Section C3

TECHNICAL SPECIFICATIONS

1 SURVEYING WORKS

1.1 Site Survey

Site survey shall be carried out to establish the ground levels and to determine any existing structures, roads, etc.

The site survey shall be carried out before the commencement of the work and – if required – during the progress of the work.

The site survey shall be carried out at a grid spacing of 5-10 meters and at every change of level of the existing ground to produce contour drawings of 0.25 meter intervals. Scale of the contour drawings shall be as directed by the Consultant.

A specialized firm approved by the Consultant shall carry out the site survey.

1.2 Survey Points (Reference Points And Bench Marks)

The contractor shall construct adequate number of reference points and bench marks for marking the setting out lines and levels.

The reference points shall consist of suitable metal plates set in 400 mm x 400 mm x 500 mm precast concrete plinth (grid pillars) and inscribed with the exact level.

All levels of the benchmarks shall be related to the agreed datum.

The proposed numbers, locations, co-ordinates, and levels of the reference points and bench marks shall be plotted on drawings and approved by the consultant prior to the commencement of the work.

Survey points in solid walls shall be stainless steel plates or cast iron, fixed firmly and sufficiently deep in the walls.

1.3 Safeguard Of Survey Points

The survey points shall not be removed from their position without the permission of the Consultant. If any of the survey points are damaged or lost due to any work carried out near their location the Contractor shall be responsible for replacing such survey points.

1.4 Surveying During The Progress Of Work

The Contractor shall assist the Consultant at any time when checking survey points, setting out, checking construction items and erection parts. The Contractor shall provide and arrange the following:

- Provision and maintenance of survey instruments and accessories
- Provision of skilled personnel
- Supply of all material required for the survey
- Exposing covered survey points
- Shifting of any machinery used for construction out of the sight lines
- Stopping all drilling, blasting, driving, and any other works causing soil vibrations and stopping during instrument observations
- Removing all obstructive accumulation of water
- Taking all necessary safety precautions
- Furnishing any marking material requested by the Consultant in connection with control surveys
- Providing additional survey points in accordance with the Consultant's instruction

2 SOIL INVESTIGATION

2.1 General

The Contractor shall carry out soil investigation to obtain sufficient information on the sub-soil conditions for the detailed design of foundations and structures under this Contract. The investigation shall cover sufficient numbers of bore holes in each area to get the longitudinal of the soil profile as required.

If required, additional investigations shall be carried out during work progress at the Contractor's expense in order to obtain additional information.

2.2 Standards

Unless otherwise specified, the following standards shall apply to the works covered by this chapter.

IS:1498	Classification and identification of soils for general engineering purposes.
IS:1888	Method of load tests on soils.
IS:1892	Code of practice for sub-surface investigation for foundations.
IS:2131	Method of Standard penetration test for soils.
IS:2132	Code of practice for thin-walled tube sampling of soils.
IS:2720	Methods of test for soils (All Parts).
IS:2809	Glossary of terms and symbols relating to soil engineering.
IS:2810	Glossary of terms and symbols relating to soil dynamics.
IS:3043	Code of practice for earthing.
IS:4078	Code of practice for indexing and storage of drill cores
IS:4434	Code of practice for in-situ vane shear test for soils
IS:4968	Method of sub-surface sounding for soils (All Parts)
IS:5249	Method of test for determination of dynamic properties of soils
IS:5529	Code of practice for in-situ permeability tests (All Parts)
IS:9214	Method of determination of modulus of sub grade reaction (K-value) of soils in field
IS:10060	Code of practice for subsurface investigation for power house sites
ASTM D 4428	Cross bore shear wave test

2.3 In-situ Testing

2.3.1 Borings In Soil

The minimum depth of borings shall be 30 meters below ground level or upto the hard stratum, whichever is earlier. At least two boreholes shall be taken to 40m depth or till sound rock is reached. Drilling and sampling shall be performed in accordance with IS Standards. Disturbed samples shall be taken in all materials at 1 meter intervals and at changes of strata and shall be contained in airtight containers. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where possible at 1 meter intervals and at changes of strata. Samples shall be sealed so that no changes in water content or soil

structure occur. Cores of cemented material shall be packed in core boxes immediately on removal from the core barrel.

2.3.2 Rock Drilling

During boring operation, once the rock strata is encountered, drilling operation shall be resorted to for determining depth and nature of rock strata.

Rotary core drilling technique with continuous core recovery should be adopted for drilling through rock. 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.

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. The pressure under which the drilling fluid should be introduced into the hole should be the minimum as required for 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 borehole the Contractor shall record the rate of sinking of drill rods, ground water table elevations if any, nature, type and sequence of rock drilled. The recovered rock cores shall be properly indexed & stored as per stipulations of IS:4078. From the recovered cores, the Contractor shall determine nature of fractures and degree of weathering of the rock for each borehole. The Contractor shall also note and record any appreciable loss of drilling fluid throughout the entire drilling operations for each borehole. The Contractor shall also determine the percentage recovery ratio and rock quality designation from the recovered cores for each stage of core advance and for all the boreholes.

The drilling operation shall be terminated either 3 metres in hard rock or 95% of core recovery whichever is later.

2.3.3 Standard Penetration Test (S.P.T.)

The standard penetration test shall be performed in all boreholes at 1.5 meter intervals and at change of soil strata. The blow count shall be recorded. If the blow count exceeds 75 or if the penetration is less than 25mm per 50 blows, the test shall be stopped. The standard penetration test shall comply with IS: 2131.

2.3.4 Static Cone-Penetration Test

The static cone penetration test shall be carried out in accordance with IS: 4968 (Part-III). The test shall be carried out by equipment of 20 tons capacity.

The location of the static cone penetration shall be close to the boreholes in order to compare between the results of the static cone and the S.P.T. in the boreholes and to establish a correlation between both tests. The results of the static cone shall be recorded as follows:

- Diagram of cone resistance qc versus depth
- Diagram of the frictions Fs versus depth
- Diagram of the friction ratio % Fs / qc versus depth

In case cemented layers occur into which the cone cannot penetrate, the Contractor shall drill through the hard soil before the cone test is continued.

2.3.5 Dynamic Cone Penetration Test

The test equipment and procedure shall meet the requirement of IS:4968 (Part II). The driving shall not be done for more than 30 cm at a time after which it shall be stopped for a minute or two. The tests shall be terminated when the blow counts exceed 35 for 100 mm. penetration when the cone is dry and 20 for 100 mm. penetration when the cone is penetrated by circulating slurry.

The results shall be reported in a suitable tabular form giving below counts for every 30 cm. penetration supplemented by a graphical plot of blow count versus depth.

2.3.6 Vane Shear Test

The test shall be conducted in the boreholes or by direct penetration from ground surface, for soft to firm clays and sensitive clays. The test shall also be conducted in case of stiff fissured clays where samples cannot be taken. The tests shall be carried out as per stipulations IS:4434. Samples shall be collected from the levels at which the tests have been conducted.

The results shall be reported in a suitable tabular form and shear strength & sensitivity shall be determined.

2.3.7 Shallow Trial Pits

Trial pits shall be carried out to a depth of 3 meters minimum below ground level and plan area of 10 square meters to examine the in-situ condition of the upper soil strata. After logging, sampling and testing the trial pits shall be backfilled and compacted.

2.3.8 Field Density

Sand replacement method shall be carried out to get the field density in the trial pits.

2.3.9 Plate Load Tests

Plate load tests confirming to IS:1888 shall be conducted at the specified locations for determination of safe bearing capacity for shallow foundations.

2.3.10 Cyclic Plate Load Tests

Cyclic Plate load tests conforming to IS:5249 shall be conducted at the specified machine foundation locations. Equipment used shall conform to IS:1888 and loading arrangement may be mechanical or hydraulic type with facility for quick application and removal of load. The initial loading and unloading cycles upto the safe bearing capacity of soil should be with five to six nos. smaller increments in load. Based on the above test, the Contractor shall recommend the coefficient of subgrade reaction & coefficient of elastic uniform compression.

2.3.11 Permeability Test

To determine the permeability coefficient of the soil, this test shall be carried out in accordance with IS:5529(Part-1), using pumping out method with piezometers installed.

2.3.12 Earth Resistivity Test

Electrical Resistivity tests at specified locations using Wenner's four-electrode Method conforming to IS:3043.

2.3.13 Dynamic Block Vibration Tests And Wave Propagation Tests

Dynamic block vibration tests are to be conducted at the machine foundation locations, in accordance with IS:5249, for evaluating the dynamic properties of soil.

Wave propagation tests for determination of shear modulus are to be conducted adjacent to the location of the block vibration tests.

2.3.14 Cross-hole shear wave test

In this method, two boreholes a known distance apart are drilled to the required depth, preferably on each side of the base location. A sensor device is located in the side or bottom of one hole at depth approximately equal to the width of foundation and a shock producing device (or small blast) in the other. A trigger is supplied with the shock so that the time for the induced wave can be picked up for estimating the shear wave velocity. The test shall be conducted as per ASTM D 4428.

2.3.15 Menard Pressure Meter Test

To determine the coefficient of earth pressure at rest and the stress-strain modulus of soil, this test shall be carried out as per IS:1892 to the full depth of bore holes at every 3.0 m intervals or change of soil stratum.

2.3.16 CBR Test

Field California Bearing Ratio tests shall be performed as per IS:2720 (part 31) in order to determine the thickness of pavements and its constituent layers.

2.3.17 Laboratory Testing

The contractor shall prepare a program of laboratory testing to the approval of the Consultant and perform such tests sufficient to classify the materials encountered in the investigation and for the reasonable estimation of the parameters required for the design and installation of the works. The laboratory test program shall include the following where applicable:

- Classification Tests
- Water content determination
- Bulk density and dry density determination
- Specific gravity of soil grains
- Particle size distribution by sieve analysis
- Particle size distribution by hydrometer analysis
- Atterberg's limit test
- Chemical Tests
- Determination of pH value in soil
- Determination of organic matter in soil
- Determination of sulphate content as SO3 of ground water and soil
- Determination of chloride content as Cl of ground water and soil
- Soil Strength Tests
- Unconfined compressive strength

- Undrained triaxial compression
- Strength Tests On Rock Or Cemented Material Cores
- Point load test Is(50)
- Unconfined compression tests
- Compressibility Tests
- Consolidation tests
- Soil Compaction Tests
- Relative density of cohesionless soil
- Modified Proctor Density

All tests and apparatus shall be in accordance with IS standards where applicable.

2.4 Final Comprehensive Report

The contractor shall submit eight (8) copies of the final comprehensive report for the Consultant's approval along with soft copy in CD. The report shall include, without limitation to, the following:

- Write-up on procedures adopted for all phases of work.
- Plot Plan showing location of field tests and reduced levels.
- Geological information about the site.
- Detailed borelog including the description of each strata encountered, classification, SPT blow count, ground water level, etc.
- All field test results
- All laboratory test results
- Cross section of soil profiles in two perpendicular & diagonal directions. General description of ground condition and general and detailed description of the different layers of the soil strata in the entire site shall be specified by interpreting and extrapolating all of the test results.
- Particular description of the ground conditions for the different layers below each main structure and foundation
- Definite recommendations shall be given for the suitable design of both shallow and deep foundations, machine foundations & underground structures; such recommendations shall include but not be limited to the following:
- The level of the supporting layer and its allowable bearing capacity, as well as the maximum size of the shallow foundations, and their expected settlement.
- The suitable pile foundation, its suitable type, cross section, length, termination criteria, structural design and its expected allowable working load, tension & horizontal load capacity.
- Engineering properties of soil.
- Soil improvement by compaction of the loose soil.
- Soil improvement by replacing the poor soil (if deemed necessary), depth of excavation, type of new material, and its expected bearing capacity after soil improvement.
- The liability of the ground to heave due to expansive soil or to collapse due to dissolution of soil particles within the founding strata.
- Assessment of ground water conditions and their probable effect on construction.
- Recommend excavation side slopes (under and above ground water level).
- The influence of sulphates and chlorides and other chemicals on the R.C. foundations and remedial measures.

- Recommend Dynamic properties of soil.
- Roads, paving and grade slabs.
- Suitability of locally available soil for backfilling purposes.
- The resistance level at various strata for installation of earthing.

3 EARTHWORK AND ROCKWORK

3.1 General

This section applies to all earth and rockwork required for the construction of buildings, any types of structure and burying service lines in the ground.

The contractor shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his tender.

Generally, all buildings and structures must be founded on bearing strata which means that all excavation work for foundations shall meet the requirements of structural analysis based on the results obtained from the soil investigation and of the available information and instruction given in writing by the Owner.

Furthermore, this division applies to excavation works in connection with pavement, roadwork and landscaping as far as earth and rockwork is concerned and deals with the handling and disposal of the materials to be re-used or taken to soil dumps on or off site.

Excavation shall be done to the required dimensions and shall be finished according to the specified lines and slops, in a way acceptable to the Owner. All necessary precautions shall be taken to cause the minimum possible alteration or disturbance to the material lying under and adjacent to the excavation final lines.

3.2 Standards

Unless otherwise specified herein, the following standards shall apply to the works covered by this chapter.

IS:1498	Classification and identification of soils for general engineering purpose.
IS:2720	Method of test for soils (All Parts).
IS:3764	Excavation works – Code of safety.
IS:4081	Safety code for blasting and related drilling operations
IS:7293	Safety code for working with construction machinery.
IS:9759	Guideline for de-watering during construction.
IS:10379	Code of practice for field control of moisture and compaction of soils for embankment and subgrade.

3.3 **Fill materials**

The fill materials used and source are to be examined and approved. Excavation materials can be used if they fulfill the requirements.

Select fill: Select fill shall have the following properties:

Well graded (uniformity index not less than 5), non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), salt free (content less than 3%), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.

All materials shall be of such nature and character that it can be compacted to the specified densities in a reasonable length of time. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials which will corrode piping or other metal.

The intention is to use select fill below plinth, floors, roads, parking areas etc.

Ordinary fill: Ordinary fill shall have the following properties:

i) Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%. For other properties see under 'Select fill'.

ii) The intention is to use ordinary fill for non-built areas.

Special fill: Special fill material shall be gravel or crushed rock (for other properties see under 'Select fill'). The intention is to use special fill e.g. as sub-base material for tanks and roads.

Rip-rap/Rockfill: Rip-rap must be of a size suitable for the place where it is to be used, as determined by the speed of the current, wave height and depth of water. Rip-rap shall be of deformable and yielding construction, using round stones if the intention is to safeguard the underlying ground against scour. If the rock infill is to be used as a foundation for structural components, the aim should be to secure effective bedding of angular stones under water. The stones must be weather and waterproof.

3.4 **Excavation**

The works shall be excavated either by hand or by use of excavating plant and tools acceptable to the Owner.

Excavation by hand may be required close to existing installations and/or underground services, but subject to special instruction of the Owner.

The contractor shall carry out all kind of earth and rockwork for the following particular works as defined hereafter (where applicable):-

i) Clearing and grubbing

ii) Excavation of top soil

iii) Open cut excavation

iv) Backfilling

v) safety precaution during earthwork

vi) mining or underground excavation (if required)

vii) Grading

viii) Replacement of material

ix) Trench excavation for service lines

x) Embankments

xi) Archaeological findings

3.4.1 **Safety precaution**

The contractor shall be responsible for all necessary safety measures.

Proper strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides etc shall be to the Contractor's debit. The additional moving of soil resulting from such damages will not be paid for.

3.4.2 **over excavation**

If somewhere, and for any reason, excavation are executed beyond the established design level, the contractor shall at his own expenses backfill with lean concrete to Owner's approval, the volume corresponding to over-excavation. He shall not receive payment for over-excavation not ordered.

3.5 **Stockpiles and disposal**

Excavated material from the works selected by the Owner for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on site as directed by the Owner.

The contractor shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Purchaser and shall not be permanently deposited elsewhere. The contractor shall trim and form the edges of spoil to profiles and levels as directed by the Owner.

The placing of materials within the waste disposal areas shall be made in layers not exceeding 0.50 m in thickness in order to obtain an appreciable degree of

compaction by means of transportation equipment and/or if required by appropriate compaction equipment.

All traffic to or from the waste disposal areas shall run over the surface of such areas in order to achieve compaction.

3.6 **Preparation of foundations**

All rock surfaces on which or against which concrete is to be poured shall be carefully cleaned and roughened to the Owner's satisfaction.

The rock surface shall be free of oil, stagnant or running water, mud, loose rock, residue and impurities or any other improper material. Rock faults, depressions and fractures shall be cleaned to a depth equal to their widths and to sound rock at both sides. Immediately before concrete placing, all rock surfaces shall be thoroughly cleaned by means of air and water jets, wire brushes, sand jets or by any other devices necessary to clean the foundation and keep it free of water, but shall be moistened prior to placing concrete.

All earth surfaces against which concrete are to be poured, shall be clean and free of any detrimental impurities, organic matter or unsuitable material. Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Owner and then protected by means of a lean concrete layer, 7.5 cm or PCC thickness as shown in the design drawings, whichever is greater. No concrete is to be poured until formation is inspected and approved by the Owner.

3.7 **Backfilling**

Foundations and structures shall be backfilled as shown on the drawings with approved material compacted in layers not exceeding 150 mm by suitable equipment until optimum stability has been obtained to the satisfaction of the Owner. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Owner.

Density requirements as per standard Proctor Test shall be in accordance with relevant parts of IS: 2720 and all tests shall be made by/on under the supervision of Purchaser at contractor's own expenses, at optimum moisture content:-

a) Backfilling of foundations and under grade slabs - 98%

b) Under roadways and parking areas - 95%

c) Embankment - 95%

The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Owner after compaction tests have been made.

Surfaces receiving fill layers shall, if smooth, be previously scarified to obtain a good key between the new fill layer and the subgrade.

Backfilling of foundation work with approved materials shall be carried out only after foundations have been inspected by the Owner.

3.8 **Soil replacement**

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favourable grain size distribution shall be used in exchange.

Prior to the commencement of work, three samples shall be taken from the anticipated borrow area and tested in respect of IS:2720 or Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

These three samples shall cover the approximate variation of materials to be expected within the borrow area.

The fill material shall be placed in horizontal layers of not more than 15 cm in compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction. Fresh water shall be used for watering of soils.

The fill material shall be compacted by vibratory roller (min. weight 20T.). The minimum required degree of compaction shall be as defined under “Tests and Properties”. One Proctor and three density tests shall be made at every fourth fill layer prior to continuation of filling work. The testing location will be indicated by the Owner. The contractor shall either provide all required laboratory facilities and staff to perform the tests or he shall co-operate with an experienced soil testing laboratory, subject to the approval of the Owner.

The results of the tests shall be made available to the Owner within 24 hours of the tests. Filling work may be continued in case all tests performed show satisfactory results.

3.9 **Groynes existing pipework etc.**

If any existing works: groynes, burried pies, pipe and cable ducts, wattle-work, fascines and the like interfere with the excavation profiles, irrespective of whether or not such structures are described in this Tender, these works shall be replaced with the approval of the Owner.

Any stored materials, such as pipes, fittings, accessories of assorted sizes or any other material obstructing the progress of work shall be reshifted by careful handling, loading, transporting, stacking and protecting. The contractor will be held responsible and liable for damage caused by him. Any such works shall be included in the lump sum.

3.9.1 **Pipe bed preparation**

Pipe beds shall be constructed to guarantee the uniform transmission of loads. The bearing section for supported profiles shall cover at least an arc of 90°.

Pipes shall be bedded in an earth foundation of uniform density and carefully shaped by means of a template supported at the desired grade, to fit the lower part of the pipe exterior.

Where rock in either ledge or boulder formation is encountered, it shall be removed below grade and replaced with suitable materials in such a manner as to provide a compacted earth cushion having a thickness under the pipe of not less than one quarter of outside pipe diameter with a minimum allowable thickness of 20 cm if not otherwise specified.

Where a firm foundation is not possible at the grade established due to soft, spongy or other unstable soil, all such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed and replaced with suitable selected materials as approved by the Owner, properly compacted to provide adequate support for the pipe.

3.10 **Blasting**

The contractor shall obtain license from the district authorities for undertaking blasting work as well as for obtaining and storing the explosives as per Explosives Rules 1940, corrected up-to-date.

Explosives used for blasting shall be stored in clean, dry, well ventilated magazines to be built for the purpose. Fuses and detonators shall be stored in separate magazines. Detonators and explosives shall be transported separately to the blast site. Explosive 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. Only the quantity of explosive required for a particular amount of firing to be done shall be brought to the site of work. All surplus explosives left after filling the holes shall be removed atleast 400 metres from the firing point.

