture content of each layer of soil shall be checked in accordance with IS-2720 (Part II), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1 percent above to 2 percent below the optimum moisture content determined in accordance with IS-2720 (Part VII).

After adding the required amount of water, the soil shall be processed by means of harrows, rotary mixers or as otherwise approved until the layer is uniformly wet.

Clods or hard lumps of earth shall be broken to have maximum size of 150 mm when being placed in the lower layers of the embankment and a maximum size of 60 mm when being placed in the top 0.5 metre portion of the embankment below the subgrade.

Hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer to minimize rutting or uneven compaction.

Where the embankment is to be constructed across low swampy ground that will not support the weight of trucks or other hauling equipment, the lower part of the fill shall be constructed by dumping successive loads in a uniformly distributed layer of a thickness not greater than that necessary to support the hauling equipment while placing subsequent layers.

3.03.06

**Compaction**

Only compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. If directed by the Engineer, the Contractor shall demonstrate the efficacy of the plant he intends to use by carrying out compaction trials.

Each layer of the material shall be thoroughly compacted to the densities specified in Table II. Subsequent layers shall be placed only after the finished layer has been tested and accepted by the Engineer.

**Table-II**  
**Compaction Requirements For Embankment**

Sl. No.	Type of work/material	Field dry density as a percentage of max. laboratory dry density as per IS:2720 (Part VII)
1.	Top 0.5 metre portion of embankment below subgrade level and shoulders	Not less than 100
2.	Other portion of embankment	Not less than 95

When density measurements reveal any soft areas in the embankment, further compaction shall be carried out as directed by the Engineer. If in spite of that, the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted to the density requirements and satisfaction of the Engineer.

3.03.07      **Drainage**

The surface of the embankment at all times during construction shall be maintained at such a cross-fall as will shed water and prevent ponding.

3.03.08      **Finishing Operations**

Finishing operations shall include the work of shaping and dressing the shoulders, road bed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the drawings or as directed by the Engineer.

Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

3.04.00      **Turfing With Sods**

3.04.01      **General**

This work shall consist of furnishing and laying of live sod of perennial turf forming grass on embankment slopes, shoulders or other locations shown on the drawings or as directed by the Engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment, provided the season is favourable for establishment of the sod.

3.04.02      **Materials**

The sod shall consist of dense, well rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be used, and shall be practically free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm and the sod shall have been freed of debris.

Thickness of the sod shall be as uniform as possible, with some 5 to 8 cm of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 25 cm x 30cm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

3.04.03      **Preparation of the Earthbed**

The area to be sodded shall have been previously constructed to the required slope and cross section. Soil on the area shall be loosened, freed from all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter and brought to a reasonably granular texture to a depth of not less than 25 mm for receiving the sod.

Where required top soil shall be spread over the slopes. Prior to placing the top soil the slopes shall be scarified to a depth of 50 mm. The top soil shall be spread to a depth which after settlement will provide the required nominal depth of 50 mm. Spreading shall be done when the ground is excessively wet.

Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly. After spreading, the materials are incorporated in the soil by dicing or other means.

#### 3.04.04 **Placing The Sods**

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist and the sod shall be placed thereon within approximately 24 hours after the same has been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

On side slopes steeper than 2 to 1, the laying of sods shall be started from bottom upwards.

At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its thorough compaction.

#### 3.04.05 **Staking the Sods**

Where the side slope is 2 to 1 or steeper and the distance along the slope is more than 2 metres, the sods shall be staked with pegs or nails spaced approximately 50 to 100 cm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

#### 3.04.06 **Top Dressing**

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter a thin layer of top soil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling water.

#### 3.04.07 **Watering and Maintenance**

The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be done so as to avoid erosion and prevent damage to sodded areas by wheels of water tanks.

The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operation and shall otherwise maintain the sod at his cost until final acceptance.

**TABLE-I**  
**PERMITTED TOLERANCES OF SURFACE REGULARITY**  
**FOR PAVEMENT COURSES**

Sl. No.	Type of Construction	Longitudinal Profile with 3 metre straight edge					Cross Profile
		Maximum Permissible Undulation mm	Maximum number of Undulations permitted in any 300 metres length exceeding : mm				Maximum Permissible variation from specified profile under camber template mm
			18	12	10	6	
1.	Earthen subgrade	25	30	-	-	-	15
2.	Granular subbase	15	-	30	-	-	12
3.	Water Bound Macadam with oversize metal (40-90mm size)	15	-	30	-	-	12
4.	Water Bound Macadam with normal size metal (20-50mm and 40-63mm size), Bituminous Penetration Macadam	12	-	-	30	-	8
5.	Surface dressing ** (two coat) over WBM (20-50mm or 40-63mm size metal), Bituminous penetration macadam or built-up spray grout	12	-	-	20	-	8
6.	Open graded premix carpet, mix seal surfacing	10	-	-	-	30	6
7.	Bituminous macadam	10	-	-	-	20 **	6
8.	Semi-dense carpet	10	-	-	-	20 **	6
9.	Asphaltic Concrete	8	-	-	-	10 **	4

### 3.05.00 Shoulder Construction

#### 3.05.01 Description

This work shall consist of constructing shoulders on either side of the pavement, in accordance with the requirements of this specification and in conformity with the lines, grades and cross sections shown on the drawings approved by the Engineer.

#### 3.05.02 Materials

Shoulder may be of selected earth or granular material conforming to the requirements of embankment construction or granular sub-base construction respectively.

3.05.03      **Construction Operations**

Except in the case of bituminous constructions, shoulders shall be constructed in advance of the laying of pavement courses. The compacted thickness of each layer of shoulder shall correspond to the compacted layer of pavement course to be laid adjacent to it. After compaction, the inside edges of shoulders shall be trimmed vertical and included area cleaned of all spilled material before proceeding with the construction of the pavement layer.

In the case of bituminous courses, shouldering operations shall start only after the pavement course has been laid and compacted.

Regardless of the method of laying, all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed, without damage to the pavement and the area so affected thoroughly cleaned.

During all stages of shoulder construction, the required cross- fall shall be maintained to drain off surface water.

3.06.00      **Kerb**

3.06.01      **Material**

Kerb, if required for construction of footpath, shall consist of precast concrete blocks with a concrete grade of M-15. The blocks shall be 100 mm wide and of suitable length. The depth of blocks unless otherwise mentioned elsewhere, shall be 375 mm considering 225 mm height of footpath from the road level.

3.06.02      **Laying**

The Kerb shall be laid by cutting trenches 150 mm deep. The width of the trench shall be minimum and just sufficient to insert the kerbs. The inside faces of the Kerbs shall be in plumb and the gap between the block shall not be more than 10 mm.

The kerbs shall be thoroughly packed with a mixture of stone chips (50%) and moorum (50%) at the outside face. The laying and packing shall be done in a proper workmanlike manner acceptable to the Engineer.

3.07.00      **Sub-base (Granular Sub-base)**

3.07.01      **Description**

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications. The material shall be laid in one or more layers as shown on the drawings and according to lines, grades and cross sections shown on the drawings or as directed by the Engineer.

### 3.07.02 Materials

The materials to be used for the work shall be natural sand, moorum, gravel, crushed stone, crushed slag, crushed concrete, brick metal, laterite, kanker etc. or combinations thereof depending upon the grading required. The mixed materials shall be free from organic or other deleterious constituents and conform to one of the three gradings given in Table-II below.

**TABLE-II**  
**Grading for Granular Sub-base Materials**

Sieve designation	<u>Percent by weight passing the seive</u>		
	Grading 1	Grading 2	Grading 3
80 mm	100	100	100
63 mm	90-100	90-100	90-100
4.75 mm	35-70	40-90	50-100
75 micron	0-20	0-25	0-30
CBR Value (Minimum) : for fraction of material passing 20 mm sieve	30%	25%	20%

**Note :** The material passing 425 micron sieve for all the three gradings when tested according to IS:2720 (Part V) shall have liquid limit and plasticity index of not more than 25 percent and 6 percent respectively.

### 3.07.03 Physical Requirements

The fraction of material passing 20 mm sieve shall give a CBR value as specified in Table-II when tested in accordance with IS:2720 (Part XVI) after preparing the samples at maximum dry density and optimum moisture content corresponding to IS:2720 (Part VII) and soaking the same in water for 4 days.

### 3.07.04 Spreading and Compacting

Immediately prior to the laying of sub-base, the subgrade already finished shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water, if necessary, and rolled with one pass of 8-10 tonne smooth wheeled roller.

The sub-base material shall be spread on the subgrade with the help of a drag spreader, motor grader or other approved means. The thickness of loose layers shall be so regulated that the maximum thickness of the layer after consolidation does not exceed 150 mm.

Moisture content of the loose material shall be checked in accordance with IS:2720 (Part II) and suitably adjusted by sprinkling additional water from a hose line, truck mounted water tank or other approved means so that at the time of compaction it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS:2720 (Part VIII). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means if so directed by the Engineer until the layer is uniformly wet.

Immediately thereafter, rolling shall be started with 8 to 10 tonne smooth wheeled rollers or other approved plant. Rolling shall commence at the edges and progress towards the centre longitudinally except that on super elevated portions it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and camber shall be checked and any high spots or depressions which become apparent corrected by removing or adding fresh material.

Rolling shall be continued till the density achieved is at least 100% of the maximum dry density for the material determined as per IS:2720 (Part VII). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction plant and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

### 3.08.00 **Water Bound Macadam Sub-base/Base Course**

#### 3.08.01 **Description**

Water bound macadam shall consist of clean, crushed aggregates mechanically interlocked by rolling,, and bonded together with screenings, binding material, where necessary and water, laid on a prepared subgrade or sub-base, as the case may be, and finished in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the approved drawings.

#### 3.08.02 **Materials**

##### a) **Coarse Aggregates - General Requirements**

Coarse aggregates shall be either crushed or broken stone. The aggregates shall conform to the physical requirements set forth in Table-III.

**TABLE-III**  
**Physical Requirements of Coarse Aggregates**  
**for Water Bound Macadam**

Sl. No.	Type of Construction Test	Test method	Requirements
1.	Sub-base	Los Angeles Abrasion Value*	50 percent maximum.
		or	
		Aggregate Impact Value	40 percent maximum.
		or IS:5640**	

Sl. No.	Type of Construction Test	Test method	Requirements
2.	Base a)	Loss Angeles Abrasion Value*	50 percent maximum.
		or Aggregate Impact Value	40 percent maximum.
		or IS:5640**	
	b)	Flakiness Index***	15 percent maximum.

\* Aggregate may satisfy requirements of either of the two tests.

\*\* Aggregates like brick metal, kankar and laterite which get softened in presence of water, shall be tested for impact value under conditions in accordance with IS:5640.

\*\*\* The requirements of Flakiness Index shall be enforced only in case of crushed or broken stone and crushed slag.

**b) Crushed or Broken Stone**

Crushed or broken stone shall be hard, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter.

**c) Grading Requirements of Coarse Aggregates**

The coarse aggregates shall conform to one of the gradings given in Table-IV, provided, however, the use of Grading No. 1 shall be restricted to sub-base courses only.

**TABLE-IV**  
**GRADING REQUIREMENTS OF COARSE AGGREGATES**

Grading No.	Size range	Sieve designation	Percent by weight passing the sieve
1.	90 mm to 40 mm	100 mm	100
		80 mm	65-85
		63 mm	25-60
		40 mm	0-15
		20 mm	0-5
2.	63 mm to 40 mm	80 mm	100
		63 mm	90-100
		50 mm	35-70
		40 mm	0-15
		20 mm	0-5



Grading No.	Size range	Sieve designation	Percent by weight passing the sieve
3.	50 mm to 20 mm	63 mm	100
		50 mm	95-100
		40 mm	35-70
		20 mm	0-10
		10 mm	0-5

d) **Screenings**

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent.

As far as possible, screenings shall conform to the gradings set forth in Table-V. Screenings of Type A in Table shall be used with coarse aggregates of grading 1 in Table IV. Screenings of Type A or B, shall be used with coarse aggregates of grading 2. Type B screenings shall be used with coarse aggregates of grading 3.

**TABLE-V**  
**GRADINGS FOR SCREENINGS**

Grading	Size of	Sieve	Percent by weight
Classi-screenings	designation		passing the sieve
fication			
A	12.5 mm	12.5 mm	100
		10.0 mm	90-100
		4.75 mm	10-30
		150 micron	0-8
B	10 mm	10 mm	100
		4.75 mm	85-100
		150 micron	10-30

e) **Binding Material**

Binding material to be used for water bound macadam construction shall comprise of a suitable material approved by the Engineer having plasticity index value of less than 6 as determined in accordance with IS:2720 (Part V).