A wooden tamping rod shall be used to push the cartridge into the shot hole. Metal rod or hammer shall not be permitted on the site of the works. The charges shall be pressed firmly into place and not rammed or pounded.

The explosive shall be fired by means of an electric detonator placed inside the cartridge and connected to the firing cable. 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.

Holes for charging explosives shall be drilled with pneumatic drills, the drilling pattern being so planned that rock pieces after blasting will be suitable for handling. The locations and depths of the holes shall be chosen so that the bed rock below the design level is not shattered and voids, fissures and cracks below

this level are not formed. The rock pieces so blasted shall be neatly stacked at allotted places. 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 atleast 45 minutes before the firing time by sounding a warning siren. The area shall be encircled by red flags. All the operations shall be carried out by competent and experienced licensed supervisors. The number of shots fired at a time shall not exceed the permissible limits. Cases of the misfired unexploded charges shall be exploded by drilling a fresh hole along side the misfired hole (but not nearer than 600 mm from it) and by exploding a new charge. The workmen shall not return to the site of firing until atleast half an hour after firing.

When blasting is conducted in the neighbourhood of roads, structures, buildings or any place which requires controlled blasting, only shallow shot holes shall be drilled. These holes shall be filled with a light charge of explosive and the blast controlled by placing steel plates with gunny bags filled with sand or earth over the holes and covering them with wire net fixed to the ground, so as to ensure that the blasted materials do not scatter.

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

3.11 Protection of existing utilities and services

During construction, the contractor shall provide all protection for existing utilities and services as may be required by his construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Owner.

In addition to the requirements as specified, herein the contractor shall comply with the following requirements:-

a) Use all necessary precautionary and protective measures required to maintain existing utilities, services and appurtenances that must be kept in operation. In particular, the contractor shall take adequate measures to prevent undermining of utilities and services presently in services.

b) Protect existing or new utilities and services where required by the contractor's operations and/or as directed by the Owner. The contractor shall be responsible for bracing and supporting utilities and services to prevent settlement, displacement or damage.

3.12 Dust control

The contractor shall use all means necessary to control dust on roads, construction areas and borrow pits.

Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

3.13 Dewatering during Construction

3.13.1 General

This division applies to the methods and techniques of ground water control. Prior to the decision for the method and technique to be applied, a comprehensive knowledge of the soil and ground water conditions have to be obtained from the results of the soil investigation and/or information given in writing by the Owner.

All costs for ground water control for keeping the construction pits dry shall be included in the relevant excavation items of the lump sum except otherwise indicated.

The method and technique shall be based on the IS:3764.

The scope of supply includes the installation of all equipment, plants, pipes, machinery, etc and its removal after completion including operation & maintenance of the equipment during the construction period.

Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and any other works required for the water control and discharge shall be part of the scope of supply. The dewatering system shall be designed and installed in such a way that alterations and extensions can be made at any time throughout the operating time, if necessary. Reserve units shall be kept ready for service when failure of any of the installed units occurs.

The contractor has to consider the possibility of a temporary failure of any pump, diesel engine and/or the electric power service and shall install emergency power units with sufficient capacity to feed the necessary power to the installed unit at the moment of failure. The contractor shall submit to the Owner, the detailed method of the envisaged pumping system for dewatering, the pump capacity and the standby reserve units. The contractor shall adjust the system if required by the Owner.

The contractor must ensure that any dewatering works will not cause any interference to his own work and to those of other contractors working elsewhere on site or at structures under construction. Any damage occurring during the above mentioned period shall then be made good by the contractor at his own expense.

During the foundation works, the excavated areas, foundation levels, and pits are to be kept free of water down to at least 0.50 m below the foundation level.

3.13.2 **Equipment**

All equipment, instruments, machineries, tools, pipelines, etc required for execution of the water control shall be in good repair and shall be kept in good working condition throughout the operation period.

3.13.3 **Execution**

Records: The contractor shall keep records of all data of importance occurring during operation of the water control system. The records shall be submitted to the Owner for information and checking every working day. For that purpose, the lowering of the water table shall be controlled by piezometers. The numbers and position of them shall be submitted to the Owner's approval. The contractor shall provide and maintain these piezometers at his own expenses during the dewatering works or as long as the Owner requires it.

Pump operations shall not be stopped nor pipes, channels and equipment for dewatering and water control removed or altered in any way, except with the express permission of the Owner. The Owner will stipulate the time of removal. Until then, the pumps and water drainage facilities shall be kept in proper working order without extra payment being granted.

Pump sumps and channels: Provision of pump sumps and channels of the dimensions required for each particular case shall include all necessary excavation of any kind of soil above and under water, backfill and consolidation, sheeting, bracing, stiffening, sealing, scaffolding accesses, as well as the disposal of water and all auxiliary works.

Routing of channels or pipes for discharge water shall be such as not to impede or obstruct any of the other works and/or operations.

The same shall be applicable for pump sumps. Prior to the determination of any arrangement of pump sumps, the Owner's approval shall be obtained.

Routing and location of water discharge lines shall be submitted to the relevant authorities and to the Owner's approval.

Difficulties during dewatering: The contractor shall consider all difficulties and additional work due to the presence of unexpected ground water during subsequent construction work. Where it is possible to keep off or divert such water without special dewatering arrangements or where work can be carried out normally under or in water, such a method may only be applied after approval from Owner has been obtained.

Ready for service condition: The contractor shall maintain ready for service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can safely be used without risk of accident. Any recommendations made by the Owner in this matter shall be carried out immediately.

Leakage: Blockouts and pipe connections through structures and their closure, proper grouting of joints, etc or repairs in the event of leakage shall be the responsibility of the contractor.

Piezometers: The ground water lowering effect is to be checked by piezometers in unfavourable positions (e.g. in the middle of the building pit) before starting the excavation. The piezometers are to be installed at unfavourable positions or in more permeable layers (in stratified sub-soil) below the bottom of the excavation. They serve to check whether or not the water pressure (head) has been sufficiently reduced in those layers below the bottom of the excavation which are more permeable. Security against hydrostatic uplift is to be demonstrated by calculation.

3.14 Test and Properties

3.14.1 General

The control of working and tests operations shall be carried out by the contractor in the presence of the Purchaser or Owner.

The contractor shall prepare sheets for statistical analysis of the field and laboratory tests, and shall submit the sheets to the Owner for approval. Controlling will consist of field and laboratory tests, such as compaction and density tests, grain size distribution and shear tests.

If not otherwise specified under relevant items, the following min. tests have to be carried out:-

a) One (1) test analyzing the ingredients of the water used for performance of the work.

b) Three (3) tests for specific gravity of soil as per IS:2720.

c) One (1) test for bearing capacity of soil for static load as per IS:1888-1982.

d) Three (3) tests for grain size analysis of soils, if “Replacement of Material” is required as per IS:2720.

e) Three (3) tests of density of soil in place of sandcone method for each second layer of “Backfilling and/or Replacement of Material and/or Roadwork” are required as per IS:2720.

All tests shall be recorded in forms acceptable to the Owner.

Tests shall be performed for each 500 m^3 of fill but not less than once per shift.

3.14.2 **Testing of select fill**

Select fill, as specified herein, shall be provided as follows:-

a) As fill or backfill within the limits of the structure/building and below basement floors as shown on the drawings to bring the subgrade up to the required elevation or for filling or backfilling against foundations walls and around footings.

b) As fill beneath grade slabs or basement floors either to bring local low areas to grade or to replace disturbed or unsuitable soil.

Place select fill in approx. 15 cm layers (compacted thickness) and compact to 98% of maximum dry density (IS:2720).

Quality control shall establish all of the following values:-

a) Unit dry weight

b) Standard penetration test: 20 blows per 10 cm penetration.

c) Plate load test as per IS:1888.

3.14.3 **Testing of ordinary fill**

Ordinary fill, as specified herein above, is required for all fill and backfill where special fill or select fill have not been specified on the drawings. Place ordinary fill in 15 cm layers (of compacted thickness) and compact to 95% of maximum dry density at optimum moisture content as per standard Proctor Density Test.

Quality control shall establish all of the following values:-

a) Unit dry weight

b) Standard penetration test: 16 blows per 10 cm penetration.

c) Plate load test as per IS:1888.

3.15 **Foundations**

3.15.1 **General**

This clause describes all foundation works which are to be performed so as to ensure the bearing of all loads without detriment for and damage to the structures. The contractor has to choose up-to-date methods and equipment to ensure this in accordance with relevant internationally recognized standards.

The soil conditions met during the foundation works especially in the foundation level are to be checked by the contractor's soil Owner, recorded and compared with previous known or investigated results. If essential differences occur, which

could be detrimental to the structures, the contractor has to inform the Owner and to propose further measures. Foundation works in such areas are to be continued only after approval of such measures by the Owner.

If there is any doubt about the soil quality or if discrepancies appear with regard to the previous decisions or investigations stated by the Owner, then additional measures are to be taken after consulting the Owner (e.g. additional excavation and lean concrete fill).

Immediately prior to concreting any footing, the contractor has to verify the specified soil conditions below the foundation level by a sounding.

For soil improvement works i.e. execution of special foundations (except replacement method) only special contractors (or sub-contractors) are acceptable subject to providing proof of experience in successful execution of such works in the form of a detailed description and references. Together with the description and the references a detailed execution programme including quality control measures relating to the actual site conditions is to be transferred to the Owner for approval.

Soil investigation at the plant site has not been done as yet, and detailed geo-technical investigation shall be required to be carried out to ascertain the safe bearing capacity and appropriate type of foundation for heavy equipment and structures.

The identified site for this project is mostly a filled up area. Detailed soil investigation would have to be done for foundation design. However the soil conditions of adjoining area given in the following paras can be used as initial idea.

Foundations in Adjoining Area:

It is understood that all the heavy structures for adjoining area were founded on the rock strata either directly or through piles and the main purpose of soil investigation was to know the depth of rock strata of the whole area.

General Condition of Soil in Adjoining Area:

Cohesive soils as sandy silt clayey silt from ground surface to the weathered rock were encountered in the area. Soils contained course sand and gravel near the ground surface. Underlying the soils, weathered rock were encountered. N-values of SPT in the upper part of the weathered rock were more than 70 and it was considered that the weathered rock could support loads transmitted from spread foundations and / or piles. Underneath the weathered rock, medium to hard rock is existing.

However, the Contractor shall carry out the soil investigation to determine soil characteristics and safe bearing capacity.

The geo-technical exploration, testing and analysis information shall be used to determine the most suitable bearing method to support each foundation. The bearing method may include Ownered fill, piling, drilled shafts, pressure injected footings or soil densification.

3.15.2 **Factor of Safety for Bearing capacity**

These are specified in Section 4.1 .

Static, dynamic and integrity tests shall be performed by an independent testing analyst.

3.15.3 **Settlement criteria**

These are specified in Section 4.1

3.15.4 **Pitwall Stability**

The excavated pit sides, walls or slopes have to be stable and established with respect to safety regulations:

IS:1200 (Part 1)	Method of measurement of building and engineering work
IS:3764	Safety code for excavation work

3.15.5 **Settlement and Expansion Joints**

Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joint width which is to be at least 2 cm is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc.).

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to IS:8009 – “Code of Practice for calculation of settlement of foundation”.

3.15.6 **Foundations at different depths**

Foundations at different levels should be based beyond a load spread angle of 30° (against the horizontal). Otherwise, the load influence (e.g. earth pressure) of the higher level structures on the lower ones must be taken into consideration.

3.15.7 **Safety against uplift**

For all parts of the structures extending into the ground water, safety against uplift has to be guaranteed during all execution stages, especially when ground water lowering is terminated.

3.15.8 **Shallow foundations**

In this clause shallow foundations are described where the footings rest on the natural bearing soil. For this kind of foundation especially the following standard is to be applied:

IS: 1080 Code of practice for design and construction of shallow foundations on soil

IS: 6403 Code of practice for determination of bearing capacity of shallow foundations

The excavation for the foundations can be done by machines, if the underground is not disturbed by this procedure. In every case, the last 20 cm above the foundation level are to be excavated by hand.

3.15.9 **Replacement**

If unsuitable soils are encountered below the grade slabs or basement floor, they are to be replaced by suitable layerwise compacted material down to the good bearing soil.

Materials and compaction method as well as quality control are described in clause 'Earth and Rockworks' of this section. Select fill is to be employed below all grade paving and basement floors.

3.16 **Special Foundation Requirements for Rotating Equipment**

Special requirements for foundation for rotating equipment are indicated in Section 4.2.

4 **CONCRETE WORKS**

Reinforced concrete structures shall be designed in accordance with the latest Indian Standards IS 456-2000.

Water retaining RCC structures shall be designed in accordance to IS:3370 Part I to IV – Code of Practice for Concrete Structures for Storage of Liquids.

4.1 **Scope**

The following works are covered by this section:-

a) furnishing and storage of materials,

b) equipment and labour for processing of aggregate, mixing, testing, transport, pouring, vibrating, compacting, finishing and curing of concrete.

4.2 Standards

Unless otherwise specified, the following standards shall apply to the works covered under this chapter,

Cement	
IS:269	33 grade ordinary Portland cement.
IS:455	Portland slag cement.
IS:1489(Part-1)	Portland pozzolana cement – Fly ash based.
IS:4032	Method of chemical analysis of hydraulic cement.
IS:6452	High alumina cement for structural use.
IS:8041	Rapid hardening portland cement.
IS:8112	43 grade ordinary Portland cement.
IS:12269	53 grade ordinary Portland cement.
IS: 12330	Sulphate resisting Portland cement.
Aggregate	
IS:383	Coarse and fine aggregates from natural sources for concrete.
IS:460	Test sieves (All parts).
IS:2386	Methods of test for aggregates for concrete (All parts).
IS:2430	Methods of sampling of aggregates for concrete.
Concrete Plain and Reinforced	
IS:456	Code of practice for plain and reinforced concrete.
IS:516	Method of test for strength of concrete.
IS:737	Wrought aluminium and aluminium alloy sheet and strips for general engineering purposes.
IS:1199	Methods of sampling and analysis of concrete.
IS:1607	Methods for test sieving.
IS:1834	Hot applied sealing compounds for joints in concrete.
IS:1838(Part-1)	Preformed fillers for expansion joint in concrete pavements and structures (non extruding & resilient type)– Bitumen impregnated fibre.
IS:1893	Criteria for earthquake resistant design of structures.
IS:2645	Integral cement water proofing compounds.
IS:2750	Steel scaffolding.
IS:2974	Code of practice for design and construction of machine foundations (All parts).
IS:3370	Code of practice for concrete structures for the storage of liquids (All parts).
IS:4326	Earthquake resistant design and construction of buildings – code of practice.

IS:6494	Code of practice for water proofing of underground water reservoirs & swimming pools.
IS:9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS:9103	Admixtures for concrete.
IS:9893	Precast concrete blocks for lintels and sills.
IS:10262	Recommended guidelines for concrete mix design.
IS:10297	Code of practice for design and construction of floors / roofs using pre-cast reinforced / pre-stressed concrete ribbed or cored slab units.
IS:10566	Methods of tests for preformed fillers for expansion joints in concrete paving and structural construction.
IS:10790	Methods of sampling of steel for prestressed and reinforced concrete (All parts).
IS:12118	Two parts polysulphide based sealants (All parts).
IS:13920	Ductile detailing of reinforced concrete structures subjected to seismic forces – code of practice.
SP:23	Handbook on concrete mixes.
BS:5606	Guide to accuracy in buildings.
ACI:347	Recommended practice for concrete formwork.
Reinforcing Steel	
IS:432(Part 1)	Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement.
IS:1566	Hard-drawn steel wire fabric for concrete reinforcement.
IS:1568	Wire cloth for general purposes.
IS:1786	High strength deformed steel bars and wires for concrete reinforcement.
IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS:2751	Recommended practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.
IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works.
IS:9417	Recommendations for welding cold worked bars for reinforced concrete constructions.
SP:34	Handbook of concrete reinforcement and detailing.

4.3 Materials

4.3.1 Quality of materials

The materials described below shall be specified and used as a basis for design.

Reinforcement shall be high yield strength deformed bars conforming to IS:1786 (Grade Fe415).

Cement: Ordinary Portland cement grade 43 conforming to IS-8112, shall be used in concrete mixes for general use viz. paving, lean concrete etc. Grade 53

ordinary Portland cement conforming to IS-12269, shall be used for concrete mixes for all structural work and special structures and foundations.

Sulphate resistant cement, conforming to IS-12330, shall be used in concrete mixes when concrete is exposed to aggressive soil/water conditions.

Aggregates: Fine aggregates shall be clean natural sand. Coarse aggregates shall be crushed rock. All aggregates shall meet the IS requirements of IS:383.

Admixtures: Plasticizers and retarders shall be used to control setting time and to obtain optimum workability. Interior slabs to be trowel finished shall use less air entrainment. The use of calcium chloride shall not be permitted.

Water: Clean water of potable quality shall be used in all concrete mixes.

4.4 Storage of Materials

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Storage of materials shall conform to IS-4082 "Recommendation on stacking and storage of construction materials and components at site". Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the contractor.

4.5 Cement

4.5.1 Sampling and testing of cement

All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties as required by relevant IS-12269 for grade 53 cement, IS-8112 for grade 43 and IS-12330 for sulphate resistant cement.

The manufacturer's test certificate will normally be accepted as proof of compliance with the specification, but the Owner may order further tests of a character specified in the appropriate Indian standards. The confirmatory tests are to be conducted by a recognized quality control organization. The contractor shall bear all expenses required for the preparation, despatch, and tests of the samples. In case the results of such tests show any sample to be inferior to specifications, the whole consignment from which the sample was taken shall not be used and shall be immediately removed from the site.

4.5.2 Delivery and storage of cement

The following information shall be provided for all cement shipments (either whole or part) which are intended for delivery to site: date of manufacture, date of original loading, destinations en-route, date of unloading, intended date of delivery to site.

Cement which has been manufactured for longer than 6 months on the proposed date of delivery to the site shall be inspected, sampled and tested for approval purposes before delivery to the site.

The contractor shall obtain and provide to the Owner the manufacturer's Bulk Average Test Certificate for each consignment of cement to the works. The certificates shall be provided before the consignments are required for use and shall show the chemical composition and physical properties determined in accordance with the relevant standard.

Samples shall be taken from each consignment of cement and tested as directed by the Owner in an approved independent laboratory.

When bulk cement deliveries are proposed, the contractor shall provide all information required by the Owner concerning off-site storage and loading arrangements and shall provide reasonable facilities for the Owner to inspect these arrangements for approval purposes.

Consignments shall be used in the order in which they were delivered.

All bagged cement shall be stored in a weatherproof building having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements shall be fully completed and approved by the Owner before any cement is delivered to site.

Each consignment of cement shall be separately stored for ease of access, identification, inspection and sampling. Sufficient stocks shall be maintained on site to ensure the proper progress of the works and the stock holdings shall be to the approval of the Owner.

If bagged cement is stored in silos it shall be charged into the silos through at 6.3 mm mesh screen which is welded or bolted to and covers the entire feed area of the silo charging hopper.

Cement stored in silos shall be adequately protected against rain, humidity and dewfall, and all silo charging and discharging points shall be properly sealed. Silo aeration equipment shall if available, incorporate de-humidifiers.

No cement from any consignment shall be used in permanent works without the approval of the Owner.

Cement which contains air-set or hardened lumps, re-powdered air-set material, foreign matter or which has been contaminated or is otherwise unsatisfactory in the opinion of the Owner will be rejected and shall be removed from site without delay.

The contractor shall be responsible for satisfying himself that the performance characteristics of cement are not such as to necessitate excessive cement content or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete notwithstanding apparent compliance with this specification.

Bulk cement shall be used for structures, bagged cement shall be used for masonry, plaster etc.

4.6 **Water**

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.

pH value of water shall not be less than 6.

Non potable water may be used for the production of concrete and processing of aggregate provided the following requirements are satisfied:-

a) The compressive strength of 150 mm cubes made and tested in accordance with IS:456 using the proposed water shall not be less than 90% of the average of strength of three similar concrete cubes prepared with distilled water.

b) The initial setting time of test block made and tested in accordance with IS:4031 and containing the proposed water shall not be less than 30 min. and shall not differ by $\pm$30 min. from the initial setting time of control test block made with distilled water.

c) The following chemical limits shall not be exceeded:

i)	Chlorides (CL^-)	< 2000 ppm
ii)	Sulphates (SO_4^-)	< 400 ppm
iii)	Organic	< 200 ppm
iv)	Inorganic	< 3000 ppm
v)	Suspended solids	< 2000 ppm

The concrete supplier shall provide chemical and physical test data for each source of water to be used prior to use.