Application of binding material may not be necessary, when the screenings used are of crushable type such as moorum or gravel.

### 3.08.03 Construction Operations

#### a) Preparation of Base

The subgrade/sub-base to receive the water bound macadam coarse shall be prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm. Where water bound macadam is to be laid over an existing black topped surface, 50 mm x 50 mm furrows shall be cut at an angle of 45 degrees to the centre line of the road at 1 metre intervals in the latter before laying the coarse aggregate.

#### b) Inverted Choke

If the water bound macadam is to be laid directly over the subgrade, without any other intervening pavement course, a 25mm course of screenings (Grading B) shall be spread on the prepared subgrade before application of the coarse aggregates is taken up.

#### c) Spreading Coarse Aggregate

The coarse aggregates shall be spread uniformly upon the prepared surface in such quantities that the thickness of the compacted layer is 100mm for grading 1 and 75-100 mm for gradings 2 and 3 for each layer.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The coarse aggregate shall not normally be spread more than 3 days in advance of the subsequent construction operations.

#### d) Rolling

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 8 to 10 tonne capacity or tandem or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Engineer.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be

compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall continue until the aggregates are thoroughly keyed and the creeping of aggregates ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done, if necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or sub-base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and re-rolling until the entire surface conforms to desired camber and grade. In no case shall the use of screenings be permitted to make up depressions.

e) **Applications of Screenings**

After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders, or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

f) **Sprinkling and Grouting**

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued, with additional screenings applied as necessary, until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or subgrade does not get damaged due to the addition of excessive quantities of water during construction.

g) **Application of Binding Material**

After the application of screenings, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

h) **Setting and Drying**

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course if in his opinion it would cause excessive damage to the surface.

3.09.00 **Tack Coat**

3.09.01 **Description**

The work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction.

3.09.02 **Materials**

Binder : The binder used for tack coat shall be bitumen of a suitable grade as approved by the Engineer and conforming to IS:73, 217 or 454, as applicable, or any other approved cutback.

3.09.03 **Construction Operations**

a) **Preparation of Base**

The surface on which the tack coat is to be applied shall be thoroughly swept and scraped clean of dust and any other extraneous material before the application of the binder.

b) **Application of Binder**

Binder shall be heated to the appropriate to the grade of bitumen used and approved by the Engineer and sprayed on the base at the rate specified below. The rate of spread in terms of straight-run bitumen shall be 5 kg. per 10 sq.m area for an existing bitumen treated surface and 10 kg per 10 sq.m area for an untreated water bound macadam surface. The binder shall be supplied uniformly with the aid of sprayers.

The tack coat shall be applied just ahead of the on-coming bituminous construction.

### 3.10.00 Bituminous Macadam Binder Course

#### 3.10.01 Description

This work shall consist of construction, in a single course, of 50 mm / 75 mm thickness of compacted crushed aggregates premixed with a bituminous binder, laid immediately after mixing, on a base prepared previously in accordance with the requirements of these Specifications, and in conformity with the lines, grades and cross sections shown on the approved drawings.

#### 3.10.02 Materials

##### a) Binder

The Binder shall be straight run bitumen of a suitable grade as directed by the Engineer complying with IS:73.

##### b) Aggregates

The aggregates shall consist of crushed stone, crushed gravel (shingle) or other stones. They shall be clean, strong, durable, of fairly cubical shape and free of disintegrated pieces, organic and other deleterious matter, and adherent coats. The aggregates shall preferably be hydrophobic and of low porosity.

The aggregates shall satisfy the physical requirements set forth in Table-VI.

**TABLE-VI**  
**PHYSICAL REQUIREMENTS OF AGGREGATES**  
**FOR BITUMINOUS MACADAM**

Sl.No.	Test	Test method	Requirements
1.	Los Angeles Abrasion *	IS:2386 (Part IV)	35% Maximum
2.	Aggregate Impact Value *	-do-	30% "
3.	Flakiness Index	IS:2386 (Part I)	35% "
4.	Stripping Value	IS:6241	25% "
5.	Water Absorption	IS:2386 (Part III)	2% "

\* Aggregates may satisfy requirements of either of the two tests.

The aggregates for bituminous macadam for different thicknesses shall conform to the grading A or B given in Tables VII & VIII.

**TABLE-VII**  
**AGGREGATES GRADING FOR 75 MM COMPACTED**  
**THICKNESS OF BITUMINOUS MACADAM**

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
63 mm	100	-
50 mm	90-100	-
40 mm	35-65	100
25 mm	20-40	70-100
20 mm	-	50-80
12.5 mm	5-20	-
4.75 mm	-	10-30
2.36 mm	-	5-20
75 micron	0-5	0-4

**TABLE-VIII**  
**AGGREGATE GRADING FOR 50 MM COMPACTED THICKNESS**  
**OF BITUMINOUS MACADAM**

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
50 mm	100	
40 mm	90-100	
25 mm	50-80	100
20 mm	-	70-100
12.5 mm	10-30	-
10 mm	-	35-60
4.75 mm	-	15-35
2.36 mm	-	5-20
75 micron	0-5	0-4

**c) Proportioning of Materials**

The binder content for premixing shall be 3.5 and 4.0 percent by weight of the total mix for aggregate grading A and B respectively, except when otherwise directed by the Engineer.

The quantities of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

**d) Variation in Proportioning of Materials**

The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content of  $\pm 0.3$  percent by weight of total mix shall, however, be permissible for individual specimens taken for quality control tests.

3.10.03      **Construction Operations**

a)      **Weather and Seasonal Limitations**

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.

b)      **Preparation of Base**

The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross sections as directed by the Engineer. The surface shall be thoroughly swept and scraped clean and free from dust and foreign matter.

c)      **Tack Coat**

A tack coat shall be applied over the base.

d)      **Preparation and Transport of Mix**

Hot mix plant of adequate capacity shall be used for preparing the mix.

The temperature of binder at the time of mixing shall be in the range 150 Deg. - 165 Deg.C and that of aggregates in the range 125 Deg. - 150 Deg.C, provided that the difference in temperature between the binder and aggregate at no time exceeds 25 Deg.C.

Mixing shall be thorough to ensure that a homogenous mixture is obtained in which all particles of the aggregates are coated uniformly.