When water is transported in tank trucks, each unit shall be accompanied by a chemical test report indicating compliance with the above requirements.
All water to be analysed by an independent laboratory before any work commences and at intervals as direct by the Owner tests and quality of water shall be in accordance with IS:456 or equivalent.

4.7 **Aggregates**

The aggregates for concrete shall be crushed natural rock subject to Employer/Owner's approval.

The aggregate to be used in the work shall be supplied from an established pit or quarry. The aggregate source shall have a minimum five (5) years history of satisfactory performance in structural concrete and consistency of supply.

The concrete supplier shall obtain from the aggregate producer, or otherwise provide current test, examination, inspection reports performed and certified by an approved laboratory for submittal to the Owner.

As a minimum, this information shall include the following items:-

Item 1 A comprehensive description, with current photographs of the pit or quarry, including but not limited to, identification by name and location, type of deposit, age, potential reserves, primary products by size including average gradation based on previous six (6) months production and the range for each sieve size; mining methods, process equipment, quality control organization and laboratory; the primary and alternate means of product transportation; listing of primary and secondary users of the product.

Item 2 Petrographic examination in accordance with IS:2386 (Part-8) performed by a qualified concrete aggregate petrographer. This report shall be based on material produced and examined within the previous six (6) months and must be representative of the current production.

Item 3 Coarse aggregate shall be sampled from current production in accordance with IS:2386 (Part 1 to 8). Three [20 mm, 10 mm & 5 mm] nominal maximum size (NMS) aggregates shall be sampled and tested as follows:-

IS 2386(Part 1):	Methods of test for aggregates for cement: Part 1 Particle size and shape (Amendments 3)
IS 2386(Part 2):	Methods of test for aggregates for concrete: Part 2 Estimation of deleterious materials and organic impurities (Amendment 1)
IS 2386(Part 3):	Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking
IS 2386(Part 4):	Methods of test for aggregates for concrete: Part 4 Mechanical properties (Amendments 3)
IS 2386(Part 5):	Methods of test for aggregates for concrete: Part 5 Soundness
IS 2386(Part 6):	Methods of test for aggregates for concrete: Part 6 Measuring mortar making properties of fine aggregates (Amendments 2)
IS 2386(Part 7):	Methods of test for aggregates for concrete: Part 7 Alkali aggregate reactivity

IS 2386(Part 8): Methods of test for aggregates for concrete: Part 8 Petrographic examination

Aggregates when subjected to the tests defined in items above, unless otherwise approved by the Owner shall meet the requirements of IS:383 and IS:456.

Testing is to be carried out at the following intervals:

Type	**Coarse Agg.**	**Fine Agg.**
Grading	Daily	Daily
Specific Gravity	7 days	7 days
Magn Sulphate soundness	30 days	-
Clay, Silt and dust content	Daily	Daily
Shape (elongation and flakiness)	3.5 days	-
Los Angeles Abrasion	Initial stage only	Initial stage only
Moisture content	2 days	2 days
Drying shrinkage	Initial only	Initial only
Organic impurities	30 days	30 days
10% fines value for concrete	7 days	-

Combined grading also on a daily basis.

4.7.1 **Storage and handling of aggregates**

Cement and densified silica fume shall be stored in separate weather-tight buildings, bins or silos that will exclude moisture and contaminants. At least two cement silos are required with enough storage for a total of 400 metric tonnes of cements.

Aggregate stockpiles shall be arranged and used in a manner to avoid segregation and to prevent contamination with other materials or with other sizes of like aggregates. Aggregate delivery trucks shall be covered to prevent wind blown contamination. Aggregate stockpiles shall be located relative to prevailing winds to mitigate the accumulation of wind-borne dust.

Adequate storage shall be provided for each aggregate. The aggregate storage area shall be on concrete pavement sloped to drain excessive moisture. The aggregate storage area shall provide bulkheads to separate piles and protect

against wind blown contaminants. Provision shall be made to shade and sprinkle the aggregates with potable water.

Aggregate stockpiles shall be built in successive horizontal layers not exceeding 1 m in thickness, with each layer being completed before the next is started. No vehicles shall be allowed to operate on top of the stockpiles.

Rescreening Coarse Aggregate: Rescreening and washing of coarse aggregates is required, if necessary, to reduce total chloride and/or sulphate contents to a level less than the maximum allowed by the specifications. If rescreening is required, the screening and washing shall be just prior to transferring aggregate to batch plant bins. Aggregates shall be dewatered over a screen to remove excess water before being stored in the batch plant bins.

Natural or manufactured sand shall be allowed to drain until it has reached a somewhat uniform moisture content before it is used.

Liquid admixtures shall be stored in such a manner to avoid contamination, evaporation and segregation in accordance with the manufacturers' recommendations.

4.7.2 **Fine aggregate**

Fine aggregate source shall be manufactured crushed stone or rock sand, excluding fines which are by products/rejects of coarse aggregate production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone nor 4% for natural sand.

The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

Crushed stone sand

a) concrete subject to abrasion 1% by weight

b) all other concrete 3% by weight

There shall be no clay or fine silt present.

The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on a IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.
Fine aggregate shall not contain appreciable amounts of flaky and/or elongated particles.

The water absorption of fine aggregate, determined in accordance with BS 812 shall not exceed 2.0% by weight.

Fine aggregate subjected to five cycles of the soundness test, specified in IS:2386 (Part-5), shall not show a loss exceeding 10% when sodium sulphate solution is used and 15% when magnesium sulphate solution is used, except where approved otherwise.

Tests are to be executed in accordance with IS:2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS:383.

The grading of the aggregates should be such as to produce a concrete of the specified proportions which will work readily into position without segregation and without the use of an excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Contractor. Washing is required if the content of salt adhering to the aggregate is found to be unacceptably high.

4.7.3 Coarse aggregate

Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The specific gravity of the coarse aggregate shall not be less than 2.5 t/m^3. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm^2 when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

The grading of coarse aggregate for concrete shall comply with the requirements of IS:383.

Samples of aggregates shall be submitted to the Owner, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the Owner have been selected, the contractor shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

4.8 Concrete Additives

4.8.1 Use of concrete additives

Concrete additives approved by the Owner shall be used to improve consistency, workability, quality and strength of the concrete.

Chemical admixtures manufacturer shall provide certified test reports from qualified independent laboratories showing actual test results indicating material that complies in all respects with the applicable specification.

Admixtures used in concrete shall conform to the appropriate specification and requirements as indicated below:-

a) Air entraining admixtures shall conform to IS:9103.

b) Water reducing and retarding admixtures shall conform to IS:9103. Accelerating admixtures shall not be used.

High range water reducers shall be naphthalene-sulfonated polymer based material. No admixtures containing chlorides shall be used.

c) Chemical admixture suppliers shall provide certified test reports with each shipment indicating compliance with the appropriate specification. The test reports shall include the chloride content of the admixture, specific gravity and solids content.

d) Fibres: Polypropylene fibres shall be collated, fibrillated polypropylene fibre of approved manufacture.

e) Corrosion inhibitors: Reinforced concrete subject to contact with seawater and brine, as a result of submergence, splashing, spry, leakage from piping or plant, or from any other cause, shall have a proprietary concrete corrosion inhibiting compound incorporated into a concrete mix.

The corrosion inhibitor shall be appropriate to the protection of steel reinforcement against corrosion throughout the 25 year design life of the structures. The corrosion inhibitor shall be compatible with the required concrete mix and shall be appropriate to the environmental exposure. Before incorporating corrosion inhibitor into any concrete mix, the contractor shall submit details for review and written consent by the Owner.

The corrosion inhibitor shall be equivalent Bipolar concrete penetrating corrosion inhibitor (CPCI) and IRNET Epoxy Phenolic Coating System of CBRI Roorkee. The dosage of which shall be as per manufacturer's instructions.

Admixtures used in production of concrete shall be the same as used in establishing the required concrete mix and shall be used in accordance with the manufacturer's directions.

4.8.2 **Accelerating and retarding additives**

Such additives shall only be used in case of necessity and after obtaining the written approval of the Owner.

4.8.3 **Plasticisers and air entraining additives**

Plasticisers and air entrainers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Owner and in accordance with the manufacturer's instructions.

4.9 **Concrete Mixes**

4.9.1 **General description and proportions and mixing**

The mix proportions are to be determined by proper mix design based on the requirements for strength, workability and the particular site in which the concrete is to be placed. The mix design shall be carried out by the contractor from approved agency. The design of mixes shall be based on the principles of IS:456-2000.

S.No.	Class	Grade of concrete	Minimum cement content (kgs/cum)	Maximum free water cement ratio
1.	Plain concrete used for lean concrete, screeds and backfill	M15	240	0.6
2.	a) Reinforcement concrete For structural work in foundation & superstructure	M25	300	0.5
	b) Reinforced concrete for water retaining structure	M25	330	0.5
3.	TG foundation deck	M40	360	0.4
4.	TG foundation substructure	M30	320	0.45
5.	Mill foundation & fan foundations	M30	320	0.45
6.	Chimney foundation	M25	365	0.5
7.	Chimney shell	M30	400	0.45
8.	Precast concrete	M25	300	0.5
9.	Pavement around buildings	M20	330	0.4
10	Piling concreting	M25	400	.5
11	Below ground level	M20	370(HSRC)	0.45
12	Above ground level	M20	330(OPC)	0.45

Concrete aggregates and cement shall be proportioned and batched by weight. Water and liquid additives shall be proportioned. If the contractor wishes to use

cement in bulk, his method of obtaining the correct proportions of cement shall be approved by the Owner before use.

4.9.2 **Trial mixes**

Before concreting commences, the contractor shall, at his own expense, make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing, transporting and compacting of the concrete with the equipment he proposes to use in any particular situation. Only materials which the contractor intends to use for concreting (including all admixtures) shall be used in the trial mixes.

Test cubes from trial mixes shall be made and tested in accordance with IS:516.

As per IS:456 and IS:516, three separate batches of concrete should be made, workability of each batch determined and three test cubes shall be made from each batch for each age (e.g. for 7 and 28 days) at which tests are required. The strength shall conform to target mean strength as per IS:456 – Requirements for design mixes.

The appropriate strength requirements may be considered to be satisfied if none of the strengths of the cubes is below the required characteristic strength and if the average strength of the nine cubes is not less than recommended by IS:456 and IS:516, trial mixes.

4.9.3 **Quality and testing**

Not more than 5% of the test results may fall below the 28 days specified strength. Making and curing of test specimens shall be in accordance with relevant IS:456, IS:516 and IS:1199.

All mixes can only be placed following approval by the Owner. The mean strength shall exceed the characteristic strength by a margin of 1.65 times the standards deviation expected from the batching plant. However, no standard deviation less than 3.5 N/mm^2 shall be used as a basis for designing a mix.

4.9.4 **Trial mixes and field tests**

Sufficient laboratory trial mixes shall be effected to show that concrete complies fully with the specified performance criteria. The following tests are to be included:-

a) Air content < 1%

b) Slump: Piles 170 $\pm$ 25 mm, regular work 80 $\pm$ 20 mm as per IS:1199.

c) Fresh and hardened concrete densities

d) Field trial mixes are to be carried out under full-scale site conditions as per IS:4925 (for structural concrete only).

e) Where directed by the Owner, concrete incorporating reinforcement details shall be cored to assess stratification of mixes. Cores of 150 x 200 mm (dia and length) are to be used.

f) Each trial mix shall have 9 x (150 x 150 mm) cubes taken to measure 24 hours/7 days and 28 day compressive strengths. These trials shall be run for three consecutive days (for structural concrete only).

g) At least 3 x sets of field trials shall be tested according to the provisions laid down in laboratory testing.

h) The average 28 day characteristic strength for trial mixes shall be higher by 10 N/mm^2 than that for cubes taken in the field. Failure to comply shall result in the mix having to be re-designed.

i) All test results will have to be complied before approval can be given.

4.9.5 **Consistency of concrete**

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Consistency of the concrete shall be checked by slump tests measured in accordance with IS-1199 and shall not exceed the values given in clause 7.1 of IS-456-2000.

4.9.6 **Mixing of concrete**

The cement and aggregate shall be thoroughly mixed in a batch-type pull mill mixer. The capacity of the mixer shall not be less than 1 (one) cubic meter and the total capacity of the batching mixing plant shall be such to accommodate the various concrete quantities to be cast in a continuous way and shall comply with the requirements of IS:456, IS:1791 and IS:12119.

The water shall not be added until all the aggregate and cement are in the drum. Mixing shall continue until the concrete is uniform in colour and for not less than 2 (two) minutes after all the materials and water are in the drum.

Partly set or excessively wet concrete shall not be used. No concrete shall be mixed by hand.

Concrete shall always be mixed in mechanical mixer unless specifically approved by the Owner 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 Owner. 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 Owner 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 Batchers 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 ± 2% of the quantity of Cement , water or total aggregates being measured and within ± 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 Owner. 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 Owner, 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.

4.9.7 **Laboratory**

The contractor shall establish and maintain a field laboratory on the site and this laboratory shall be available at all time to the Owner.

The laboratory must have qualified technicians to carry out all tests and must be adequately equipped to ensure that all necessary testing work can be carried out in compliance with the standards.

4.10 **Strength of Concrete**

4.10.1 **Testing of fresh concrete by means of test cubes**

All test cubes shall be made and tested for compressive strength in accordance with IS:456, IS:516 and IS:1199.

The minimum required strength for different classes of concrete is as shown in clause "General description and proportions and mixing" here-above.

The grade of concrete required will depend partly on the particular use and the characteristic strength needed to provide the structure with adequate ultimate strength and partly on the exposure conditions and the cover provided to any reinforcement.

A minimum of four test samples (of six test cubes each) shall be taken on each concreting day (from the same mix) and for at least each 40 m^3 of concrete mixed. At least one sample shall be taken for each shift.

For columns, beams and cantilevers seven (7) cubes for every 15 m^3 of concrete poured shall be taken. The concrete for test samples shall be taken directly from the concrete mixer and shall be handled (vibrated etc) under similar conditions to those prevailing during the construction. The moulds for the test cubes shall be made of steel. Tests shall be carried out in an approved laboratory.

The strength level of each type and each strength concrete will be evaluated separately and the concrete strength will be considered satisfactory if:

i) **Compressive strength**: The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:-

   a) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in col. 2 of Table 11 of IS:456.

   b) Any individual test result complies with the appropriate limits in col. 3 of Table 11 of IS:456.

ii) **Flexural strength**: When both the following conditions are met, the concrete complies with the specified flexural strength:-

a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.

b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2.

If the results are less than those specified, the Owner must suspend all concreting work and order further tests. Any concrete found not to comply with the specification shall be broken out and replaced to the satisfaction of the Owner.

The contractor shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

4.10.2 **Testing of concrete in structures**

The types of tests described hereinafter are applicable to the finished parts of the structures. They may be used in routine inspection and for quality control.

Type of tests:

a) Cutting cores: The procedure used shall comply with the requirements of IS:516 or an approved equivalent standard.

b) Gamma radiography: The testing shall be carried out in accordance with the requirement of IS:13311 Part 1 or equivalent.

c) Ultrasonic test: Such tests may be used to obtain approximate indications of the strength of the concrete in the structures (IS:13311 Part 1).

d) Electromagnetic cover measuring devices: Such tests may be used to verify the position of the reinforcement and shall be in accordance with the requirements of design (IS:13311 Part 1).

e) Rebound hammer test: Such tests may be used to obtain approximate indications of the strength of the concrete (Ref. IS:13311, Part 2).

f) Load tests of structures or parts of structures: If the results of the above mentioned check tests show that the quality of the materials is inadequate or if other defects are revealed, the Owner may require a loading test to be made.

For the purpose of testing floors, roofs and similar structures and their supports, the test load shall be equivalent to the sum of the characteristic dead load and one-and-a quarter times (1.25 times) the characteristic imposed load for a period of 24 hours which the works or part thereof to be tested have been designed.

Wherever certain procedures for testing of parts in structures (e.g. piles) are required by standards or codes of practice, these are to be followed. All tests must be conducted in the presence of the Owner.

If within 24 hours of removal of the imposed load, the structure does not recover at least 75% of the deflection under superimposed load, the test may be repeated after a lapse of 72 hours. If the recovery is less than 80%, the structure shall be deemed to be unacceptable.

If the result of the test is not satisfactory, the Owner shall instruct that the part of the works concerned be taken down or cut and reconstructed to comply with this specification. The contractor shall at his own cost take down or cut out and reconstruct the defective work.

The Owner may require other tests to be made. Number of samples, tests and types will be as per Owner requirements.

All the costs for the above mentioned tests shall be borne by the contractor.

4.11 Transport of Concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The concrete shall be transported in dumpers or trucks. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Owner.

The contractor shall obtain permission at least 24 hours in advance of any concrete pour.

4.12 Concreting Operations

4.12.1 Inspection prior to concreting

All concreting methods shall be subject to the approval of the Owner.

Concrete placing shall not be started until the Owner has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

4.12.2 Placing of concrete

Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

The contractor shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

The temperature of concrete shall not exceed 40°C measured at discharge into the works.

The maximum allowable temperature of any point within any cast element is 60°C. The maximum allowable temperature differential between any two points in the same element is 15°C. Additional temperature control measures during construction (such as the use of insulated formwork) will be required. Contractor to prepare a process control chart and method statement verifying measures to achieve these requirements.

Temperature monitoring of concrete work is required where:

a) the minimum dimension of any casting is 0.8 metres or more, or

b) where otherwise instructed by the Owner.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than 6 hours time shall be subject to the same treatment as the construction joints.

Concrete shall not be dropped into place from a height exceeding 1.5 metres. Trunking and chutes to Owner's approval shall be used for any concrete to be deposited from a height exceeding 1.5 m.

Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

4.12.3 **Compaction and mechanical vibration of concrete**

As concrete is being placed it shall be compacted by mechanical vibrators complying with IS:2505, IS:2506, IS:2514 & IS:4656, to obtain a dense material free from honeycombing, free from water and air holes.

The contractor shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation caused, but complete compaction of the concrete is achieved.

4.12.4 **Finish of concrete**

The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

4.12.5 **Construction, expansion and contraction joints**

4.12.5.1 Construction joints

The number of construction joints should be kept as low as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings. Alternatively, the location of joints should be subject to agreement between the Owner and the Contractor before any work commences. Construction joints should be at right angles to the general direction of the member and should take due account of shear and other stresses.

Concrete should not be allowed to run to a feather edge and vertical joints should be formed against a stop board.

The top surface of a layer of concrete should be level and reasonably flat unless design considerations make this undesirable. Joint lines should be so arranged that they coincide with features of the finished work.

If a kicker (i.e. a starter stub) is used it should be at least 70 mm high and carefully constructed. The kicker must be incorporated with the previous concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

The maximum horizontal length of wall to be poured in one operation in any one direction is 7.5 metres. A period of 7 days to be allowed between adjacent pours except where water stops are provided when this can be reduced with Owner's approval. Alternatively a gap of 600 mm wide shall be left between adjacent pours and filled after 7 days from the date of formation subject to Owner's approval.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast should be free from laitance and should be roughened to the extent that the largest aggregate is exposed but not disturbed. Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Particular care should be taken in the placing of the new concrete close to the joint. This concrete should be particularly well compacted and if possible a vibrator should be used.

Where the Owner considers that special preparation is necessary, i.e. for an in-situ structural connection, preparation should be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush, which is sufficient to remove the outer mortar skin and expose the larger aggregate. Where this treatment is impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking of hardened surfaces should be avoided.

A record shall be kept on site of the time and date of placing the concrete in each section of the work.

4.12.5.2 Expansion and contraction joints

The expansion joints, contraction joints and other permanent structure joints shall be provided in positions as shown in the drawings.
Joints shall be straight and vertical, except where other specified, and concrete surfaces on both sides of the joint shall be flush. Where necessary, waterstops of a type approved by the Owner shall be embedded in the concrete. The waterstop should be made of high quality material which must obtain its resilience through the service live of the structure for the double function of movement and sealing. The surface of waterstops should be carefully rounded to ensure tightness of the joint even under heavy water pressure. To ensure a good tightness with or without movement of the joints the waterstop should be provided with anchor parts. The cross-section of the waterstops should be determined in accordance with the presumed maximum water pressure and joint movements. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

All joints between structural steel and concrete parts shall be sealed by a suitable permanent flexible compound.

4.12.6 **Concreting at night**

When approval is given to carry out concreting operations (under control of the Owner) at night or in places where daylight is excluded, the contractor has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

4.12.7 **Concreting in high ambient temperature**

"IS:7861 (Part 1) – concreting in hot weather" shall apply.

The temperature of the mixed concrete at the time of placement shall not exceed 40°C. The contractor shall take special measures in the mixing, placing and curing of concrete. These measures shall include the shading of aggregates,

spraying of aggregates with water, cooling of the mix constituents (introduction of ice to the mixing water) and reduction of transportation time to the minimum. During placing suitable measures shall be provided to prevent premature setting of concrete placed in contact with hot surfaces. All concreting areas, formwork and reinforcement shall be shielded from the direct rays of the sun and sprayed with water when necessary.

4.12.8 **Protective measures for concrete**

In general, the cover of rebars shall be as per IS:456 taking into account the site conditions. However, the minimum concrete cover shall not be less than:

a)	Concrete parts above ground (external surface)	:	40 mm
b)	Concrete exposed to underground & groundwater	:	50 mm
c)	Slabs	:	20 mm
d)	Beams	:	25 mm
e)	Columns	:	40 mm

Immediately after the compaction of the concrete has been finished, the contractor shall ensure adequate protection from the weather. Excessive drying can lead to crack formation as a result of plastic contraction. The concrete surface shall be covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays kept constant moist for at least 7 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Owner. Where formwork cannot be removed within 24 hours after placing the concrete, the formwork shall be kept shaded from the direct rays of the sun and shall be sprayed with water.

Owner's approval to the use of a particular curing compound and to the method of application will only be given after the contractor has completed satisfactory site trials and a sample panel has stood for at least 28 days.

Where large sections of concrete are poured, special precautions to the approval of the Owner shall be taken to reduce and dissipate the heat generated by the setting and hardening of the concrete (e.g. built-in cooling water pipe system).

The minimum amount of reinforcement shall be present to prevent shrinking cracks.

No load of any kind, however light, shall be allowed on concrete which has not properly set and the contractor shall prevent any load to be imposed on the concrete structures until it has been declared by the Owner to be ready to carry loads.

4.12.9 **Concreting under-water**

Underwater concreting shall be done as per IS:456. Underwater concrete must comply with the following characteristics:-

a) The quantity of cement must be not less than 350 kg/m^3 when using aggregate mixes with a maximum particle size of 40 mm.

b) The water-cement ratio must not exceed 0.6.

c) Preferred aggregates are those with continuous grading curves lying approximately in the middle of the favourable range.

d) Slump shall be as per clause 7.1 of IS:456.

Underwater concrete is to be placed continuously without interruption. For water depths upto 1 m the concrete may be placed without tremie. In the case of water depths exceeding 1 m, the concrete is to be placed in such a way that it does not fall freely through the water. The tremies must at all times dip sufficiently far into the freshly placed concrete to ensure that the concrete emerging from the tremie does not come into contact with the water.

All work connected with the placing of concrete underwater shall be designed, directed and inspected with due regard to local circumstances and purposes. Work shall not proceed until all phases and methods to be used in the placing operations have been approved by the Owner.

4.13 **Concrete with Special Properties**

4.13.1 **General requirements**

The pre-condition for obtaining concrete with special properties is that it should be made with the appropriate composition, that it is placed in such a way that segregation does not occur and further that it is fully compacted and given appropriate curing.

4.13.2 **Waterproof concrete**

This concrete must meet the provisions of IS:3370. Waterproof concrete must be sufficiently dense (impermeable).

4.13.3 **Waterproofing and protection of underground concrete structures**

Water aggressive to concrete should be kept away from the fresh concrete.

Concrete which is exposed for a prolonged period to “very severe” chemical attack must be protected against direct access of the aggressive substances.

The protection, which is to be laid as protection to all concrete surfaces in contact with the ground, shall consist of an approved waterproofing membrane. The

membrane shall adhere to all concrete surfaces, including undersides of structures and other surfaces where concrete is cast in contact with the membrane.

Such membranes shall be PVC sheets of minimum 0.35 mm thickness with knobs of Maxlock supplied by Maxcorona Owners Pvt. Ltd., or equivalent.

The waterproof membranes shall be installed in strict accordance with manufacturer's instructions.

The membranes shall extend 15 cm above ground level.

When setting forms and reinforcing steel caution shall be exercised to avoid damage to the impervious membrane. The surface of the impervious membrane extending outside the forms shall be protected during subsequent operations.

Any puncture or damaged areas shall be cleaned and patched according to manufacturer's instructions.

4.13.4 **Concrete with high wearing resistance**

Concrete which is exposed to severe mechanical action, e.g., due to intensive traffic, sliding of bulk materials, frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids, or other causes, should possess high wearing resistance and correspond at least to grade 30.

The aggregate upto 4 mm size should consist predominantly of quartz or materials of at least equal hardness; the coarser particles should consist of stone or artificial materials possessing high abrasion resistance. In the case of particularly severe mechanical action, it will be necessary to use special hard materials. The particles of all types of aggregate should have a moderately rough surface and be of compact shape. The combined aggregate should be as coarsely graded as possible.

Furthermore, the concrete should be as stiff as possible, in order that there will be no concentration of cement slurry or water in the top layer. The concrete should be kept moist for at least 7 days after placing.

4.14 **Finishing of formed surfaces**

Fins and other surface projections shall be removed from all formed surfaces except exterior surfaces that shall be covered with earth backfill. Exterior surfaces that shall be exposed above grade and all interior surfaces, except those not usually exposed to view, shall be cleaned and rubbed. Rubbing shall produce a smooth, uniform surface free of marks, voids, surface glaze, and discolorations.

Rubbing shall be done by hand with a carborundum stone using only the mortar produced by the rubbing action and the application of water.

Projecting ends of all form ties shall be removed. The resulting recesses shall be cleaned, wetted, and filled with patching mortar. Patches on rubbed surfaces shall match the texture of the adjacent concrete.

4.15 Finishing of unformed surfaces

No surface treatment shall be required for buried or permanently submerged concrete. As a minimum, unformed surfaces shall be finished by screeding and floating. Surfaces requiring a trowelled finish shall be finished by screeding, floating, and trowelling.

Float finished and screeded surfaces shall be finished to provide a flat profile with-in a 6 mm deviation as measured from a 3 meter straightedge. Trowel finished surfaces shall be finished to form a flat plane. The surface profile shall not deviate more than 3 mm when measured from a 3 meter straightedge.

4.15.1 Screeding

Screeding shall provide a concrete surface conforming to the designated elevations and contours with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited to the tolerances specified.

4.15.2 Floating

The surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently to work. Coarse aggregate disturbed by the float or causing a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth float finish of uniform texture and color.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

4.15.3 Trowelling

The exposed portions of the tops of equipment bases, tops of interior curbs, and the surfaces of interior slabs not receiving a separate finish shall receive a steel trowel finish. Trowelling shall be performed after the second floating when the surface has hardened sufficiently to prevent excess cement from being drawn to the surface. Trowelling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

Surfaces to be covered with neoprene-hypalon coatings shall be lightly trowelled but not burnished.

4.15.4 **Brooming**

Brooming shall follow the float finish for exterior surfaces where a nonslip surface is required. Brooming shall be done with an acceptable steel or fiber broom not less than 450 mm wide. Brooming ridges shall be transverse to the normal traffic direction and shall be between 1.5 mm and 3 mm deep. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free of porous spots, irregularities, depressions, and small pockets or rough spots.

4.15.5 **Aggregate Exposure**

Surface mortar shall be removed and the aggregate exposed from surfaces that shall be covered with mortar, concrete, or grout at a later time.

4.15.6 **Edging**

Unless specified to be beveled, exposed edges of floated or troweled surfaces shall be edged with a tool having a 6 mm corner radius.

4.15.7 **Finishing mortar**

Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 102 kilograms of concrete sand to one bag of Portland cement, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 50 mm.

4.16 **Separate finishes**

Certain slab surfaces shall be finished with a separate concrete finish or floor covering.

Base slab surfaces shall be ground or filled until each surface is within the specified tolerances. Low areas shall be filled. High spots shall be ground slightly lower than required and then filled and smoothed to the proper elevation and surface.

Surfaces that receive epoxy set quarry tile and resilient tile shall be flat with a profile that shall not deviate more than 3 mm from a 3 meter straightedge placed on any part of the surface. These surfaces shall be either trowel finished concrete at the elevation indicated on the drawings or a float finished surface set 3 mm low and leveled with trowel finished fill material.

Surfaces that receive a mortar set quarry tile, ceramic tile, or terrazzo finish shall be given a smooth, tight, and uniform float finish with a profile tolerance of 6 mm as measured from a 3 meter straightedge.

4.17 Formwork

4.17.1 Design and construction

For stability and type of formwork and support framing used, IS:14687 is to be observed.

The formwork and the supporting structure are to be so dimensioned as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances specified in section 5.1.3(c) "Dimensional Tolerances".

The contractor shall submit in sufficient time in advance for the approval of the Owner the calculations, designs and details of the methods adopted and materials proposed for the formwork.

Particular attention must be paid to the formwork supports and braces to avoid any slip when the concrete is poured.

4.17.2 Materials for formwork

Forms shall be constructed from steel or from sound timber well seasoned and free from shakes. Plywood lining for forms shall be of timber which is resin-bonded and water repellent.

Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout. Connections shall be constructed to permit easy removal of the shuttering and shall be either nailed, screwed, bolted, or otherwise secured so as to be strong enough to retain the correct shape during consolidation of the concrete. Where a slope exceeds 1 V : 2 ½ H formwork shall be provided for the top of the concrete faces and anchored to prevent flotation.

The details of fair faced concrete facades have to be to the satisfaction of the Owner. The concrete surface for facades has to be absolutely stainless and all efforts have to be taken to achieve this.

4.17.3 Grading of formwork and of finished concrete surfaces

Quality of formwork, materials to be used and treatments of surface are graded according to the finish of the concrete surface as given in IS:14687.

The type and treatment of the formwork lining (plywood, metal, plastics, etc) should be appropriate to the grade of concrete finish required.

4.17.4 Preparation and inspection of formwork

Before concrete is placed, all formwork shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free from sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non-staining mineral oil) where applicable. Surfaces which are not oiled shall be wetted thoroughly to prevent warping.

4.17.5 Erection and placing of formwork

All formwork shall be erected and placed in accordance with the construction drawings approved by the Owner. Shuttering shall be true to line and braced and strutted to prevent deformation under weight and pressure of the wet concrete, live-loads, wind and other forces. The deflections shall not exceed 3mm.

The formwork for beams and slabs shall be erected so that the form on the sides of the beams and of the soffits of slabs can be removed without disturbing the beam soffit.

If the formwork for columns is erected to the full height of the columns, one side shall be provided with openings for concreting in order to guarantee a proper compaction of the poured concrete.

Formwork for walls and elsewhere shall be arranged for a maximum concreting height of 2.5 m in a single pour. Where necessary panel openings are to be provided in the forms for cleaning, inspection, access of vibrators, etc.

Before placing of concrete, bolts, ties and fixings shall be positioned and all devices used for forming openings, holes, pockets, chases, recesses, etc shall be fixed to the formwork carefully.

Panels shall be put together to ensure a perfect fit at the joint and fixed in both directions.

Where concrete surfaces will be exposed to view (permanently exposed surfaces) the formwork shall be such as to produce a completely true, smooth surface, free from perceptible irregularities or to show clearly the desired texture. Such formwork shall be marked on the drawings as “Fair-faced Formwork”.

Where concrete surfaces will be covered (non-exposed surfaces), the formwork shall be referred to and marked as “Sawn Formwork”.

Internal spacers and ties, if any, shall be so arranged that after removing of the forms no holes shall extend through the concrete, in the case of watertight concrete or to be closed by plastic plugs and epoxy mortar in all other cases.

All formwork will be inspected and approved by the Owner before concrete placing commences but this shall not relieve the contractor of any of his responsibilities under the contract.

4.17.6 **Striking of formwork**

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or designed loads likely to be applied with a normal factor of safety. It shall be removed in such a manner that no shock or injury shall result to the concrete.

Before removal of the formwork, the concrete shall be examined and removal shall proceed only on the instructions and under the supervision of a competent person.

In accordance with IS:456 clause 11.3.1, the striking period for cast in-situ concrete under certain conditions may be taken as follows:-

	TYPE OF FORMWORK	Minimum period before striking formwork
a)	Vertical formwork to columns, walls, beams	16 to 24 hours
b)	Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
c)	Soffit formwork to beams (props to be refixed immediately after removal of formwok)	7 days
d)	Props to slabs:	
	1) Spanning upto 4.5 m	7 days
	2) Spanning over 4.5 m	14 days
e)	Props to beams and arches:	
	1) Spanning upto 6 m	14 days
	2) Spanning over 6 m	21 days

Special care is necessary in the case of components which have to carry nearly the full calculated load as soon as the formwork is struck.

Columns, piers and walls are to be struck before the beams and slabs supported by them. Scaffolds, formwork supports and self-supporting floor formwork are to be carefully lowered by releasing the devices.

Extreme care shall be taken to avoid chipping of corners during removal of formwork.

To keep deflections through creep and shrinkage to a small amount, auxiliary supports should be left in place or immediately repositioned after striking.

4.18 Reinforcing Steel

4.18.1 General

Reinforcing steel used in reinforced concrete shall comply with the following standards:-

a) Deformed bars conforming to IS: 1786.

b) Fusion bonded epoxy coated bars conforming to IS: 13620 – 1993.

b) Mild steel conforming to IS: 432.

c) Mesh reinforcement conforming to IS: 1566.

In the event of presence of alkalinity or corrosive nature of soil, fusion bonded epoxy coated rebars shall be used for all foundations upto plinth level and in TG deck.

4.18.2 Binding wire

1) Plastic coated binding wires to be used for epoxy coated rebars.

2) Binding wire for general use shall be 1.6 mm dia galvanized annealed wire.

4.18.3 Reinforcement supports

Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing; supporting, and fastening the reinforcement.

Spacers shall be cast from concrete of the same quality as that in which they will be embedded.

Concrete block spacers shall be cast in metal moulds with an approved means of separating blocks and of ensuring that the blocks are of the proper size.

Coated binding wire shall be incorporated into the blocks to enable them to be securely attached to vertical or horizontal bars and the contractor shall demonstrate both that the blocks are of the requisite strength and that the means of attachment to the reinforcement are adequate.

4.18.4 **Certificates**

Each consignment of steel reinforcement shall be accompanied by a test certificate from the manufacturer showing that the steel has been tested and analysed and the date of such tests and analyses and that such tests and analyses comply in all respects with the standards. The following tests shall be carried out on reinforcement:-

a) Cast analysis

b) Carbon equivalent value

c) Tensile strength, yield stress, elongation

d) Bend test

e) Bond classification

f) Chemical analysis

4.18.5 **Epoxy coating of reinforcement**

Wherever epoxy coated reinforcement is used, reinforcing bars, fabric and special steel connections shall be protected against corrosion by means of an epoxy coating as per IS:13620.

At the same time, the contractor shall furnish written certification from the coating applicator that the coated reinforcement bars were cleaned, coated and tested in accordance with the requirements of this specification.

Coating materials shall be heat-cured epoxy resin powders applied by electrostatic spray process. The thickness of the coating shall be 250 μm.

Reinforcement bars which are to be coated shall be clean and free from rust, scale, oil, grease and similar contaminants. The surface shall be abrasive blasted to Swedish Standard SA3. As soon as possible after cleaning and before any visible oxidation to the surface occurs, the steel shall be coated with a fusion-bonded powder epoxy coating applied by electrostatic process.

4.18.6 **Stock of reinforcing steel**

In order to ensure due progress of the works, the contractor shall at all times maintain on the site a stock of reinforcing steel sufficient for the following month's work. No reinforcing steel shall be used upon the works until it has been accepted as satisfactory by the Owner.

4.18.7 **Rejection**

The Owner at his discretion may order random testing of the reinforcement steel and in the event of any failed test reject the entire lot notwithstanding the manufacturer's or coating applicator's certificates.

The contractor shall remove all rejected reinforcing steel from the site without delay at his own expense.

4.18.8 **Production handling of Epoxy coated bars**

Bars shall be handled and stored in a manner to prevent damage to the coating. Bars or coating damaged in handling or other operations shall be satisfactorily repaired at no additional cost to the Employer. All systems for handling the coated bars shall have padded contact areas wherever possible. All bundling bands shall be padded and all bundles shall be lifted with a strong-back or spreader bar will a minimum of three supports to the bundle. The bars or bundles shall not be dropped or dragged. Extra care in handling of these bars will be beneficial to the contractor in reducing or eliminating in place coating repairs.

4.18.9 **Storage**

All bars for reinforcement and steel fabric reinforcement shall be stored on the site under cover on timber or concrete supports suitably spaced and of sufficient height to keep the steel not less than 150 mm clear of the ground.

4.18.10 **Bar-bending schedules**

The contractor shall prepare bar bending schedules based on the detailed reinforcement drawings. These shall be presented to the Owner for approval. Approval of these schedules by the Owner in no way absolves the contractor from full responsibility for their completeness and correctness in every way nor shall any claim for extra cost or time be allowed on the grounds of such errors or discrepancies which may arise between drawings and schedules.

4.19 **Waterstops**

Water stops shall be PVC or equivalent and shall be eye-letted with a minimum 25 cm width. Type and manufacturer shall be submitted to the Owner's approval.

All intersection pieces shall be prefabricated by the manufacturer and only welding of butt-joints in running lengths will be allowed to be carried out on the site.

The site welding of butt-joints shall be executed by using the manufacturer's purpose-made electrically heated jig and work shall be done by a competent and trained personnel only. The manufacturer's instructions shall be carefully observed.

The wings of the waterstops shall be formed with corrugations or bulbs to achieve a good bond. Moreover, the waterstops shall conform to the following requirements:-

a) The tensile strength not less than 10 N/mm^2 when tested.

b) The ultimate elongation shall not be less than 22% when tested.

c) The tear resistance shall not be less than 2 N/mm^2 when tested.

d) The material shall not crack when tested.

e) Under accelerated elongation, the tensile strength shall not be less than 8 N/mm^2 and the ultimate elongation shall not be less than 200%.

The waterstops shall be installed so that they are securely held in position during the placing of concrete which shall be fully and properly compacted around the waterstops to prevent voids or porous areas. Adequate clearance between the reinforcement and all the waterstops shall be kept to permit proper compaction of concrete.

No holes or nailing shall be made through any waterstop for fixing purposes. Jointing by lapping two pieces of waterstops shall not be permitted.

The free edges of waterstops shall at all times be protected from direct sunlight.

4.20 Curing

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed.

Trowelled surfaces, except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane curing compound or with water. Only water curing shall be used if the surface receives a separate finish.

4.20.1 Water curing

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Water curing shall begin within 12 hours in dry weather and within 24 hours in damp weather. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water may be interrupted for surface rubbing. The concrete surface shall not be permitted to dry.

After the rubbing has been completed, rubbed surfaces shall be covered with burlap and kept saturated for the remainder of the curing period.

4.20.2 **Membrane curing**

Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible after finishing without causing damage to the surface. Membrane curing compound shall be spray applied at a coverage of not more than 7.4 square meters per liter. Membrane curing shall not be used on surfaces that shall be covered at a later date with mortar, concrete, damp--proofing, tile, or any coating. Membrane curing shall not be used on cast-in-place concrete bases for field erected tanks.

4.21 **Floor Sealer**

All concrete floors shall be given two coats of clear floor sealer in addition to that applied as membrane curing compound. The first coat shall be applied at the end of the curing period before any traffic is permitted on the floor. The second coat shall be applied after the floor has been cleaned in preparation for the final inspection. Floor sealer shall be applied in strict accordance with the manufacturer's recommendations.

4.22 **Repairing of Damaged or Defective Concrete**

Concrete which has completed its final setting shall be inspected by the Owner and any cracks, honeycomb areas, segregations, etc shall be marked. No repairs shall be carried out until direction by the Owner.

Surface defects in formed concrete shall be repaired to the satisfaction of the Construction Manager within 24 hours. Concrete that is porous, honeycombed, or otherwise defective to a depth in excess of 25 mm shall be cut out and removed to sound concrete. Edges shall be square cut to avoid feathering. Cut surfaces shall be coated with epoxy bonding compound before the concrete is placed.

Defective concrete shall be replaced within 48 hours after the forms have been removed.

Concrete repair work shall not interfere with the curing of surrounding concrete. Mortar and concrete used in repair work shall be adequately cured and shall be finished to match adjacent surfaces.