The mixture shall be transported from the mixing plant to the point of use in suitable vehicles. The vehicles employed for transport shall be clean and be covered over in transit if so directed by the Engineer.

e)      **Spreading**

The mix shall be spread immediately after mixing by means of a self propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to the specified lines, grade and cross sections. However, in restricted locations and in narrow widths, where the available plants cannot operate in the opinion of the Engineer, he may permit manual laying of the mix.

The temperature of mix at the time of laying shall be in the range 110 Deg. - 135 Deg.C.

In multilayer construction, the longitudinal joint in one layer shall offset that in the layer below by about 150 mm. However, the joint in the topmost layer shall be at the centre line of the pavement.

Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material.

f) **Rolling**

After the spreading of mix, rolling shall be done by 8 to 10 tonne power rollers or other approved plant. Rolling should start as soon as possible after the material has been spread. Rolling shall be done with care to keep from unduly roughening the pavement surface.

Rolling of the longitudinal joint shall be done immediately behind the paving operation. After this, the rolling shall commence at the edges and progress towards the centre longitudinally except that on super-elevated portions it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The initial or breakdown rolling shall be done as soon as it is possible to roll the mixture without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the break down rolling as closely as possible and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for removal of roller marks.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh material. The rolling shall then be continued till the entire surface has been rolled to compaction, there is no crushing of aggregate and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller wheels shall be kept damp if necessary to avoid the bituminous material from sticking to the wheels and being picked up. In no case shall fuel lubricating oil be used for this purpose.

Rolling operations shall be completed in every respect before the temperature of the mix falls below 80 Deg.C.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

The bituminous macadam shall be provided with final surfacing without any delay. If there is to be any delay, the course shall be covered by a seal coat before allowing any traffic over it.



### 3.11.00 **Open-Graded Premix Carpet**

#### 3.11.01 **Description**

This work shall consist of laying and compacting an open-graded carpet of 2 cm thickness in a single course composed of suitable small sized aggregates premixed with a bituminous binder on a previously prepared base, to form a wearing course, in accordance with the requirements of these specifications.

#### 3.11.02 **Materials**

##### a) **Binder**

The binder shall be bitumen of a suitable grade, as approved by the Engineer, and satisfying the requirements of IS:73, 217, 454 or other approved cutback as applicable.

##### b) **Aggregates**

The aggregates shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be obtained by crushing rock, gravel or river shingle and be free of elongated and flaky pieces, soft and disintegrated materials, and vegetable or other deleterious matter. They shall preferably be hydrophobic type.

The aggregates shall satisfy the quality requirements set forth in Table VI except that the Flakiness Index shall be limited to a maximum of 30.

##### c) **Proportioning of Materials**

The materials shall be proportioned as per quantities given in Table IX.

**TABLE-IX**

**QUANTITIES OF MATERIALS REQUIRED FOR**  
**10 SQ.M OF ROAD SURFACE FOR**  
**2 CM THICK OPEN-GRADED PREMIX CARPET**

#### Aggregates of Carpet

i)	Stone chippings - 12 mm size; passing 20 mm sieve and retained on 10 mm sieve	0.18 Cu.m
ii)	Stone chippings - 10 mm size; passing 12.5 mm sieve and retained on 6.3 mm sieve	0.09 Cu.m
	Total :	<u>0.27 Cu.m</u>

Binder for premixing (quantities in terms of straight run bitumen)

i)	For 0.18 Cu.m of 12 mm size stone chippings at 52 kg per Cu.m	9.5 Kg.
ii)	For 0.09 Cu.m of 10 mm size stone chippings at 56 kg per Cu.m	5.1 Kg.
Total :		<u>14.6 Kg.</u>

### 3.11.03 Construction Operation

#### a) Weather and Seasonal Limitations

Open-graded premix carpet shall not be laid during rainy weather or when the base course is damp or wet or when the atmospheric temperature in shade is 16 Deg.C or below.

#### b) Preparation of Base

The underlying base on which the bituminous carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Table I as directed by the Engineer. The surface shall be well cleaned by removing caked earth and other foreign matter with wire brushes, sweeping with brooms and finally dusting with sacks as necessary.

#### c) Tack Coat

A tack coat complying with clause 3.9 shall be applied over the base preparatory to laying of the carpet. Application of tack coat shall, however, not be necessary when the laying of carpet follows soon after the provision of a bituminous course.

#### d) Preparation of Premix

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Engineer, in boilers of suitable design avoiding local overheating and ensuring a continuous supply.

The aggregates shall be dry and suitably heated to a temperature as directed by the Engineer before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified.

The mixing of binder with chippings shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and be covered over in transit if so directed.

e) **Spreading and Rolling**

The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader, without any undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material has been laid rolling shall commence with 6 to 8 tonne power rollers, preferably of smooth wheel tandem type, or other approved plant. Rolling shall begin at the edges and progress toward the centre longitudinally, except that on the super elevated portions it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roller marks eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby.

The edges along and transverse of the carpet laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

f) **Seal Coat**

A seal coat conforming to clause 3.12 shall be applied to the surface immediately after laying the carpet. No traffic shall be allowed on the road till the seal coat has been placed.

3.12.00 **Seal Coat**

3.12.01 **Description**

This work shall consist of application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade and camber.

Seal coat shall be of either of the two types below, as specified :

Type A : Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chippings.

Type B : Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

3.12.02 **Materials**

a) **Binder**

The binder shall be bitumen of a suitable grade as directed by the Engineer and conforming to the requirements of IS:73, 217 or 454 as applicable or any other approved cutback.

The quantity of binder to be utilised, in terms of straight run bitumen shall be 9.8 kg and 6.8 kg per 10 square metre area for Type A and Type B seal coat respectively.

b) **Stone Chippings for Type A Seal Coat**

The stone chippings shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of elongated or flaky pieces, soft or disintegrated stone, vegetable or other deleterious matter. Stone chippings shall be of 6 mm size defined as 100 percent passing through 10 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metre per 10 square metre area. The chippings shall satisfy the quality requirements spelled out in Table VI except that the upper limit for flakiness Index shall be 30.

c) **Fine Aggregate for Type B Seal Coat**

The fine aggregate shall be sand or fine grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky material, organic matter or other deleterious substances. The aggregate shall pass 1.7 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cubic metre per 10 square metre area.