4.23 **Waterproofing**

A waterproofing seal shall be provided for all below grade structures where applicable by external tanking with PVC sheets of 1.0 mm thickness with knobs for membrane type water-proofing. In addition, joints in deep underground structures shall be provided with structural water-proofing.

4.24 Damp Proofing

Damp-proof course 40 mm thick, consisting of cement concrete 1:2:4, with admixture of approved water-proofing compound shall be laid at plinth level for walls of all buildings for protection of super-structure against moisture and dampness.

4.25 Standard Grouting

4.25.1 Ordinary grout shall be provided for miscellaneous structure base plates viz. operating platforms (not supporting equipment), pipe supports upto 2.5 m height (above concrete top), cross-over, staircases and ladders.

The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. Based on requirement for obtaining non-shrink grout, aluminium powder may be used as an admixture. The grout proportions shall be limited as follows:-

	Use	Grout thickness	Mix proportions	W/C ratio
a)	Fluid mix	Under 25 mm	One part Portland cement to one part of sand	0.44
b)	General	25 mm and over but less than 50mm	One part Portland cement to 2 parts of sand	0.53

4.25.2 a) Sand shall be such as to produce a flowable grout without any tendency to segregate.

b) Sand for general grouting purposes shall be graded within the following limits:-

i) Passing IS 2.36 mm sieve : 95 to 100%

ii) Passing IS 1.18 mm sieve : 65 to 95%

iii) Passing IS 300 micron sieve : 10 to 30%

iv) Passing IS 150 micron sieve : 3 to 10%

c) Sand for fluid grouts shall have the fine material passing the 300 and 150 micron sieves at the upper limits specified above.

4.25.3 a) Surfaces to be grouted shall be thoroughly roughened and cleaned of all foreign matter and laitance.

b) Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material. The use of hot, strong caustic solution for this purpose will be permitted.

4.25.4 a) Prior to grouting, the hardened concrete surfaces to be grouted shall be saturated with water.

b) Water in anchor bolt holes shall be removed before grouting is started.

4.25.5 Forms around base plates shall be reasonably tight to prevent leakage of the grout.

4.25.6 Adequate clearance shall be provided between forms and base plate to permit grout to be worked properly into place.

4.25.7 Grouting, once started, shall be done quickly and continuously to prevent segregation, bleeding and breakdown of initial set. Grout shall be worked from one side of one end to the other to prevent entrapment of air. To distribute the grout and to ensure more complete contact between base plate and foundation and to help release entrapped air link chains can be used to work the grout into place.

4.25.8 Grouting through holes in base plates shall be by pressure grouting.

4.26 **Special Non-Shrinking Grout**

4.26.1 Special grout, where specified on the drawings, shall be provided in strict accordance with the manufacturer's instructions/specifications. Pre-mixed Grout Conbextra GP-2 of 'FOSROC' make or equivalent of crushing strength 650 kg/cm^2 for major equipment foundations and Conbextra GP-1 having crushing strength of 450 kg/cm^2 for other foundations where concrete grade M25 or higher is provided.

4.26.2 Forms and shims used to obtain adequate clearance shall not be removed and the anchor bolts shall not be tightened for at least three days after placing the grout. After the removal of forms and shims, area occupied by shims shall be filled and the area between the base and edge of the foundation shall be finished smooth to allow drainage away from the base. Attachment of interconnecting piping of machinery and complete load transfer of machinery shall not be done before the bolts are tightened. During this period, grouting work shall be properly cured using rags/gunny bags.

4.26.3 In view of extremely small proportion (about 0.01% by weight of cement) of the aluminium powder required, it is necessary to take all precautions to ensure

thorough mixing. It is advisable to mix the blend of aluminium powder thoroughly with sand and cement before water is added because aluminium powder has a tendency to float on water.

4.26.4 Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed in the proportion of 1:1:1 (1 cement: 1 admixture: 1 sand), or as per manufacturer's instructions.

4.26.5 Pre-mixed non-shrinking grout shall be used all as per manufacturer's instructions and without any additional materials/admixtures such as cement, sand and aggregates etc.

5 STRUCTURAL STEEL WORK

PART I FABRICATION OF STRUCTURAL STEEL WORK

5.01.00 SCOPE

This specification covers supply and/or taking delivery of raw steel materials from owner's stores, 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.

5.02.00 GENERAL

5.02.01 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) Prepare and submit monthly materials reconciliation statement showing effective utilization of raw steel materials as received from Owner's stores.

e) Furnish quarterly and monthly requirement of matching steel sections for maintaining required progress of fabrication in accordance with the approved programme and take delivery of all raw steel materials from Owner's stores or supply of such matching steel sections in case the same are not supplied by the owner.

f) 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).

g) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.

h) Suitably mark, bundle and pack for transport all fabricated materials.

i) 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.

j) Insure, load and transport all fabricated steelwork field connection materials to site.

k) Furnish necessary test certificates of all raw steel material supplied by the Contractor.

5.02.02 **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.

5.02.03 **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:-

LIST OF IS CODES - RELEVANT TO FABRICATION OF STRUCTURAL STEEL WORK

IS Codes		Description
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 fushion welded butt joints in steel plates.
IS:1200	-	Method of measurement of steel work and iron (Part - 8) work.
IS:1239	-	Mild steel tubes, tubular and other wrought (Part - 1&2) steel fittings

IS:1363 - Hexagon head bolts, screws and nuts of product (Part - 1 to 3) grade C.

IS:1364 - Hexagon head bolts, screws and nuts of product (Part - 1 to 5) grade A & B.

IS:1365 - Slotted counter sunk head screws (dia. 1.6 to 20 mm)

IS:1367 - Technical supply conditions for threaded steel (Part - 1 to 18) 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 galvanizing 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 - Code of practice for protection of iron and (Part - I to III) 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 - Code of practice for painting of ferrons metal (Part - I & II) 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.

5.02.04 **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.

5.02.05 **Materials to be used**

a) **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 ampereage (Polarity in case of D.C. supply) for which the electrodes are suitable.

b) **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 : -

1) IS : 801 - Cold formed light gauge steel structural member.

2) IS : 806 - Steel tubes in general building construction.

3) IS : 1161 - Steel tubes for structural purpose.

4) IS : 1977 - Structural steel (Ordinary quality) St-42-0

5) IS : 2062 - Steel for general structural purpose

6) IS : 8500 - Structural steel-microalloyed (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.

c) **Electrodes**

All electrodes to be used under the Contract shall comply with any of the following Indian Standard Specifications as may be applicable : -

1) IS : 814 - Covered electrodes for metal arc welding structural steel

2) IS : 815 - Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.

3) IS : 7280 - Base wire electrode for submerged arc welding.

d) **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/mm2 and a minimum elongation of 23 per cent on a gauge length of 5.6 √A, where 'A' is the cross sectional area of the test specimen : -

1) IS:1367 - Technical supply conditions for threaded fastners.

2) 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.

e) **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 : -

1) IS : 1977 - Structural steel (Ordinary Quality) St-42-0

2) IS : 2062 - Steel for general structural purpose

3) IS : 8500 - Structural steel – microalloyed (medium & high strength quality)

4) IS : 6623 - High Strength Structural Nuts

5) IS : 6649 - Hardened and tampered washers for high strength structural bolts & nuts.

f) **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 rasin based zinc rich primer (such as blast steel EZ1 of Shalimer Paints Ltd., or equivalent) may be necessary.

5.02.06 **STORAGE OF MATERIAL**

a) **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.

b) **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.

c) **Electrodes**

The electrodes for electric are 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.

d) **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.

e) **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.

5.02.07 **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 Washers checks,	:	Manufacturer's certificate, dimension 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.

5.02.08 **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.

5.02.09 **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 centerline 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.

5.03.00 WORKMANSHIP

5.03.01 Fabrication

a) **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.

b) **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.

c) **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 gauges 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.

d) **Planing of edges**

Planing 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.

e) **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.

5.03.02 **Bolted construction**

a) **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 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm 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.

b) **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 either twisted not 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.

5.03.03 **Welded Construction**

a) **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.

b) **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.

c) **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.

d) **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.

e) **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.

f) **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 hand warm. 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.

g) **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.

h) **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.

5.03.04 **Finish**

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-butted over the whole section with a clearance not exceeding 0.2 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 2.0 mm.

5.03.05 **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.

5.03.06 **Lacing bars**

The ends of lacing bars shall be neat and free from burrs.

5.03.07 **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.

5.03.08 **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.

5.03.09 **Architectural Clearances**

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

5.03.10 **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.

5.03.11 **Castings**

Steel castings shall be annealed

5.03.12 **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.

5.03.13 **Shop painting**

a) **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.

b) **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.

c) **Contact surfaces**

Contact surface shall be cleaned in accordance with Sub-clause 3.13.01 before assembly.

d) **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.

e) **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.

5.03.14 **Galvanizing**

a) **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.

b) **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.

c) **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.

5.04.00 INSPECTION, TESTING, ACCEPTANCE CRITERIA AND DELIVERY

5.04.01 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.

5.04.02 **Testing and Acceptance Criteria**

a) **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.

b) **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.

c) **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.

(1) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.

(2) 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.

d) **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.

e) **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.

f) **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.

g) **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.

5.04.03 **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.

5.04.04 **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.

5.04.05 **Delivery of materials**

a) **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.

b) **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.

c) **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.

5.05.00 INFORMATION TO BE SUBMITTED

5.05.01 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.

5.05.02 **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) List of phase wise requirement of matching steel section in six (6) copies in accordance with the approved schedule shall be submitted within 2 (two) weeks after the award of the contract, and/or receipt of the design drawings.

c) 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 up-to-date status of preparation of detailed shop drawings, bill of materials, procurement of materials, actual fabrication done, shipping and all other relevant information.

d) Detailed monthly material reconciliation statements relevant to the work done and reported in the Progress Report, giving the stock at hand of raw steel, work in progress, finished materials and scrap.

e) Results of any test as and when conducted and as required by the Engineer.

f) Manufacturer's mill test report in respect of steel materials, bolts, nuts and electrodes as may be applicable.

PART II ERECTION OF STRUCTURAL STEEL WORK

5.01.00 **SCOPE**

This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at Site, and/or from Owner's Site Stores or store Yard, installing the same in position, painting and grouting the stanchion bases all complete as per Drawings, this Specification and other provision of the Contract.

5.02.00 **GENERAL**

5.02.01 **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, leveling, 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.

5.02.02 **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.

5.02.03 **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

5.02.04 **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.

5.02.05 **Material**

a) **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 the 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 2.01.00 and as specified herein before.

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.

b) **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.

5.02.06 **Storage of materials**

a) **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.

b) **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.

c) **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.

5.02.07 **Quality control**

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:

a)	Erection	:	Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.
b)	Grouting	:	Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, Consistency and strength of grout.
c)	Painting	:	Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

5.02.08 **Taking Delivery**

The erection Contractor shall take delivery of fabricated structural steel and necessary connection materials supplied by the fabrication Contractor from railhead, trucks and/or the Owner's stores at site 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.

5.03.00 WORKMANSHIP

5.03.01 Erection

a) **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.

b) **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.

c) **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.

d) **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.

e) **Setting out**

Positioning and leveling 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.

f) **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.

i) **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

Bolts length not exceeding 8xdia. or 200 mm	**Bolt length exceeding 8xdia. or 200 mm**	**Remarks**
1/2 turn	2/3 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.

ii) **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

Nominal Bolt Diameter (mm)	Torque to be applied (Kg.M) for bolt class 8.8 of IS : 1367
20	59.94
22	81.63
24	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.

g) **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.

h) **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.

5.03.02 **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.

5.03.03 **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 cementious 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, leveled 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 leveled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall be thoroughly cleaned.

5.03.04 **Painting after erection**

Field painting, if required to be done by the erection Contractor, shall only be done after the structure is erected, leveled, 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.

5.03.05 **Stainless Steel Plate Lining in Bunker Hopper**

The hopper portion of the coal bunkers shall be lined with stainless steel plates of 3 to 6 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.

5.03.06 **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.

5.03.07 **Safety Measures during Erection**

The safety measures to workmen and supervisors during all types of erection work (e.g., use of lifting appliances, slingning, 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.

5.04.00 **TESTING AND ACCEPTANCE CRITERIA**

5.04.01 **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.

a) **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.

b) **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.

c) **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.

d) **Repair for subsequent test and use after strength tests**

An actual structure which has passed the "Strength Test" as specified in Sub-clause 4.01.02 herein before 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 4.01.01. herein before.

5.04.02 **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) Shifting of column axis at foundation level with respect to building line		
		i) In longitudinal direction	i) ± 3.0 mm
Component	**Description**		**Variation Allowed**
		ii) In lateral direction	ii) ± 3.0 mm
	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) ± 3.5 mm from true vertical
		ii) For a column greater than 10M but less than 40M height any 10M	ii) ± 3.5 mm from true vertical for length measured

			between connection levels, but not more than ± 7.0 mm per 30 m length
	c)	For adjacent pairs of columns across the width of the building prior to placing of truss.	± 9 mm on true span.
	d)	For any individual column deviation of any bearing or resting level from levels shown on drawings.	± 3.0 mm
	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.	3 mm
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 10 mm whichever is the least
Component	**Description**		**Variation Allowed**
	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 20 mm whichever is the least
Crane Girders & Tracks	a)	Difference in levels of crane rail measured between adjacent columns.	2.0 mm
	b)	Deviation to crane rail gauge	± 3.0 mm
	c)	Relative shifting of ends of adjacent crane rail in plan and elevation after thermit welding.	1.0 mm

	d) Deviation of crane rail axis from centre line of Web.	± 3.5 mm
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 Deg. C per unit length.	

II. **For Building without Cranes**

The maximum tolerances for line and level of the steel work shall be ± 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.

5.04.03 **Acceptance**

Structures and members which have passed the tests and conform to all requirements specified in the foregoing Sub-clause 4.01.00, 4.01.01, 4.01.02, 4.01.03 and 4.01.04 and other applicable provisions of this Specification and are within the limits of tolerances specified in Sub-clause 4.02.00 and/or otherwise approved by the Engineer shall be treated as approved and accepted for the purpose of fulfilment of the provisions of this Contract.

5.05.00 **INFORMATION TO BE SUBMITTED**

5.05.01 **Before Tender**

Along with the Tenders the Tenderers will be required to submit the following information :

a) **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.

b) **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.

c) **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.

5.05.02 **After award of the Contract**

After award of the contract, the Contractor shall submit the following:

a) **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.

b) **Weekly Progress Report**

The Contractor shall submit weekly 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 5.02.01 above. Any shortfall in the achievement in a particular week must be made up within the next week. Along with this report, the Contractor shall also furnish details of fabricated materials in hand at site and the strength of his workers.

6 CHIMNEY

6.1.0.0 SCOPE

This specification covers plain and reinforced cement concrete work, lining and insulation work, miscellaneous steel and metal work, painting and protective treatment work, lightning protection system and aviation obstruction lighting system, connected with construction of RCC Chimney.

6.2.0.0 GENERAL

6.2.1.0 Work to be provided for by the Contractor

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

a) Furnish all labour, supervision, services, insurance, material, power, fuel, forms, templates, supports, scaffolding, tools, plants, construction equipment, approaches, transportation etc. required for the entire work.

b) Design and prepare working drawings for formworks, scaffoldings, supports, staging etc. and submit them for approval.

c) Prepare and submit for approval, as per approved schedule, detailed drawings for R.C. work in shell, hopper, platforms and ground floor and bending schedules for reinforcement bars, showing the positions and details of spacers, chairs, supports, hangers, openings etc.

d) Prepare detailed fabrication and erection marking drawings for steel and metal works and submit them for approval.

e) Prepare detailed shop drawings for various inserts, anchors, sleeves, frames, templates, anchor bolts etc. showing relative locations of their installations and submit them for approval.

f) Prepare and submit for approval the detailed schemes for operations like material handling, placement of concrete etc. and for items like approaches, services etc.

g) Design and submit for approval the mix proportions for concrete to be adopted on job.

h) Furnish samples and submit for approval the results of tests for various properties of the following materials: -

(i) Ingredients of concrete
(ii) Concrete

(iii) Metal work components
(iv) Acid proof bricks
(v) Fire bricks
(vi) Castable refractories
(vii) Insulation material
(viii) Paints
(ix) Electrical Items.

i) Provide all incidental items not specified or shown on drawings in particular but reasonably implied or necessary for successful completion of the work in accordance with drawings and specifications.

j) Produce, if directed by the Owner, a guarantee, in approved proforma, for satisfactory performance, for a specified period, of material manufactured by specialist firms.

6.2.2.0 **Work by others**

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

6.2.3.0 **Codes and Standards**

All works under this Specification, unless specified otherwise, shall conform to the latest revisions/replacements of the following Indian Standard Codes, Criteria, Specifications, along with those mentioned therein. In case any particular aspect of work is not covered by Indian Standards, other standard specification, as may be specified by the Owner, shall be followed. 'IS Specification' shall mean Codes, Criteria etc. of ISI :

IS:6 Moderate heat duty fire clay refractories, Group-A.

IS:104 Ready mixed paint, brushing, zinc chrome, priming.

IS:158 Ready mixed paint, brushing, bituminous, black, lead- free, acid, alkali, water and heat resisting for general purposes.

IS:269 Ordinary, and low heat Portland cement.

IS:383 Coarse and fine aggregates from natural sources for concrete.

IS:432 Mild steel and medium tensile steel bars.

IS:456 Code of practice for plain and reinforced concrete.

IS:516 Methods of test for strength of concrete.

IS:732 Code of practice for electrical wiring installations (System voltage not exceeding 650 Volts).

IS:800 Code of practice for general construction in steel.

IS:808 Rolled steel beam, channel & angle sections.

IS:813 Scheme of symbols for welding.

IS:814 Covered electrodes for metal arc welding of structural 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 and testing of metal arc welders.

IS:818 Code of practice for safety and health requirements in electric and gas welding and cutting operations.

IS:822 Code of procedure for inspection of welds.

IS:9595 Recommendation for Metal Arc Welding of Carbon and Carbon Manganese steels.

IS:1139 Hot rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcements.

IS:1161 Steel tubes for structural purposes.

IS:1199 Methods of sampling and analysis of concrete.

IS:1200 Methods of measurement of building works.

IS:1239 (Part-I) Mild steel tubes.

IS:1367 Technical supply conditions for threaded fasteners.

IS:1526 Sizes and shapes for firebricks (230 mm. series).

IS:1566 Hard-drawn steel wire fabric for concrete reinforcement.

IS:1608 Methods for tensile testing of steel products.

IS:1730 Dimensions for steel plate, sheet and strip for structural and general engineering purposes.

IS:1731 Dimensions for steel flats for structural and general engineering purposes.

IS:1786 Cold-twisted steel bars for concrete reinforcement.

IS:1791 Batch type concrete mixers.

IS:1977 Structural steel (ordinary quality).

IS:2062 Steel for general structural purposes

IS:2074 Ready mixed paint, red oxide - zinc chrome priming.

IS:2309 Code of practice for the protection of buildings and allied structures against lightning.

IS:2386 Methods of test for aggregates for concrete. (Part-I) Particle size and shape.

IS:2386 Estimation of deleterious materials and organic (Part-II) impurities.

IS:2386 Specific gravity, density, voids, absorption and (Part-III) bulking.

IS:2386 Mechanical properties. (Part-IV)

IS:2386 Soundness. (Part-V)

IS:2386 Measuring mortar making properties of fine aggregate. (Part-VI)

IS:2386 Alkali aggregate reactivity. (Part-VII)

IS:2386 Petrographic examination. (Part-VIII)

IS:2502 Code of practice for bending and fixing of bars for concrete reinforcement.

IS:2505 Concrete vibrators, immersion type.

IS:2506 Screed board concrete vibrators.

IS:2633 Methods of testing uniformity of coating on zinc coated articles.

IS:2722 Portable swing weigh batchers for concrete (single and double bucket type).

IS:2750 Steel scaffoldings.

IS:2751 Code of practice for welding of mild steel bars used for reinforced concrete construction.

IS:3025 Methods of sampling and test (Physical and Chemical) for water used in industry.

IS:3346 Method for the determination of thermal conductivity of thermal insulation materials (two slab, guarded hot- plate method).

IS:3495 Method of test for clay building bricks. (Part-I to IV)

IS:3550 Methods of test for routine control for water used in industry.

IS:3558 Code of practice for use of immersion vibrators for consolidating concrete.

IS:3677 Unbonded rock and slag wool for thermal insulation.

IS:4014 Code of practice for steel tubular scaffolding. (Part-I&II)

IS:4031 Method of physical tests for hydraulic cement.

IS:4634 Method for testing performance of batch-type concrete mixers.
IS:4687 Gland packing asbestos.

IS:4860 Acid-resistant bricks.

IS:4990 Plywood for concrete shuttering work.

IS:4998 Criteria for design of reinforced concrete chimneys. (Part-I)

IS:5410 Cement paint, colour as required.

IS:5445 Long fluted machine reamers with Morse taper shanks.

IS:5495 Sizes and shapes for firebrick (300 mm. and higher series).

IS:8112 High strength ordinary Portland cement.

CP326 British Standard - Protection of structures against lightning.

NEPA 78 Code of protection against lightning.

Draft Code of Practice for the protection of buildings against lightning - 1954 of Institution of Owners (India).

The Indian Electricity Rules.

The requirements of Department of Civil Aviation, Govt. of India.

6.2.4.0 **Conformity with drawings and specifications**

The Contractor shall carry out all the work in strict accordance with approved drawings and specification issued to him and as per Contractor's detailed drawings approved by the Consulting Owner. Prior to concreting, the Contractor

shall prepare a check list on a set format of all items of work involved, and inform the Owner well in advance so that the Owner shall have the opportunity of satisfying himself if the works mentioned in the format are done according to drawings and specification, and he can allow the Contractor in writing to start pouring of concrete. The entire operation of concreting shall be carried on as per specification, to the complete satisfaction of the Owner. No deviation from the drawings will be allowed unless otherwise directed by the Owner in writing.

For steelwork and metal work, the Contractor shall design all connections, inserts for scaffolding, supply and fabricate all steelwork and metal work and furnish all connection materials in accordance with approved shop drawings prepared by him and/or as instructed by the Owner, keeping in view the maximum utilisation of the available sizes and shapes for metal components.

6.2.5.0 **Materials to be used**

6.2.5.1 **General Requirement**

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

6.2.5.2 **Cement**

Refer concrete works.

6.2.5.3 **Coarse Aggregate**

Refer concrete works

6.2.5.4 **Fine Aggregate**

Refer concrete works

6.2.5.5 **Water**

Refer concrete works

6.2.5.6 **Reinforcement**

Refer concrete works

6.2.5.7 **Structural Steel**

All steel materials to be used in construction of Chimney ladder, hand rails, flue opening frame, access door frame, door shutters etc. shall comply with IS:2062, IS:1239, IS:1367, IS:1608 & with other relevant IS Specifications.

6.2.5.8 **Paints**

Paints to be used for shop coat of fabricated steel shall conform to the IS:2074. Paint for treatment of outside face of Chimney with Cement water proof paint shall conform to IS:5410.

6.2.5.9 **Fire Bricks, Acid Resistant Bricks and Castable Refractories**

Fire Bricks for the internal lining of the shell shall conform to IS:6-1967 Group-A and IS:5445. Acid resistant bricks for internal lining of shell and hopper shall conform to IS:4860. Castable refractories shall be of hydraulic setting, rapid hardening type. It shall have refractory properties similar to Fire bricks conforming to IS:6, Group-A and working temperature shall be upto 1350^{o}C.

6.2.6.0 **Storage of Materials**

6.2.6.1 **General**

Refer concrete works

6.2.6.2 **Cement**

Refer concrete works

6.2.6.3 **Aggregate**

Refer concrete works

6.2.6.4 **Reinforcement**

Refer concrete works

6.2.6.5 **Steel, Metal and Fittings**

All steel, metal and fittings to be used for fabrication and erection shall be stored section wise and lengthwise in separate stacks, off ground, so that they can be handled, inspected, measured and accounted for easily at any time. If required by the Owner, the materials may have to be stored in a covered shed.

6.2.6.6 **Paints**

Paints shall be stored under cover, in air-tight containers. Paints supplied in sealed containers shall be used as soon as possible once the container is opened. Left over paints shall be kept in air-tight containers.

6.2.6.7 **Bricks**

Bricks shall be stored in systematic stacks for ease of handling and counting. While unloading the bricks from trucks, they shall be stacked right away and shall not be dumped in a heap.

6.2.6.8 **Insulation Material**

All insulation materials like glass or mineral wool, asbestos ropes etc. shall be stored in packing boxes, under covered shed, avoiding their coming in contact with objectionable matter.

6.2.6.9 **Electrical Items**

All electrical items shall be stored properly under covered water- tight shed so that they do not come in contact with moisture or cement dust.

6.2.7.0 **Quality Control**

Contractor shall establish and maintain quality control for different items or work and materials as may be directed by the Owner to assure compliance with contract requirement and submit to the Owner records of the same. The Contractor shall submit all records and test results in original to the Owner for his approval, if so desired by him.

The quality control operation shall include but shall not be limited to the following items of work :

a)	Cement	:	Test to satisfy relevant IS Specifications if supplied by the Contractor.
b)	Aggregate	:	Physical, Chemical and Mineralogical qualities, grading, moisture contents and impurities.
c)	Water	:	Impurities Test.
d)	Reinforcement	:	Material tests or certificates to satisfy relevant IS Specification if supplied by the Contractor
e)	Structural Steel	:	Material tests or certificate to satisfy relevant IS Specification if supplied by the Contractor.
f)	Bricks	:	Compressive strength, water absorption, efflorescence, warpage.

6.3.0.0 **EXECUTION**

6.3.1.0 **Concrete**

6.3.1.1 **Trial Mix, Grades of Concrete**

Refer concrete works.

6.3.1.2 **Batching of concrete**

Refer concrete works.

6.3.1.3 **Mixing of Concrete**

Refer concrete works.

6.3.1.4 **Workability of Concrete**

Refer concrete works.

6.3.1.5 **Placing and Compaction of Concrete**

Refer concrete works.

6.3.1.6 **Curing of Concrete**

Refer concrete works.

6.3.1.7 **Construction Joints**

Refer concrete works.

6.3.1.8 **Ordinary Concrete**

Ordinary concrete like lean concrete shall be of nominal mix as per relevant clauses of IS:456.

6.3.2.0 **Reinforcement**

6.3.2.1 **Bending of Reinforcement**

Refer concrete works.

6.3.2.2 **Placing**

Refer concrete works.

6.3.2.3 **Fixing of Reinforcement**

Refer concrete works.

6.3.3.0 **Forms**

6.3.3.1 **Design and Material of formwork**

The shuttering for the chimney shell shall be either steel formwork or steel framed plywood formwork of adequate thickness, proper surface texture and with requisite supports and battens to produce a shell surface which will be even, smooth and of uniform curvature and batter as per Drawing and free from all blemishes.

The Contractor shall be responsible for designing the formwork, alongwith its supports etc. Contractor shall obtain the approval of the Owner for the design of forms, before assembling them. Approval of the Owner does not relieve the Contractor of his responsibility to ensure the soundness of formwork.

6.3.3.2 **Installation of Formwork**

All formwork shall be set to plumb and to line and level, or curvature or batter as per drawing. All shutters shall be adequately supported, to the satisfaction of the Owner, to prevent deflection under dead weight of concrete, imposed load of workmen, materials and plant and to withstand vibration.

No joint in any props shall be allowed. The joints in formwork shall be watertight. Surface of formwork shall be oiled with approved quality mould oil which shall not stain the surface of the shell.

6.3.3.3 **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.

a) Out of plumb between two consecutive lifts : 3 mm.

b) Errors in level : 3 mm.

c) Errors in sectional dimensions : 5 mm.

d) Out of plumb in general : 1 in 1000 of height subject to a maximum of 200 mm.

However, the Contractor shall aim at improving upon this figure. Should the limitations exceed, the Contractor shall, if directed by the Owner, demolish that portion of work and recast at his own cost, to the complete satisfaction of the Owner. No tolerance shall be allowed between the two consecutive plates of the formwork either radially or vertically placed.

6.3.3.4 **Stripping of formwork**

Unless otherwise permitted in writing by the Owner, the minimum period of keeping formwork in position after the completion of pouring of concrete shall conform to relevant clause of IS:456. For the chimney shell the stripping time shall be 48 hours minimum.

Formwork shall be so arranged as to permit removal without jarring or damaging the concrete. Immediately after stripping of formwork, the Owner shall be informed by the Contractor. The Contractor shall ensure that the site is cleared of stripped shuttering nails or any other material which might hinder the inspection, so that the Owner can inspect the concrete surface.

6.3.3.5 **Re-use of formwork**

Before re-use, all forms shall be thoroughly scraped, cleaned, examined, repaired, and treated with mould oil as specified herein before. Formwork, declared unfit or unserviceable, by the Owner, shall not be used or reused.

6.3.3.6 **Construction by slip-form Method**

Slip-form construction will be encouraged if proposed by the Tenderer. Type of Slip-form proposed should be indicated in the offer with sketches, drawings and construction statement as explained hereinafter. Number, type and capacities of jacks, the control system and achievable rate of progress in mm/hour should also be indicated. The chosen scheme shall be of a past proven design. A certified performance record of the scheme should be submitted with the offer to guarantee workability of the scheme both from execution time and safety point of view.

The Tenderer should furnish a brief but comprehensive statement indicating the planning & programme and method of work to be followed, for the approval of Owner at the time of submitting Tender. This statement shall include the following items :

I) Type and description of Slip-form equipment and its accessories.

ii) Design of scaffolding and staging.

iii) Description of materials including admixtures to be used for construction.

iv) Manpower planning, construction spaces required, standby arrangement.

v) Rate of Slip-forming.

vi) Proposed workability requirement of concrete and type of cement & admixture to be used.

vii) Quality assurance programme.

viii) Method of Transportation of material

ix) Method of curing and rectification of defects.

x) Planned interruption, if proposed and activities during planned interruption. Treatment of construction joint.

xi) Contingency solution for unplanned interruptions.

xii) Time of completion.

While selecting the Contractor, due consideration will be given to the merit of the above mentioned statement proposed by the Tenderer and minimum time of completion, apart from his past experience in such types of work as also technical and financial resources of the Tenderer.

Not withstanding what have been specified in earlier clauses, following guide lines are being presented which should be kept in view by intending Tenderer, while quoting for Slip-form method of construction:

1. Care to be taken to prevent dragging of concrete alongwith upward movement of the shuttering. For this purpose following steps are advisable:

   a) Shutter plates have to be smooth and should be thoroughly clean. Before fixing them in position all the surfaces which will be coming in contact with concrete to have a coat of epoxy paint.

   b) In areas where concrete thickness is 750 mm or more rate of pouring should be such that minimum slipping of shuttering is 100 mm per hour.

   c) Mix design should be so done that it will be self-lubricant at the contact face of shutter and concrete and thus reduce friction. Suitable cement of approved manufacturer (conforming to relevant I.S. Specification) may be used for the purpose. An optimum ratio of coarse/fine aggregate should be established to suit the purpose depending on availability of aggregates.

   d) Mix design also should be so done that it has a slump of 50 mm at the point where concrete is placed under an ambient temperature of around 40^{o}C. This will also keep vibration by needle vibrators to required minimum. Slump should not drop down to zero in less than 45 minutes. Suitable retarding agent or plasticizer of approved manufacture may be added in mix to achieve this purpose. These admixtures to be properly identified by preliminary tests both for performance and for compatibility with particular type of cement proposed to be used.

Additional steps like spraying of water over the shutters and keeping down the temperature of coarse aggregates by continuous spraying of water over those may be resorted to if ambient temperature is more than 40^{o}C.

2. Care must be taken to prevent twist, which predominantly occur in the initial stages because of low slipping rate, in the horizontal plane of Slip-form assembly. A thorough check on this aspect must be kept at every 15 minutes interval. One person should exclusively be assigned this work together with rectifying any defect.

3. Every endeavor has to be made so as not to occur any tilt in the shutter assembly. To achieve this following steps need be taken:

   a) Performance of jacks has to be closely observed and any defective one needs immediate replacement. Difference in levels of opposite jacks at any instant of time should not exceed 5 mm.

   b) Loading on Slip-form truss/yokes has to be fairly equal.

   c) Sleeve through which jacking rod passes has to be of sufficient length so that later gets an uniform clearance and does not get any chance to tilt. Sleeve should have a minimum wall thickness of 3.25 mm and should be such that jacking rod gets a maximum clearance of 1 mm to 1.5 mm around.

4. For taper walled chimneys overlapping of shutters which are kept to effect the tapering, needs careful attention otherwise these may be filled with concrete slurry.

5. In designing the mix following aspects should be borne in mind:

   a) Cement used should have an initial setting time of not less than 50 minutes and preferably should have a specific surface around 3600 Sq.Cm. per gram.

   b) Coarse and fine aggregates should be well graded and rounded aggregates offer better performance in Slip-form technique. These help to keep down water/cement ratio and also offers better lubrication between concrete and shutter surface. 40 mm down size of coarse aggregates should preferably be used unless reinforcement detailing calls for lesser size aggregates.

   c) From the point of view of creep, shrinkage as well as initial setting property of concrete, cement content should not preferably be more than 400 Kg. per Cu.M of concrete.

d) Minimum compressive strength (after 4 to 6 hours of mixing) of concrete immediately below the shutter as slip form proceeds should be between 0.1 to 0.2 Newton/ Sq.mm.

e) It is advisable to use cement from a single source during the entire operation of slipform technique since once the system starts, there might not be any time left for conducting trial mixes if the source of procurement of cement changes.

6. Large diameter vibrator needles should not be used for vibrating concrete. Sizes of these needles should preferably be restricted to 25 mm diameter and to 40 mm diameter - only in exceptional cases. At least two nos. standby vibrator units should always be maintained on top of working deck at all time during the entire period of slipform operation.

7. It is preferable to have membrane curing compounds sprayed on fresh surfaces emerging out of shutter panels for ensuring proper curing at great heights.

   In case such spraying is not envisaged then elaborate arrangement has to be made for adequate supply of water both on inside and outside vertical surfaces with spraying arrangement, necessary length of pipelines and pump of adequate head to serve the purpose. It is always advisable to have a stand-by pump for effective utilisation of the system.

8. If Slipforming is carried out in summer, rate of slipping should be around 400 mm per hour. If lesser value is contemplated appropriate retarders should be specified.

9. Exact number and capacity of jacks as well as spacing of yoke frames are to be determined taking into account various loadings including self weight of the system, dead and live loads on working and other platforms, horizontal load on formwork, wind load etc.

   It is desirable that jacking system, based on which the entire slipform system works, should consist of jacks 3 Tonne/6 Tonne capacity and a hydraulic pump with necessary pipe connections.

   Spacing of yoke legs should preferably be kept within 2 metres to prevent overloading on jacks and consequent failure resulting in twist of the formwork.

   Jacking rods should be of 25 mm diameter for 3 Tonne Jacks and 32 mm diameter for 6 Tonne Jacks.

10. At least 30% spare jacks and jacking rods should be kept ready during the entire operation. It is obligatory to maintain spare hydraulic pump alongwith a set of loose pipes in perfect working condition on top of working deck.

11. In sections where thickness is 500 mm or more it is prudent to go in for two nos. of jacks for each slipform yoke.

12. For effective utility of this technique following areas need careful attentions at the very conceptual stage:

    a) Detailed quality assurance programme.

    b) Advance Planning and preparations.

    c) Arrangement for on site supervision and adequate access facilities.

13. Construction methods including description and types of different equipment proposed to be used, structural arrangement and analysis of the system, description and type of different materials, planned interruptions, description and frequency of various checks and tests for Slipform technique as well as for material, method of preparing, transporting and pouring of concrete, solution for probable defects during slipping, sequence of operations during planned interruptions etc. should be prepared beforehand by executing agency and to be approved by Owner before starting the actual work.

14. Placing and binding of reinforcement is also a very critical item and needs special attention. From practical considerations not more than two or three layers of horizontal steel can be tied at a time and this causes a definite limitation in placement of reinforcement.

    Vertical reinforcements should be kept vertical by providing suitable holders within the slipform system.

15. It is desirable to have a break of at least one day for every two weeks of continuous operation. Such break should be utilised for various maintenance activities, removal of jack rods etc.

16. Numbers and locations of hoists for lifting concrete, reinforcement and other materials have to be planned well in advance. Capacity of hoists should be such as to match with hourly requirement of concrete and reinforcement. If felt necessary one hoist may be exclusively earmarked for transporting concrete.

    For movement of personnel supervising the work a separate hoist must be arranged for.

17. The system being operative round the clock it is obligatory to have adequate lighting arrangement both on various platform levels as well as on ground below. Arrangement has to be made for facilitating continuous upward movement of the entire system alongwith slipform.

18. Winches for lifting men and material and mixers, if located within unsafe area around chimney, should be protected by adequate shelter from possible damage.

19. Proper tele-communication system has to be established between the personnel working on top of Chimney and control room below.

20. A small laboratory should be maintained at site for testing different materials like cement, coarse and fine aggregates. A cube testing machine may also be installed at site for getting quick feed back results.

    Apart from using plumb bobs, level and theodolite instruments for survey purpose arrangement should also be kept for lasers.

21. In case of interruption in the course of slipping of formwork following measures should be taken:

    a) Provision of a key and additional reinforcement at the junction of new and old concrete.

    b) Slipform system should be brought up freely to have a minimum overlap of 100 mm or so over previously cast concrete.

    c) Washing of old concrete surface with compressed air and water jet and thereafter pouring a layer of neat cement grout.

    d) Clearing of shuttering panels of loose materials, concrete etc. by compressed air and applying a coat of epoxy paint, if felt necessary by Owner.

    e) Neatly finishing the interface of old or new concrete as soon as it comes out of shutter panel.

22. It is preferable to suspend the construction work under high wind condition.

23. It is of utmost importance that for effective implementation of this system an Owner fully conversant with Slipform technique with enough experience in planning and control of formwork should be in overall command of the site and he should be ably supported by well trained mid level supervisory staff, skilled workers and operators.

24. Operation of slipform method of construction is a continuous one and it demands continuous/intermediate inspection of accuracies in line, level, dimensions and position and immediate rectification of any noticed deviation. All these ask for personnel of high quality having constant vigilance over the construction activity.

25. While all the activities in effective implementation of the work needs utmost care keeping safety of men and material in mind it is obligatory

that all activities should be carried out under the guidance of a qualified and trained safety Owner.

Safety measures as listed below must be adhered to but should not be limited to only these:

a) Safety helmets and belts to be provided to all supervising staff and workers.

b) Safety nets to be provided below both inside and outside platforms as instructed by Owner.

c) Handrailing and toe guard to be provided around all openings and platforms.

d) Regular maintenance of equipment, checking of hoists, scaffoldings etc.

e) Passenger hoist must have multiple ropes.

f) Emergency lights, coloured lamps to be provided in accordance with relevant Indian Standards and as supplemented in the Specification and to be operative in case of sudden power failure Emergency standby generator must be kept ready during the entire period of slipform method of construction.

g) Emergency vehicles, first aid facilities must be kept ready during the entire period of work.

26. Permissible construction tolerances should be limited to the following:

Variation in wall thickness	:	(-) 5 mm, (+) 25 mm
Variation from Design Diameter	:	(±) 25 mm or (±) 12.5 mm per 3 m dia. whichever is larger, but in no case more than (±) 75 mm.
Out of Plumb in General :		1 in 1000 of height subject to a maximum of 200 mm.

Although deviations in general will not be encouraged, the Contractor however may mention in his offer the additions to or deviations from drawings/Technical Conditions/Schedule of items issued with the tender papers and any other special requirement implied with the adoption of the Slipform method, which may include but need not be limited to the following items as applicable:

a) Particular requirement of type and brand of cement, if any.

b) Special admixture to be added to concrete.

c) Any change required in the geometry of the Chimney including the shell thickness or side slope from that shown in the N.I.T. drawing.

d) Any change/special requirement in the arrangement of reinforcement.

e) Implications if any of necessary in situ bending of rebars for corbels/ brackets etc. and straightening/cleaning of the same prior to casting of brackets.

f) Any additional constructional opening in the shell required at ground level for concreting.

All deviations from tenders must be justified and tender price shall include all such variation/deviation. Such deviation without assigning any reason will be rejected.

6.3.4.0 **Chimney Steel and Metal Work**

6.3.4.1 **General**

All workmanship shall be of best practice in modern structural shops, and shall conform to the provisions of the IS:800 and other relevant IS Specifications, unless otherwise specified.