3.12.03 **Construction Operations**

a) **Preparation of Base**

The seal coat shall be applied immediately after the laying of bituminous course which is required to be sealed. Before application of seal coat materials the surface shall be cleaned free of any dust or other extraneous matter.

b) **Construction of Type A Seal Coat**

The binder shall be heated in boilers of suitable design, to the temperature appropriate to the grade of bitumen approved by the Engineer and sprayed on the dry surface in a uniform manner preferably with the help of mechanical sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage or any other reason shall be suitably corrected before the stone chippings are spread.

Immediately after the application of binder, stone chippings in a dry and clean state, shall be spread uniformly on the surface, preferably by means of a mechanical gritter, otherwise manually so as to cover the surface completely. If necessary, the surface shall be broomed to ensure uniform spread of chippings.

Immediately after the application of the cover material, the entire surface shall be rolled with a 8-10 tonne smooth wheeled roller. Rolling shall commence at the edges and progress towards the centre except in super elevated portions where it shall proceed from the inner edge to the outer. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly bedded in the binder and present a uniform closed surface.

c) **Construction of Type B Seal Coat**

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

The binder shall be heated in boilers of suitable design, to the temperature appropriate to the grade of bitumen approved by the Engineer. Also the aggregates shall be dry and suitably heated to a temperature directed by the Engineer before the same are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued till the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 6-8 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

3.12.04 **Opening to Traffic**

In the case of Type B Seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. However, as regards Type A seal coat, traffic shall not be permitted until the following day.

3.13.00 **Repair of Existing Water Bound Macadam Surface**

Pot holes or patches and ruts in water bound macadam base or surface course, which is to be surface treated, shall be repaired by removal of all loose material by cutting in rectangular patches and replacing with suitable materials. The repair shall be done as under :

Pot holes, patches and ruts shall be drained of water and cut to regular shape with vertical sides, and then be filled either with i) coarse aggregate and screenings conforming to the specification for water bound macadam and compacted with rollers or other approved rammer or ii) premixed material conforming to the specification for open graded premix carpet and compacted with rollers or other approved means after painting the sides and bottom of the holes with a thin application of bitumen or a combination of both as directed by the Engineer.

The above is only applicable in case of damage to the existing water bound macadam surfaces. In case, however, it is found that there has been damage to the granular sub-base as well, the area of the damaged surface shall be repaired by removal of all loose materials, cut to regular shape with vertical sides and relaid with graded material as per specification of granular sub-base and then surfaced with water bound macadam as per specification for the same.

3.14.00      **Road Side Drains**

3.14.01      **Formation of Drains**

The road side drains shall be made in sizes and slopes as shown on approved drawings. The sides and bottom shall be neatly dressed after excavation. Proper connections shall be made to the culverts, outside plant area, as per drawings and instructions of the Engineer.

The excavated spoils shall be transported and filled in low areas within the plant area or in embankments as instructed by the Engineer. The lining for the drains shall be as per Drawing. Lining of drains may be of bricks or cement concrete blocks of M15 grade concrete as shown on approved drawing or as directed by the Engineer. If shown on approved drawing, drains may be of R.C.C. construction with necessary slopes.

3.15.00      **Culverts**

Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per the instructions of Engineer after clearing the site, etc. as per specifications of earthwork. Backfilling with ramming and watering shall be done after construction of the foundations.

The construction of culverts shall be done true to lines and levels and as shown on the drawing. The specification for Masonry and/or Plain and Reinforced Cement concrete shall be followed, as applicable.

3.16.00      **Pipe Culverts and Drainage Pipes**

3.16.01      **Materials**

The drainage pipes shall be made of R.C.C. and shall be either Class NP2 or NP3 as shown on approved drawings.

Pipe culverts shall be made of reinforced concrete pipe and shall be of class NP4 or of RDSO class for railway as shown in the drawing. All pipes shall meet the requirements of IS:458 - Latest edition and shall be procured from approved manufacturers with collars as per manufacturer's standard specifications. The tenderer shall specifically mention the particular manufacturer's product he proposes to use.

Cement shall be ordinary Portland Cement as per IS:269 - Latest edition.

Aggregates shall be as per IS:383 - Latest edition - Maximum size shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller.

Fine aggregates for concrete shall be as per IS:383 - Latest edition.

### 3.16.02 **Laying of Pipes**

Laying of concrete pipes shall correspond to IS:783 - Latest edition - and to specification given below :

- a) The foundation bed for pipe shall be excavated true to lines and grades shown on the drawings or as directed by the Engineer. When trenching is involved its width on either side of the pipe shall not be less than 150mm nor more than one-third the diameter of pipe unless otherwise instructed/permitted by the Engineer. The sides of the trench shall be as nearly vertical as possible. Side slope, shoring, bailing out water, etc. as required shall be done by the Contractor. Side slips, if there be any, shall be removed by the Contractor. After laying of the pipes are completed, backfilling of the trenches shall be done in 250 mm layers, measured loose, clods and lumps broken, watered and compacted with iron rammers to the satisfaction of the Engineer. The surplus spoils shall be transported and filled in low areas within the plant area, as instructed by the Engineer.

When bed-rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock/ boulders in the area shall be removed and space filled with approved earth free from stone or fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Filling of trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

When two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

Laying of pipes shall start from the outlet and proceed towards inlet.

All pipes and fittings shall be gradually lowered into the trench or placed on the supports by approved means taking due care not to damage them. Under no circumstances the pipes shall be dropped into the trench or on supports from a height.

- b) Pipe bedding shall be first class projection bedding for positive projecting pipes as per IS:783 - Latest edition - having a projection ratio of not greater than 0.70, in which the pipe is carefully bedded on fine granular materials in an earth foundation carefully shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height, and in which earthfilling material is thoroughly rammed and tamped in layers not exceeding 15 cm in depth around the pipe for the remainder of the lower 30 percent of its height.

If the pipe is laid in trench, pipe bedding shall be first class bedding as per IS-783.

When indicated on the drawings or directed by the Engineer, the pipe shall be bedded on a cradle constructed of concrete having a mix not leaner than M15. The shape and dimension of the cradle shall be as indicated on the drawing or directed by the Engineer. The pipe shall be laid on the concrete bedding before the concrete has set.

- c) The drop walls shall be made with first class brickwork in 1:4 cement mortar.
- d) The pipe culverts shall be made with proper care regarding the invert of the pipe, gradient, if any, etc. as specified on drawings and/or as instructed by the Engineer.
- e) Where R.C.C. pipes are encased in concrete at road crossings or at other places the pipes need be suitably supported avoiding reinforcements of concrete blocks, joints properly done before concreting is taken up. Concreting of total height of block may be done in a single operation or may be done upto some height for pipes to be properly laid in position and remaining height of block to be concreted subsequently.
- f) The R.C.C. pipes shall be joined with cement mortar. Cement mortar shall consist of 1 part cement and 2 parts of clean sand with only enough water for workability. Procedure of jointing shall be as per IS:783 - latest edition.

### 3.16.03 **Relation with Water Supply Pipeline**

Unless specifically cleared by the Engineer, under no circumstances shall drainage pipes be allowed to come close to water supply pipelines.

### 3.17.00 **Manholes and Inspection Chambers**

The maximum distance between manholes shall be 30 meter unless specifically permitted otherwise. In addition at every change of alignment, gradient or diameter there shall be a manhole or inspection chamber. The distance between manhole or inspection chamber and gully chamber shall not exceed 6 meters unless permitted otherwise. Manhole shall be constructed so as to be watertight under test. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide smooth flow.



Connection to existing pipelines shall be through a manhole.

Manholes shall be provided with standard covers, usually C.I. or as directed by the Engineer. The covers shall be close fitting so as to prevent gases from coming out.

#### 4.00.00      **TESTING AND ACCEPTANCE CRITERIA**

All testing, as mentioned in the body of the specification and as mentioned in Clause No. 900 of Specification for Roads and Bridge Works, 1983 published by IRC on behalf of Ministry of Shipping and Transport (Roads Wing) shall be carried out by the Contractor as per direction of the Engineer.

**SPECIFICATION NO. C-12**

**FOR**

**RESERVOIR WITH IMPERMEABLE LINING**

**SPECIFICATION NO. C-12  
FOR  
RESERVOIR WITH IMPERMEABLE LINING**

**C O N T E N T S**

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**SPECIFICATION NO. C-12  
FOR  
RESERVOIR WITH IMPERMEABLE LINING**

**1.00.00 SCOPE**

The scope of work under this specification broadly covers, but not limited to, lining of the raw water reservoir with LDPE film and including all other work as described below or as needed to have the raw water reservoir completely waterproof against leakages. The work covers preparation of subgrade including removal of any undesirable material from the soil, providing lining of the film including heat sealing the joints, etc. protection of the films by laying earth or precast concrete blocks/ brick tiles/bricks in cement-mortar, as the case may be, providing antiweed and/or anti-termite treatment, anchoring of the lining by providing trenches and toe walls, etc. and all other work necessary, whether described/specified or not, for making the work complete and successful in all respect.

The testing against leak-proofness of the reservoir after completion of the work may have to be done at some places chosen at random by the Engineer. In case any defect is found in the lining work, the Contractor shall have to repair the same or re-do the whole work without any extra cost to the Owner. It is intended that the lining work must be done with utmost care, so that there is no damage to the LDPE lining during execution of the work.

**2.00.00 GENERAL**

**2.01.00 Work to be provided by the Contractor**

Work to be provided by the Contractor unless specified otherwise will include, but not limited to the following:-

- a) Furnish all labour, supervision, services, materials, scaffolds, equipment, tools and plant, transportation, necessary approaches etc. required for the work.
- b) Prepare detail drawing, if needed, for the work, fencing of area for protective measure, provide dewatering arrangement by pumping, if required, etc.

**2.02.00 Work to be provided by Others**

No work under this specification will be provided by any agency other than the contractor unless specifically mentioned elsewhere in the contract or prior approval of the Owner is taken in this respect.

2.03.00 **Codes and Standards**

IS:2508 - 1977 - Specification for Low Density Polyethylene Films and other relevant IS specifications, Code of Practice, Manufacturers Standard Catalogues, etc. are to be used for completing the job in addition to this specification.

2.04.00 **Conformity with Designs**

The Contractor is to carry out the work as per the specification, drawings issued to him and/or Contractor's drawings which are approved by the Engineer and/or Engineer's instructions. If any deviation is likely to occur, then the Contractor should take Engineer's prior approval before starting of such work. Under no circumstances, the work to be performed should deviate from the specification or drawings unless approval of Engineer is taken.

2.05.00 **Materials to be used**

2.05.01 **General**

All materials to be used for the Work, must meet the specification requirements or the provisions of IS Code and should be of best quality available and approved by the Engineer. In case of bought-out items, certificate from the supplier or its deputed agency must be produced along with samples and approval taken from the Engineer before the items are bought.

Decision of the Engineer in cases of bought-out items shall be final.

2.05.02 **LDPE Films**

The black LDPE (Low Density Polyethylene) films - heavy duty & wide width - as manufactured and marketed by Indian Petro-Chemicals Corporation Limited (IPCL) from INDOTHENE, or equivalent shall be used for lining work. INDOTHENE grade shall be 22 FA 002, the basic mechanical properties of films made from this grade being as follows :-

Property	Test Method	Unit	Mean Value Range 22 FA 02
Melt Flow Index	ASTM D 1238	gm/10 min	0.2
Density	ASTM D 1505	gm/cc	0.922
Tensile Strength at Break	ASTM D 638	Kg/sq.cm	300
Elongation at Break	ASTM D 638	%	700
Vicat Softening Point	ASTM D 1525	deg.C	98-100
Crystalline Melting Point	ASTM D 2117	deg.C	111-112

Property	Test Method	Unit	Mean Value Range 22 FA 02
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Dart Impact*	ASTM D 1709	gm	310-320
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\* (determined on a 50 microns thick film)

The addition of carbon black masterbatch is to be carried out in certain proportions so that around 2.5% of carbon black is present in the final product of heavy-duty black film.

The film shall be free from any objectionable odour, particularly with reference to the use of reservoir water for drinking purpose.

Film rolls shall not be allowed to remain exposed to sun during its storage. These are to be kept indoors or to be covered with empty gunny bags.

### 2.05.03 Earth/Soil

The excavated soil, selectively taken from the stacks of the same Contractor and/or stacks left by other agencies shall be used for covering films, and shall be free from pebbles, stones, vegetation and sieved to segregate stones, etc. present in it, if directed by the Engineer. The minimum clay-content of this soil shall be 25%. No fine sand layer excavated shall be used as cover over films.

### 2.05.04 Pre-cast Concrete

Ingredients used in pre-cast concrete blocks (to be used for covering films) shall conform to the relevant provisions in IS:456, latest revision.