6.3.4.2 **Fabrication**

Rolled materials, before being used for fabrication, shall be straight and shall be within the tolerance laid down in the IS:852. Straightening, if necessary, may be done by mechanical means and if required, by applying localised heat the temperature of the material not exceeding 600 Deg.C locally. Cutting of mild steel members shall be effected by power saw or gas cutting. If gas cutting is used, allowance shall be made in working out the effective length, based on the shop drawing and templates. Care shall be taken in gas cutting so that the member does not bend or warp. Edge preparation for welding may be done by gas cutting with necessary precautions and cleaning. Holes shall be drilled with power drill. Arrangement shall be made for clamping the member to be drilled so that the member is not displaced while drilling is in progress. When two or more members are to be drilled together, all the parts shall be clamped together. After drilling they shall be separated and burs shall be removed with power driven hand grinder. Bolt holes shall not be formed by a gas cutting torch.

6.3.4.3 **Assembly**

Riveting, bolting and welding shall be carried out as per requirements laid down in IS:800. Shop assembly of elements of platforms or the entire platforms, brackets and similar items if required and/or asked for by the Owner, shall be arranged so as to check the accuracy of fit. Necessary temporary supports like props, cross bracings etc. shall be provided to keep the parts in place both for

mock up and at the time of erection. Each steel piece shall bear erection marking, written in paint.

6.3.4.4 **Painting**

If steel and iron members are to be painted as per contract, it shall be done as per requirement laid down in IS:800. A coat of shop painting shall be applied to all steel and metal work, unless stated otherwise. All steel ladder, platforms, balconies, hand railing, frames, doors etc. which are specified for painting shall be painted first with two coats of red oxide zinc chromate paint conforming to IS:2074 and then with two coats of Synthetic enamel paint (as per IS:2932 & 2933) or aluminium paint (as per IS:2339) of approved quality or acid resisting paints as specified in drawing or elsewhere.

Total dry-film thickness of paints provided on structures located outside windshield shall be 190 microns and that on inside be 125 microns minimum.

All paints shall be of make and shade as instructed and approved by the Owner. Necessary test certificates, manufacturer's literature and samples shall be submitted to the Owner, for his approval, before bulk purchase is made.

The metal surfaces which are to be painted shall be prepared properly by rubbing, washing, treating prior to application of paint as per paint manufacturer's specifications and as per relevant IS Specifications.

6.3.4.5 **Galvanizing**

All steel including threaded bolts, nuts and washers, unless specified otherwise in contract, shall be hot dip galvanized in accordance with American Society for Testing and Material Specification ASTM 123 or IS:2629 - Recommended practice for Hot- Dip Galvanising of Iron and Steel.

All members to be galvanized shall be cleaned thoroughly, to the satisfaction of the Owner, by the process of pickling. Pickling shall be carried out in an acid bath containing sulphuric or hydrochloric acid of suitable and adjusted concentration and temperature. Pickling process shall be completed by rinsing the members thoroughly in warm water.

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath and it shall meet all the requirements when tested in accordance with IS:2633 and IS:4759. The zinc coating shall be of uniform thickness. If the galvanizing of any member is damaged, the Owner shall be shown of the extent of damage and if so directed, the galvanizing may have to be redone in the similar manner stated above.

6.3.4.6 **Erection**

Erection of structural members and C.I. Chimney caps shall be done as per requirement of IS:800. The Contractor shall submit to the Owner a programme of erection for his approval. All plant, equipment, tools, tackle and any other

accessories required for the erection shall be provided by the Contractor. Storing and handling of fabricated materials for erection, setting out of members, providing temporary supports, bracing, fasteners, bolts, nuts etc. shall be the responsibility of the Contractor and shall be taken into account in quoting the rate.

6.3.4.7 **Cast Iron Chimney Cap**

The cast iron cap, fitted at the top of the chimney, shall be of thickness not less than 10 mm. This shall preferably be a single cap covering both the concrete shell and the lining, with the segments bolted together securely and properly anchored inside the concrete in such a manner as to form a complete annular unit, allowing for unequal circumferential and vertical expansion and contraction of concrete shell and lining and for deflection of shaft due to wind.

All bolts, nuts, washers, rag bolts and other fasteners as required for fixing cast iron cap shall be of bronze material. Gaps between segments are to be filled with asbestos mill-board or fiber-glass packing. Casting is to be assembled to match with the dimensions specified in drawings, before despatch to site. C.I. caps to be painted with two coats of acid resisting paints over primer coats as recommended by paint manufacturer.

6.3.5.0 **Insulation and Protective Treatment**

6.3.5.1 **Acid and Heat Resistant Paint**

The inside surface of concrete shell and corbels and outside surface for height as specified in the drawing shall receive a protective treatment of three coats of acid and heat resistant black paint. The quality and type of the paint shall have the prior approval of the Owner. For this, a small area shall be painted and a sample of paint shall be shown to the Owner.

The surface to be painted shall be prepared and primary coat, if required as per the paint manufacturer's specification and direction of the Owner, shall be applied. The paint shall conform, unless otherwise stated, to the requirement of IS:158. Necessary samples, test certificates and manufacturer's literature shall be submitted to the Owner for his approval. The surface to be painted shall be completely dry before the paint is applied and the drying time between consecutive coats shall not be less than 5 hours.

6.3.5.2 **Cement Paint**

The outside face of the Chimney shell, unless specified otherwise, shall be painted with Cement waterproof paint. The quality shall be approved by the Owner. Necessary samples shall be submitted to the Owner for his approval. The surface of the shell shall be prepared as per paint manufacturer's specification. In addition, care shall be taken that the surface is free from stain, honey comb and any rough and uneven surface. The joints between two shuttering and two lifts of shuttering shall be so prepared that any unevenness, if

by chance exists, shall be removed. If one coat of paint is not sufficient to give the required finish, the Contractor, at his own cost, shall repaint the surface, until the Owner is satisfied with the workmanship. The paint shall conform, unless otherwise stated, to IS:5410. Necessary samples, test certificates and manufacturer's literature shall be submitted to the Owner for approval.

6.3.5.3 **Acid Resistant Brick Lining**

The Contractor shall use acid resistant bricks for the job as indicated in the Drawing. They shall be fine grained in texture, dense and homogeneous. The brick shall be sound, true to shape, flat and free form flaws and other manufacturing defects affecting their utility. The bricks shall conform to IS:4860-1968 Class-I for acid resistant bricks. The bricks shall be of necessary curvature and of taper so that the lining conforms to the inner radius of the flue lining and hopper surface. No attempt shall be made to use straight bricks and than to try to match with the inner radius of the lining of chimney by providing extra mortar. No broken bricks shall generally be used. The compressive strength of the bricks shall not be less than 700 Kg/Sq.cm as per IS:4860 Class-I. The Contractor shall provide sample for visual inspection and approval. For testing purposes, the Contractor shall select, at random, bricks from the stack, in presence of the Owner. The sample bricks thus collected, shall be sent to laboratory for testing of compressive strength, acid resistance and water absorption. The cost of sending to the laboratory, testing and any other incidental expenditure shall be borne by the Contractor and the rate should include such test.

The Contractor shall submit to the Owner the original test results for his scrutiny and approval.

Bricks shall be thoroughly wetted before using. The mortar to be used shall have similar characteristics, i.e., it shall also be acid resistant. The mortar shall be acid-proof mortar-potassium silicate type (resistant to sulphuric acid) as per IS-4832 Part-I & IS-4441. The mortar shall also be tested at Contractor's cost, in a laboratory approved by the Owner. The mortar shall be used immediately after mixing. The water cement ratio and the workability shall be strictly maintained. The brickwork shall be flush pointed, after necessary raking of joints and cleaning of surfaces. The lining shall be kept wet for a period of at least 3 days, after which exposed face shall be thoroughly cleaned. The air space and all ventilation holes in the shell and corbels shall be kept clean of any mortar for thorough ventilation. The mortar between bricks shall not be more than 3 mm thick and the mortar used shall be freshly prepared, used within the setting time. No retampering shall be permitted.

6.3.5.4 **Fire Brick Lining**

The Contractor shall use fire bricks for lining of the Chimney and hopper as shown in the drawing. The bricks shall be of necessary curvature and of taper so that the lining conforms to the inner radius of the flue lining. No attempt shall be made to use straight bricks and then to try to match with the inner radius of flue lining of chimney by providing extra mortar. Fire bricks shall be well burnt,

compact and of homogeneous texture generally white to yellowish white in colour and free from cracks and other flaws; no broken bricks shall be allowed to be used except for closing the course. The crushing strength of the bricks shall be not less than 200 Kg./Sq.cm and shall be of Group-A conforming to IS:6-1983, Specification for Moderate Heat Duty Fire clay Refractories, Group-A. The water absorption of the bricks shall not exceed 13% and the density of bricks shall be approximately 1800 to 2000 kg/Cu.m. Thermal conductivity of fire brick shall not exceed 1 kcal/hr.m.deg.C. Sample of bricks shall be submitted by the contractor for approval of the Owner. For testing of bricks sample shall be taken according to the scheme given in IS:1528-1962, IS for Sampling and Physical Testing of Refractory Material; and cost for testing and incidental expenditure shall be borne by the Contractor and rates quoted shall include the cost.

The brick shall be laid with air setting fire clay mortar free from potassium/ Sodium silicate. The mortar may be "Tataset-FK-40" manufactured by Tata Refractories Ltd. or equivalent. The material shall be kept in a cool place under covered shed before use. The mortar shall be applied strictly as per manufacturer's instructions.

Thickness of mortar joint shall not be more than 3 mm. The bricks are to be laid one course of header followed by two courses of stretchers and so on or as directed by the Owner. The exposed face shall be true to the line, parallel to the Chimney shell unless shown otherwise. Steel straps made of flats shall be provided on the exterior surface of brick lining both circumferentially and vertically for both acid resistant brick lining and firebrick lining. The steel straps shall be double hot dip galvanised.

6.3.5.5 **Insulation and Packing**

All packing and insulation material shall be of thickness, diameter and type, shown in the drawing. The packing and insulating material shall be made of asbestos rope, vermiculite concrete, slag or mineral wool and asbestos mill boards.

a) **Asbestos Rope**

The diameter of the rope shall be as per drawing. The material shall be of best quality available in the market and shall be purchased after a sample is approved by the Owner. The rope shall be plain, Grade-I, conforming to IS:4687-1968. The strand shall be long, well twisted and no torn thread shall stick out. The rope shall be firmly packed so as to prevent gas leakage.

b) **Slag or mineral wool**

The thickness of packed slag wool shall be as shown in the dwg. The packed density of the wool shall be within the range of 175 to 200 Kg./cu.m. and the co-efficient of thermal conductivity shall conform to the requirement of IS:3677 at a mean temperature of 150 Deg.C. The material shall be well packed in position where possible. IS:3677 for Rock

and Slag wool mats for thermal insulation may be referred for guidance. The co-efficient of thermal conductivity and packed density shall be tested according to IS:3677 and IS:3346.

c) **Vermiculite Concrete**

Vermiculite concrete shall be made by mixing exfoliated vermiculite, Portland cement and water. It shall be of Grade-B, having a density of 210 Kg./Cu.M. The vermiculite aggregate size shall be maximum 6 mm. The mix shall be 1 cement and 8 vermiculite by volume.

d) **Asbestos Mill Board**

Asbestos mill board shall be of thickness as indicated in drawing. It shall be of best quality of standard make available in the market and samples shall be submitted to the Owner for approval. It shall be plain, dense and homogeneous texture, without cracks, flaw and any other manufacturing defect. It shall be laid directly onto the concrete bed after removing any loose material or any aggregate. The concrete shall be prepared without mortar so that the board can have a good seating.

6.3.6.0 Lightning Protection System

6.3.6.1 General

The lightning protection system to be installed on the chimney by the Contractor shall be strictly as per drawings and specifications and shall satisfy the following requirements.

6.3.6.2 Air Terminals

The Chimney shall be provided with pointed air terminals uniformly distributed along the top rim of the chimney. The projected length of the air terminals above the top of the chimney shall not be less than 1000 mm. The air terminals shall be made of lead coated solid copper rods having a minimum diameter of 20 mm. The air terminals shall be secured to the top of chimney by at least two fasteners of substantial construction to withstand high wind pressure acting in the area commensurate with the height involved. All the air terminals shall be electrically connected together by means of a band ring of 75 x 6 mm galvanized steel flat which shall form a close loop 600 mm. below the top of the chimney. Each segment for the cast iron cap of the chimney shall be connected to this galvanized steel flat band by means of tightly bolted connections.

6.3.6.3 Down Conductors

There will be two separate system of vertical down conductors of 50x6 mm Galvanised Steel flats spaced as shown in the drawings. One system, envisaged for lightning protection, will have two numbers of down conductors starting from the top encircling band leading to the ground. The other system, envisaged for

earthing of platforms/ ladders etc. on the stack, will also have ground conductors originating below the platform and leading to ground. Galvanised steel 50x6 mm flat bands shall be provided below each platform. These bands shall be connected to each ground conductor. No part of the down conductor system for lightning protection shall have electrical contact with hand rails of platform, cage ladder and encircling band ring forming the earthing system.

The connections of the galvanized steel down conductors to the copper air terminals shall be brazed and connection to the nearest grounding grid at the bottom shall be arc welded. Connection between any two galvanized steel flats/bands shall be made by arc welding.

The galvanized steel flat encircling bands shall be supported at an interval of maximum 600 mm. and the vertical down conductors shall be supported at an interval of approx. 2500 mm. The fasteners shall be of same grade of material as the conductors and have to be galvanized. The conductor shall be laid straight and sharp bends shall be avoided as far as practicable. A suitable bolted test piece shall be provided at each down conductor at a convenient height near the bottom of the chimney.

At all supports, the portion embedded inside the chimney shell concrete shall not touch the reinforcement bars and shall be duly insulated from them.

6.3.6.4 **Bonding**

All exposed metallic parts of the chimney shall be bonded to the ground conductors. Such parts shall include ladders, balconies, conduits, etc. If the metal has considerable length, it shall be bonded at each end. If the metallic components are composed of electrically discontinuous parts, each part shall be bonded to the ground conductors. The bond shall have a minimum cross sectional area equal to that of the ground conductor.

6.3.6.5 **Joints**

The joints in the lightning/ground conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors. All joints, except those for the air terminals, shall be done by arc welding process. Overlapping of the conductors at straight joints shall not be less than 200 mm. The bolted joint of the test piece shall be covered with thick coating of bituminous paint after successful testing. The connections between the down conductors/short piece (of 50 x 6 mm galvanized steel flat) and the copper air terminals shall be brass brazed as shown in the drawing (with the help of brass rods, manufactured by Indian Oxygen Limited (Silos or Ruptum 14) or equivalent.

6.3.7.0 **Aviation Obstruction Lighting System**

6.3.7.1 **Lighting System**

The Contractor shall supply and install the aviation obstruction Lighting system on the chimney strictly as per drawings and specification and shall consist of the following items:

a) 4 sets of single obstruction lights with fixtures at balcony levels.

b) Complete G.I. conduits, PVC insulated wires, G.I. grounding conductor, weatherproof outdoor junction box and all accessories viz. supports, clamps, junction boxes, etc. to make the installation complete in all respects. Conduit wiring shall be from the lighting fixtures to the junction box located at the bottom of the chimney.

6.3.7.2 **Lighting Fixtures**

The lighting fixtures shall be suitable for 240 V ± 10%, 50 Hz ± 5%, single phase, A.C. supply. All fixtures and accessories shall be weatherproof, outdoor type, capable of withstanding highly humid and flue-laden atmosphere. The obstruction lighting fixtures shall be equivalent to G.E.C. Cat. No. ZH750 and complete with all necessary accessories. The intensity of each light shall not be less than 10 (ten) candles of red light. A set of four nos. single lights shall be installed on each balcony at 90 Deg apart with suitable supporting arrangement to withstand high wind pressure.

6.3.7.3 **Conduit Wiring**

All the obstruction lights shall be uniformly distributed over three single-phase circuits. Conduit wiring for lighting installation shall be done with PVC cables drawn through the G.I. conduit of proper size. The GI conduits shall be terminated to a fuse box mounted on the chimney shell, at an accessible height from the ground. The cables shall be 1100/650V Grade, 1/c, 10 Sq.mm, PVC insulated and sheathed Stranded Aluminium conductor. The size of wires from junction box to lighting fixtures shall be 1/C-2.5 sq.mm, PVC insulated stranded copper conductor. The conduits shall be clamped at interval not greater than 600 mm. by means of approved type of saddles, clamps, etc. securely fixed on the shell/ladder. PVC bush shall be used at either end of the conduit. The minimum size of conduit to be used for the installations shall be 65 mm. Pull boxes, at intervals of not more than 10 meters, inspection bends, etc. are to be provided at suitable locations to facilitate laying of wires. 8 SWG G.I. wire shall be run along the conduit for grounding purpose. All conduit accessories and junction boxes shall be hot-dip galvanized and of approved type. Wiring shall be done as per the relevant IS. Specification.

6.3.7.4 **Junction Box**

The junction box at the chimney bottom shall be weatherproof and suitable for flue laden atmosphere and provided with suitable terminal blocks and conduit knockouts for incoming and outgoing conduits. 4-core PVC insulated cable with Aluminium Conductor will be used to feed power supply to the bottom most

junction box. Purchaser will arrange for laying the cables but the Contractor shall terminate this cable to the bottom most junction box which shall have suitable double compression type cable gland.

6.3.7.5 **Painting and Lead Coating**

All welded joints with galvanized steel shall be provided with cold galvanizing paint. Other accessories necessary for lightning protection as well as brackets, supports and other items of obstruction lighting installations, shall be painted with two coats of Red Oxide priming paint and one coat of Aluminium finishing paint. The Red Oxide paint shall be applied on the down conductors and bands before installation and the Aluminium paint coating shall be applied after the installation is over. The copper air terminals, conductors, fasteners and other accessories upto the top encircling band shall have a continuous lead covering of about 2 mm. thickness, for protection against corrosion due to gases and weather.

6.3.7.6 **Temporary Obstruction Lights**

The Contractor shall provide at least two (2) lights located at diametrically opposite points at the top of the chimney during the period of construction till the permanent obstruction lights are installed and energised, to serve as temporary obstruction lighting.

6.3.8.0 **Sampling Port**

Sampling ports of minimum 0.1 m dia. shall be provided in the Chimney as shown in the drawing to maintain records of emission. Minimum length of port shall be 0.5 m measured from inside face of the lining to the outside end of the port. The port shall be provided with industrial flange capped when not in use. Location of port shall be at least two times the top diameter below the stack exit and at least eight times the stack diameter above the last obstruction. One meter below sampling port a working platform has to be provided at least 1 m wide with safe guardrail and access ladder. Ladder well shall be located at least 1 m away from ports. There shall be no obstructions within 1 m horizontal radius on platform beneath ports. A power source of 220 V, 15A single phase 50 Hz AC shall be located on the platform. There shall be two ports 90 Deg. apart when stack dia. is less than 3 m plus port length and 4 ports when stack dia. is more than 3 m plus port length.

6.3.9.0 **MS insert plates for mounting of instruments for the measurement of amplitude of vibration and wind speed**

For mounting of accelerometer and wind speed censors 600 x 600 x 20 thick, MS inserts with 25 nos. threaded (1/2" whitworth) holes shall be fixed on the outer circumference of the chimney shell with MS lugs as shown on the drawing. During casting, the holes shall be temporarily plugged to prevent concrete from filling in the holes. Two nos. of such inserts shall be fixed at the top of the chimney for mounting accelerometers and a set of four nos. of such inserts shall be fixed at one-third and two-third heights of the chimney for mounting wind speed censors. A working platform of 1 meter width with safe guardrail shall be provided 1 metre below each level of these inserts as shown on the drawing.

For laying of cables, the same cable tray used for illumination/ aviation light shall be utilised.

6.4.0 TESTING AND ACCEPTANCE CRITERIA

6.4.1.0 General

The Contractor shall carry out all sampling and testing in accordance with the relevant IS Specifications and as supplemented herein, for the following items or any other item as may be required by the Owner, at his own cost, unless otherwise specified in this specification. The Contractor shall get the specimens tested in laboratory, approved by the Owner and shall submit to him, the original test results in triplicate, within seven days after the completion of the test.

6.4.2.0 Cement

Representative samples shall be taken as per the relevant IS Specification from each consignment of Cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time, compressive strength and soundness tests, and the Contractor shall carry out the above tests as per relevant Indian Standard. If the cement is supplied by the Contractor the test shall be carried out by him at his own cost.

6.4.3.0 Aggregate

The Contractor shall carry out any or all the tests on aggregates as may be required by the Owner, 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 IS specifications.

6.4.4.0 Water

Sampling and testing of water being used for concrete works shall be carried out as per IS:3550, by the Contractor, at regular intervals and whenever directed by the Owner. The final acceptance criterion in case of doubt shall be as per IS:3025.