All precast work shall be carried out in a yard made for the purpose. This yard shall be dry properly levelled and having a hard and even surface. If the ground is to be used as a soffit form of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:3 proportion) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Engineer casting will have to be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal. The yard shall preferably be fenced.

Lifting hooks, where necessary or as directed by the Engineer, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after installation.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Engineer. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Engineer. The Contractor shall render all help with instruments, materials and men to the Engineer for checking the proper installation of the precast units. All minor defects shall be touched up with a paste of 1 part cement and 3 parts sand.

2.05.05      **Bricks and Brick Tiles**

Bricks and brick tiles shall be of first class (class A) quality, well burnt, of uniform size, shape and colour, free from cracks, flaws or nodules of free lime and emit clear ringing sound when struck. Fractured surface shall show uniform texture free from grits, holes etc. compressive strengths shall be 50 Kg/sq.cm minimum for common bricks. Water absorption after 24 hours immersion shall not exceed 15% by weight for common bricks. Dimensional tolerance shall not exceed 8% of the size shown in drawings for common bricks. All bricks shall have rectangular faces and sharp straight edges. The bricks shall show no efflorescence after soaking in water and drying in shade.

If the Tenderer can not arrange for such quality bricks during execution, he should clearly indicate it in his offer. Samples of bricks/brick tiles have to be got approved by the Engineer. Any brick or consignment of bricks not found upto the specification shall be outright rejected and shall be removed immediately from site at the Contractor's own cost.

3.00.00      **EXECUTION**

The Work shall be strictly executed according to the provisions of this specification, final drawings to be issued, instructions of the Engineer at site, and/or catalogues of the approved manufacturer of LDPE films.

3.01.00      **Preparation of Sub-grade**

The subgrade shall be true to level, well compacted and free from undulations. All sharp objects such as rock pieces, boulders, stones, pebbles, roots and weeds shall be cleared to prevent puncturing of the film, and holes are to be filled up with proper material and compacted as directed by the Engineer. If the bed/sides of excavation for the reservoir is a rock-cut terrain, sharp protrusions shall be levelled off. It is important that the bed as well as sloping sides and berm of the reservoir are well compacted to the satisfaction of the Engineer.

3.02.00      **Treatment of Weed-Infested Areas**

For safe guarding LDPE film against the growth of weeds, weedicides (such as Biodex-C, Gammaxene, Fernoxene or equivalent products) should be mixed with water in accordance with the manufacturer's instructions (3 litres of weedicide mixed with 200 litres of water is a standard practice) and this solution should be spread over the earth with a chemical spraying pump on side slopes. No weedicide treatment is required in bed.

The anti-weed treatment should be given only after moisture content of the soil is brought below 29%. After completion of the spraying of anti-weed chemicals and before taking up the next activity, a period of 24 hours should be allowed for penetration of the chemical into the soil.

### 3.03.00      **Anti-Termite Treatment**

The danger of termites at the bed of the reservoir is rather remote. However in the case of infested areas, suitable insecticide slurries with insecticides such as BHC may be used over the subgrade and before laying the film to prevent termite attack.

The tenderer, in his offer, shall quote separately for spraying suitable insecticide slurries in each square metre of treated area, and shall clearly indicate the type of insecticide, he proposes to use, manufacturer's name, proportion of ingredients in the slurry, and method of application, etc.

### 3.04.00      **Ancillary Work**

- a)      A toe wall of bricks/precast concrete blocks in 1:4 cement- sand mortar is to be constructed at the foot of the embankment/side slope as shown in the drawing. The top layer of the brick-precast concrete block shall be laid only after anchoring the LDPE film used in the lining of the sides and bed of the reservoir.
- b)      A trench 300 mm wide x 300 mm deep is to be excavated on the top of the embankment as shown in the drawing, for anchoring LDPE film from the side slopes.

### 3.05.00      **Laying of LDPE Film**

#### 3.05.01      **General**

The following precautions/procedures shall be observed during laying operation:

- a)      LDPE film rolls should not be rough-handled or dragged, as the film may get damaged in the process.
- b)      Workers should not walk on the film while the lining operation is in progress. In case this is unavoidable, they should walk barefoot.
- c)      LDPE films unrolled during lining should be carefully inspected for holes & other defects. The affected area can be rectified by putting patches.
- d)      No sharp-edged object should be placed or rolled over the film.
- e)      The black LDPE film should not be placed when the temperature is below 32 deg.F (0 deg.C) or above 100 deg.F (38 deg.C).

#### 3.05.02      **Bed Lining**

##### a)      **Film Laying**

On the level bed of the reservoir, a layer of fine sand of 12 mm thickness is to be spread to provide a cushion for the LDPE film. Sand is to be properly sieved so that there is no broken stone, brickbat or any undesirable material which may damage the film.



LDPE film of about 6 or 7 metre width and 70 to 80 metre length are then laid over sand with due care. The film should be spread loosely (with 5% allowance in each direction) and distributed evenly along the length and breadth of the film. When the film laying is undertaken at mid-day, it is recommended that the film be spread only in the area that can be covered with soil or tiles or other materials by the end of the day.

The subsequent and adjacent length of the LDPE film is to be heat sealed for prevention of water losses through the joint.

b) **Bed Cover**

i) **With Earth**

The bed cover shall be 300 mm of selected earth. Before placing the earth cover, the black LDPE film shall be minutely inspected to ensure that there are no perforations present in the film. Any such perforations should be heat sealed with at least 100 mm patch all around it.

A 50 mm thick layer finely powdered and sieved earth shall be first spread over the laid film. Subsequent layers (not exceeding 150 mm thick each) shall then be laid carefully and compacted by light wooden rammers.

ii) **With Tiles**

The bed cover may be provided with tiles in lieu of earth. Brick tiles or bricks or precast concrete blocks shall be laid in 1.5 cement mortar of a minimum thickness of 15mm as shown on the drawing. The joints are left open and finally filled with 1.3 cement sand mortar.

The lining shall be cured for minimum 7(seven) days.

3.05.03 **Side Lining**

The sides of the reservoir including berm shown on the drawing is to be lined with LDPE films.

a) **Film Laying**

The film is spread over the subgrade directly. Lining operation in the reservoir sides are to be the same as that for the bed excepting that no sand cushion is provided. One end of the film is anchored in the toe wall and the other end of the film is loosely held at the top of the embankment, at least 30 cm beyond the trench by placing bricks on it and subsequently anchored inside the trench.

b) **Side Cover**

Brick tiles or bricks or precast concrete blocks shall be laid in 1:5 cement mortar of a minimum thickness of 15 mm as shown in the drawing. The joints are left open and finally filled with 1:3 cement-sand mortar, after anchoring of films is over.

The lining shall be cured for minimum 7 (seven) days.

3.05.04 **Anchoring of LDPE films**

The films from side slopes and bed of the reservoir are to be first anchored inside the toe walls. The loose end of the film at the top of the embankment shall be buried in the trench and covered with compacted earth and subsequently with tiles/blocks as shown on the drawing.

3.05.05 **Heat Sealing of LDPE film**

The heat sealing shall be done by an electric iron having three parallel sealing bars. A long piece of plywood is to be placed below the LDPE film to be heat sealed. On the plywood, a rubber gasket is to be laid to provide a cushion for better welding of the film. On the rubber padding, a cellophane tape is to be spread and on this the LDPE film, with 150 mm overlap is to be stretched. On the overlapped LDPE film another cellophane tape is to be placed to prevent the heat sealer from sticking to the LDPE film. After this, the electric iron is to be pressed on the overlap joint for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of the joints. After heat sealing, the cellophane tape is to be removed and the joints are to be tested for leaks.

4.00.00 **ACCEPTANCE CRITERIA**

The installations shall present a neat appearance and shall be checked for water tightness. The following shall be specifically checked :-

- a) LDPE film against mechanical damage if any.
- b) Laying of LDPE films.
- c) Method of jointing (Heat sealing).
- d) End sealing or, anchoring of LDPE films.
- e) Laying and joints of cover tiles.

# 1 X 100 MW NAMRUP COMBINED CYCLE REPLACEMENT POWER PROJECT

## DESCRIPTION OF MAJOR BUILDINGS / STRUCTURES/ FOUNDATION SYSTEM

### ANNEXURE-A

SL NO	LIST OF STRUCTURES / BUILDINGS	LENGTH (M)	WIDTH (M)	HEIGHT (M)	No Reqd.	No of Storey	REMARKS (Types of Building / Struc./ Fdn)				
							Frame/Struc	Foundation	Roof	Floors	Cladding
1	Gas Turbine & Steam Turbine Building				1	-	Struc. Steel	RCC fdn. on Pile	RCC slab cast on metal deck formwork	RCC (Grating floors in part)	Colour coated profiled sheet Brick masonry upto 2.1m
2	Electrical Control Building				1	2	Struc. Steel	RCC fdn. on Pile	RCC	RCC	- DO -
3	GT. Foundation	-	-	-	1	-		RCC Block fdn. on Pile	-	-	-
4	STG. Foundation	-	-	-	1	-		RCC frame fdn. On Pile	-	-	-
5	BFP Foundation	-	-	-	1	-		RCC block on Pile	-	-	-
6	HRSG. Foundations	-	-	-	1	-	RCC	RCC fdn. on Pile	-	-	-
7	Main Stack Foundation				1	-	RCC	RCC mat fdn. On Pile	-	-	-
8	By-Pass Stack Foundation				1	-	RCC	RCC mat fdn. On Pile	-	-	-
9	DM Plant Building		-	-			RCC	RCC fdn. On Pile	RCC	RCC	Brick Masonry
10	Raw Water Reservoir & Pump House		-	-			RCC	RCC Raft/ spread fdn.	RCC	RCC	Colour coated profiled sheet Brick masonry upto 2.1m
11	Clarified Water storage tank and Pump House		-	-	-	-	RCC	RCC Raft/ spread fdn.	RCC	RCC	Brick Masonry
12	Fire Water tank and Pump House		-	-	-	-	RCC	RCC Raft/ spread fdn.	RCC	RCC	- DO -
13A	Transformer Foundations		-	-	-	-	-	RCC fdn. on Pile	-	-	-
13B	Fire Wall		-	-				RCC fdn. on Pile	-	-	RCC
13C	Transformer Yard Trenches, Duct banks, Pull pits, Manholes, Paving		-	-			RCC	RCC	-	-	-
13D	Oil Pit in transformer yard				1	-	RCC	RCC Raft	-	-	-
14	CW Pump House with Forebay & Elec. Annexe. Building.				1	1	RCC Sump , Forebay and Struc. Steel framed	RCC Raft / spread fdn.	RCC	RCC	Colour coated profiled sheet Brick masonry upto 2.1m

# 1 X 100 MW NAMRUP COMBINED CYCLE REPLACEMENT POWER PROJECT

## DESCRIPTION OF MAJOR BUILDINGS / STRUCTURES/ FOUNDATION SYSTEM

### ANNEXURE-A

SL NO	LIST OF STRUCTURES / BUILDINGS	LENGTH (M)	WIDTH (M)	HEIGHT (M)	No Reqd.	No of Storey	REMARKS (Types of Building / Struc./ Fdn)				
							Frame/Struc	Foundation	Roof	Floors	Cladding
							superstruc				
15	Switchyard Relay Room						RCC	RCC fdn.	RCC	RCC	Brick Masonry
16	Air Compressor & DG Building				1	1	Struc. Steel	RCC fdn. On Pile	RCC	RCC	Colour coated profiled sheet Brick masonry upto 2.1m
17	DG Foundation						RCC	RCC Block on pile	-	-	-
18	BFP and Deaerator Building				1	1	Struc. Steel framed	RCC fdn.on pile	RCC	RCC / Grating	Brick Masonry
19	CW Chlorination Building				1	1	RCC	RCC	RCC	RCC	Brick Masonry
20	Chemical House				1	1	RCC	RCC	RCC	RCC	Brick Masonry
21	Gas Booster Compressor House				1	1	Struc. Steel framed / RCC	RCC fdn. on Pile	RCC	RCC	Brick Masonry
22	Outdoor Pipe & Cable Trenches				-	-	RCC	RCC Raft	-	-	RCC
23	Pipe / Cable Rack				-	-	Struc. Steel	RCC fdn. on pile	-	-	-
24	Storm Drains and Culverts	-	-	-	-		RCC	-	-	-	-
25	Switchyard structures incl. Equipment.						Struc. Steel	RCC fdn.	-	-	-

[Note: All Building dimensions (length, width & height) and No. of stories to be designed by EPC contactor]