6.4.5.0 Concrete

The Contractor shall take cubes for works test as per requirement laid down in IS:516 regularly from the day's pour. The number of test cubes to be taken shall be as per IS:456. The Owner may also use his discretion in deciding the rate of cubes to be taken. The acceptance criteria is to meet the requirement of IS:456. If the cube test results indicate that some portions of the work is below the required strength, the Owner may order demolition of that portion of work which is below strength and ask the Contractor to rebuild, provided a satisfactory method of load testing is not possible. Such testing or demolishing and rebuilding shall be carried out by the Contractor at his own cost.

6.5.0.0 **INFORMATION TO BE SUBMITTED**

6.5.1.0 **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 with which association is sought for to execute the special items of work in the contract.

d) Types of formwork proposed to be used. All details as per clause 3.3.6 to be submitted, if slip form method is proposed to be used.

e) Proposal for lifting of men and material in constructing the chimney.

6.5.2.0 **After Award**

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

6.5.2.1 **Programme of execution and requirement of materials**

Within 30 days of the award of the Contract, the Contractor will submit a Master Programme for completion of the work giving month wise requirement 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 & conditions of the Contract. In case the Contractor proposes to take on hire any machinery or tools and plants from the Owner, the detailed phased out programme of such hire is also to be submitted.

The master programme may have to be reviewed and updated by the Contractor quarterly or at more frequent intervals as may be directed by the Owner depending on the exigencies of the work.

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

6.5.2.2 **Samples**

Samples of all materials proposed to be used shall be submitted as directed by the Owner, in sufficient quantities, free of cost, for approval. All samples shall be submitted well in advance of starting work at site. Approved samples will be preserved by the Owner for future reference. The approval of the Owner shall not, in any way, relieve the Contractor of his responsibility of supplying material of specified quality.

6.5.2.3 **Design Mix**

Design mix as per details of this specification giving proportions of ingredients, sources of aggregates and cement along with accompanying test results of trial mixes as per relevant IS Specifications shall be submitted to the Owner, for his approval, before it can be used on the work.

6.5.2.4 **Detail Drawings**

Following items shall be provided by the Contractor which are to be approved by the Owner.

a) Detail drawings and designs of form work including scaffolding to be used. If slipform method of construction is adopted, then detail drawings showing all the arrangements for slipform technique including methods for reducing internal diameter and providing required slopes on outer diameter.

b) Detail drawings and bar bending schedules for concrete components.

c) Shop drawings for steel and metal work, including inserts etc.

d) Detail drawings for templates and temporary supports for embedments.

6.5.2.5 **Reports**

Following Test Reports shall be furnished by the Contractor:

a) Mill Test Report for cement and reinforcing steel if the materials are supplied by the Contractor.

b) Inspection Report of formwork and reinforcement.

c) Reports of tests of various material and concrete.

d) Any other data or report or test result required by the relevant IS Specifications and if required by the Owner for satisfactory quality control of the workmanship.

7 MASONRY AND PLASTERING WORKS

7.1 General

This chapter covers the furnishing and installation of all brick work, damp-proof courses and plastering works.

7.2 Standards

Unless specifically mentioned otherwise, all applicable codes and Standards in their latest editions as published by the Indian Standards Institution and all other such as may be published by them during the currency of the Contract, shall

govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

IS:1077	Common burnt clay building bricks
IS:1542	Sand for plaster
IS:1661	Code of practice for application of cement and cement-lime plaster finishes
IS:2116	Sand for masonry mortars
IS:2212	Code of practice for brickwork
IS:2250	Code of practice for preparation and use of masonry mortars
IS:2691	Burnt clay facing bricks
IS:3495	Methods of tests of burnt clay building bricks
IS:3696	Safety code for scaffolds and ladders (All parts)
IS:5454	Methods of sampling of clay building bricks

7.3 Materials

Cement

Cement used for mortar shall be ordinary Portland cement conforming to IS:269 / IS:8112 / IS:12269 or Sulphate resisting cement conforming to IS:12330.

Sand

The sand shall be approved river or pit sand and it shall conform to IS:2116 for masonry mortar and to IS:1542 for plaster mortar.

Mortar

Cement Mortar for brickwork shall conform to IS:2250. The cement mortar to be used shall be in proportion of 1:6 for full brick walls and 1:4 for half thick brick walls.

Water

Water for mixing and curing shall comply with the requirement of IS:456

Bricks

The bricks used shall be of Class 50 bricks conforming to IS:1077 having a minimum compressive strength of 50 kg/cm2. Bricks are to be whole, uniform texture, sound, well burnt, free from cracks, square and well shaped, uniform in size, uniform red cherry or copper colour and shall emit a clear ringing sound when struck. Slight distortion or rounded edges are permitted provided no difficulty arises during laying of uniform course.

Water absorption after 24 hours immersion shall not exceed 20% by weight. Dimensional tolerance shall not exceed 8%. Representative samples shall be submitted and approved samples shall be retained by the Consultant for future comparison.

7.4 Storage and Handling

Bricks shall not be dumped at site. These shall be stacked in regular tiers on firm ground, even as these are unloaded, to minimise breakage and defacement of bricks. Bricks selected for different situation of use in the work shall be stacked separately.

7.5 Workmanship

Brick work

Whole of the brickwork shall be carried out by the Contractor in a uniform manner. All the bricks shall be kept under water till they are completely soaked and shall be used for the works on their becoming skin dry. The Contractor shall set out and build all brickwork to the dimension, thickness and heights shown on the drawings. The Contractor shall build all brickwork in English bond and half brick walls and casing to pipe, chases etc in stretcher bond. Brickbats shall not be used except where required for bond.

The Contractor shall lay bricks in full mortar beds with shoved joints. The joints are not to exceed 10 mm in thickness and are to be full of mortar, close, well finished and neatly struck. The vertical joints in any course shall not be nearer than quarter of a brick length from those in the course below. All joints shall be of same width except for small variations to maintain bond. The brickwork shall be laid plumb and trim to line and level. No portion of brickwork shall be raised more than 1 metre above another at one time. If the mortar in any course has begun to set, the joints shall be raked out before another course is laid. The top course of brickwork in reinforced concrete framed structure shall be wedged against reinforced concrete surface and joint well filled with mortar. The Contractor shall flush up thoroughly with mortar all joints as the work proceeds. Where brickwork is to receive plaster, the joints shall be raked to a depth of 10 mm to provide proper bond.

All half brick walls shall be reinforced with 2 nos. 8 dia bars at every fourth course. All masonry units shall be bonded to concrete and steel columns by galvanised metal wall ties (4mm thick, 50mm vide 200mm long) at the rate of one tie at every fourth course.

The brickwork as it progresses shall be thoroughly watered on its faces and top. New work shall be properly bonded with the old work. The surface of unfinished work shall be cleaned and thoroughly wetted before joining new work to it. Any work in which the mortar perishes shall be dismantled and rebuilt by the Contractor.

The Contractor shall carry out work in as clean a manner as possible and shall remove excess material and mortar droppings daily. Where brick walls are to receive plaster, excess materials and mortar droppings shall be removed and the surface shall be brushed clean. During cleaning operations, adjacent work shall be protected. Any damage resulting from improper protection shall be made good by the Contractor at his own cost.

Encasing of structural steel shall be done by building masonry work round flanges, webs etc., and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be wrapped with chicken wire mesh when shown on drawings or instructed by the Consultant. The minimum lap in chicken wire mesh shall be 50 mm. Other steel embedments shall be generally embedded in mortar and masonry unit shall be cut as required.

Plastering

Unless otherwise specified, all plaster work shall be carried out according to IS:1661. The thickness and proportions of cement plaster shall be as specified in the drawing.

The surface to be plastered shall be cleaned of all extraneous matter and rubbish. In brickwork the joints shall be raked and concrete surface roughened by chipping or hacking. Any shuttering material adhering to the concrete shall be removed. The Contractor shall make plaster pads of the required thickness of plaster for correctness of plumb, line and level. The surface shall be thoroughly watered and soaked and aerated and all holes shall be closed before starting plastering operation.

Plaster, when more than 15 mm thick shall be applied in two coats - a base coat followed by the finishing coat. Thickness of under coat shall be of sufficient to fill up all unevenness in the surface, no single coat, however, shall exceed 15 mm in thickness.

For one coat plaster work, the plaster shall be laid slightly thicker than the specified thickness and the surface then levelled with flat wooden rule to the required thickness. The plaster shall be well pressed into the joints and the surface finished as specified.

For two coats of plaster work, the first coat shall be applied as described above except that the surface shall be left rough and keys formed for the application of second coat. The second coat shall be applied a day or two after the first coat has set, but the first coat shall not be allowed to dry. The second coat shall consist of mortar ground very fine and shall be laid on with a wooden rule to a specified thickness, rubbed smooth and levelled and the surface plastered completely the same day. The levelling shall be continued till the plaster is quite dry and all moisture that exudes from the plaster shall be wiped off with a fine cloth. The surface shall be kept dry until exudation of moisture ceases, during the process of rubbing.

Sand Faced Plaster

The plaster shall be applied in two coats. The first coat or the scratch coat should be approximately 14 mm and shall be continuously carried out without breaks to the full length of wall or upto doors, windows etc. The scratch coat shall be dashed on the prepared surface with heavy pressure, brought to true and even surface and then lightly roughened by cross scratch lines to provide bond for finish coat. The scratch coat shall be cured for at least 7 days and then allowed to dry.

The second coat shall be 6 mm thick and it shall not be applied until at least 10 days have elapsed after the application of the first coat. Before application of the second coat, the scratch coat shall be evenly damped. This coat shall be applied from top to bottom in one operation and without joints, finish shall be straight, true and even. Only approved river sand shall be used for the second coat and for finishing work. Sand for finish shall be of even coarse size and shall be dashed on the surface and sponged.

Plaster-Of-Paris Punning
Plastered surfaces, where specified, shall be finished with plaster-of-paris punning. The thickness of punning shall be 2 mm and shall be applied by skilled workmen. The finish shall be smooth, even and free from undulation. Before bulk work is taken up, a sample of punning shall be done on roughly 1 sq.m area and approval of Consultant taken. The work shall then completed as per approved sample.

7.6 Curing
The brick masonry works shall be cured for a period of fourteen (14) days after laying and the plaster shall be cured for a period of seven (7) days.

7.7 Expansion & Separation Joints
Location and details of expansion joints shall be strictly as shown in the drawings. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints, if any, shall have to be got approved by the Consultant.

Separation joints shall be with standard water proof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Consultant.

7.8 Damp Proof Course with Cement Concrete
The proportion of cement to aggregates shall be 1:1½:3 using 6 mm down stone chips with a waterproofing admixture. The percentage of waterproof admixture shall be as per manufacturer's specification but not less than 1% by weight of cement. The brick masonry surface shall be levelled, flushed up and prepared as directed to receive the damp-proof course. The thickness of damp proof course shall be 40 mm. In masonry walls of buildings it shall normally be placed above the external ground level. It shall be laid for the full width of the wall. The top surface shall be kept rough or ribbed for proper adhesion of mortar for brickwork coming over it. All exposed surfaces of the damp proof course shall be finished fair and smooth. It shall be cured for at least seven days. After the surface has partially set, it shall be cleaned with brushes and finally with a piece of cloth lightly soaked in kerosene oil. Then hot bitumen (residual petroleum bitumen of penetration 80/100 of approved quality) shall be applied over the prepared surface in two coats at the rate of 1.7kg per sq. meter per coat and dry sand spread over it.

7.9 Sample Panels
Sample panels of external finish shall be executed for the demonstration of colour and surface texture to the satisfaction of the Purchaser / Consultant.

8 WATER PROOFING

8.1 General
The work covered by this chapter shall include the requirements in respect of materials, workmanship and quality for water proofing of roofs and underground structures.

8.2 Standards

Unless specifically mentioned otherwise, all applicable codes and Standards in their latest editions as published by the Bureau of Indian Standards and all other such as may be published by them during the currency of the contract, shall govern in respect of design, workmanship, quality and properties of materials and method of testing. Some of the relevant available codes are listed hereunder:

IS:1322	Bitumen felts for water proofing and damp proofing
IS:1346	Code of practice for waterproofing of roofs with bitumen felts
IS:1580	Bituminous compounds for water proofing and caulking purposes.
IS:1609	Code of practice for laying damp-proofing treatment using bitumen felts
IS:2645	Integral cement water proofing compounds
IS:3067	Code of practice for general design details and preparatory work for damp-proofing and water-proofing of buildings.
IS:7193	Specification for glass fibre base coal tar pitch and bitumen felts.

8.3 Materials

Membrane water proofing

Membrane water proofing treatment with 'Roofosol' two component coating or equivalent. 30 mm thick Polyurethane foam spray insulation with a density of 40 to 45 kg/m^3 shall be provided conforming to IS: 13205. The roof surface shall be finished with concrete/brick tiles.

Bitumen Felt

Bitumen felt shall be used for water proofing and damp proofing and shall conform to IS:1322.

Bituminous Polymeric Membrane For Roof Water Proofing.

Bituminous Polymeric membrane used for waterproofing of roofs shall be 5 layered membrane consisting of a central core of 90 microns thick High Molecular High Density Polyethylene (HMHDPE) film protected on both sides with polymeric asphaltic mix and further covered on both sides with protective thermo-fusible HMHDPE film. For precast roofs, the top HMHDPE layer shall be substituted with embossed aluminium foil 75 microns thick. Product to be used for cast-in-situ roof slab shall be MULTIPLAS STANDARD or approved equivalent and that for roof with precast slab panels shall be MULTIPLAS ALUMINIUM or approved equivalent.

Bituminous Polymeric Membrane For Underground Damp Proofing.

The membrane used for waterproofing underground structures shall be 7 layered membrane similar to 5 layered roofing membrane, but reinforced with a non woven polyester mat of minimum 140 g/m2 for additional mechanical strength and covered with additional layer of polymeric asphalt. Product to be used shall be MULTIPLAS HYPER or approved equivalent.

Fibre Glass Tissue Reinforced Bitumen Felt
It shall conform to IS:7193, consisting of reinforcing glass fibre base coated on both sides with bitumen modified with thermo-plastic polymers.

Bonding Materials
Bonding materials used for applying the polymeric bituminous membrane on surfaces shall be fibre and solvent based, rubber modified bituminous primer of density 0.92 g/cm3 with viscosity 500 to 10,000 cps.

Bonding materials used for applying the bituminous felts on surfaces shall be industrial bitumen of blown type conforming to IS:702 or residual paving bitumen conforming to IS:73 or a mixture thereof.

Cold applied bitumen shall be homogeneous emulsion of bitumen and plasticizers. The bitumen content shall be more than 35%. When applied it shall remain plastic at 00C

Water Proofing Admixture
The water proofing admixture shall conform to IS:2645 and shall be approved by the Purchaser's Owner.

Cement
Cement shall conform to IS:269.

Aggregates
The aggregates shall conform to IS:383. Fine aggregate shall be river sand or pit sand from approved pits. Coarse aggregate shall be stone chips of size not exceeding 6 mm.

Metal Flashings
Metal flashings shall be of 18 gauge or 20 gauge galvanised iron.

8.4 Workmanship

Waterproofing Of Roof
With Hessian Based Bitumen Felts
The roof slab shall be cleaned of all dust, dirt, grit etc., and if rough, it shall be made reasonably smooth either by chipping of projections or by applying a thin coat of cement slurry of cement, sand and water. The roof surface shall be re-graded prior to waterproofing either with cement mortar or lime-surkhi mortar. At the places of drain outlets, projecting pipes, parapet walls and expansion joints etc. the surface shall be prepared as indicated in IS:1346.

The workmanship in general shall conform to IS:1346 unless otherwise specified. Over the hardened and finished surface of roof slab, a thin layer of approved bitumen primer shall be first brushed over and allowed to dry.

The felt shall be first cut to the required lengths and laid out flat on the roof in position at right angles to the direction of run-off gradient. Each length of felt thus laid in position shall be rolled up for a distance of half of its length. Then the bonding material heated to correct temperature shall be poured on to the roof

across the full width of the rolled felt as the latter is steadily rolled out and pressed down. The other half shall be then bonded in the same way.

Minimum overlaps of 100 mm shall be kept at the end and the sides of strips of felt. All overlaps shall be firmly bonded with hot bitumen. Laying of successive layers of felt shall be so arranged that the joints are staggered with those of the layer beneath it.

In case of roofs with parapets, a chase 75 mm deep shall be cut in the parapet masonry at about 150 mm above the roof level and the felt shall be laid as flashings in widths with a minimum overlap of 100 mm. The lower edge of flashing shall overlap the felt laid on flat portion of the roof and the upper edge of the flashing shall be tucked into the groove made in the parapet. After the flashings have been properly bonded, the chase shall be cleaned and shall be filled up with cement mortar (1:4) flush with the face of the wall and allowed to set by adequate curing.

In case of drain mouths, waterproofing shall be done as specified for the roof excepting that the treatment shall be carried inside the drainpipes overlapping at least 100 mm.

For gutters, a priming coat shall first be applied. Over this, specified number of layers of felt shall be laid and bonded together with hot bitumen and finally painted with a coat of hot bitumen at not less than 1.5 kg per sq. metre. The felt layers laid separately in the gutters shall be overlapped with the corresponding layers on the roof proper. The felt treatment shall be carried down into the outlet pipes to a minimum depth of 100 mm.

After the treatment is over, the surface shall be covered by pea-sized gravel or grit at the rate of 0.6 cu.m per 100 sq.m. On flashings and at drain mouths a finish of two coats of approved bituminous primer shall be provided.

With Polymeric Bituminous Membrane
The roof slabs surface shall be prepared in line with that for hessian based bitumen felt.

Over the hardened and finished surface of roof slab, suitable approved primer such as MULTIPLAS PRIMER or approved equivalent is coated at the rate of 250 g/cm2. The waterproofing membrane is unrolled over the coated surface with overlaps of 100 mm and bonded completely to the substrate. The overlaps are then sealed by flame. Installation of the waterproofing membrane shall be strictly as per the manufacturer's instructions and supervision.

Other details shall be the same as those for hessian based bitumen felt.

After the treatment is over, the surface shall be covered with 20 mm plaster of cement mortar (1:4) reinforced with chicken wire mesh, marked off into squares 600 mm wide with expansion joints provided at a distance of 3 metres for cast-in-situ accessible roofs.

With Fibre Glass Tissue Reinforced Bitumen Felt
Water proofing for roofs shall be according to the guide lines in IS:1346. Other requirements shall be the same as those for hessian based bitumen felt.

For all roof water proofing item of works, the water tightness of the roof shall be tested by filling the roof with 300 mm height of water for 7 days and checking sign of leakage. Further roofing work shall be applied only after the water has been removed and the membrane is completely is completely dry.

With Brick Lime Concrete And Pressed Flat Tiles
The exposed surfaces of the roof slab shall be thoroughly cleaned. A layer of brick lime concrete shall be laid over the cleaned surface. Brick lime concrete shall be 1:2:4 by volume using 20 mm down graded brickbats. The slope of the lime concrete layer shall be 1:100 and the minimum thickness shall be 50 mm. The slope of the draining surfaces shall be formed on all the sides as necessary.

Care shall be taken to check the quantity of water. The quantity of water shall be so as to make the concrete just workable. Cement sand mortar (1:3) with approved water proofing agent shall be laid over the under bed to a thickness of 20 mm. Pressed flat tiles shall be set over the mortar and pointed with the same cement mortar.

Thermal Insulation
The thermal insulation of roof (where required) shall be extruded polystyrene rigid foam boards with a thickness of not less than 50 mm. The material and workmanship shall be as per relevant I.S. code.

Roof drainage
The location, size and the number of rainwater outlet shall be proposed by the contractor and approved by the consultant. The outlet shall be connected to down pipes. Down pipe shall be of suitable size compatible with the outlets and fitted with 450 shoe.

Damp proofing of underground structures
Damp proofing for under ground structures wherever indicated shall be done with hessian based bitumen felts as per recommendations of IS:1609 clause 5.2(b), for heavy treatment, with three layers of felt. The method of laying damp proofing treatment shall be as per clause 6 of IS: 1609.

8.5 Acceptance Criteria

The slopes and surface level shall be such as to allow quick draining of water without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

The water tightness of the roof shall be tested by ponding the roof with 300mm height of water for 7 days and checking for any signs of leakage.

The Contractor shall furnish a performance guarantee of all the waterproofing treatment for a minimum period of five (5) years.

9 PLUMBING AND SANITARY INSTALLATIONS

9.1 General

The work under this chapter comprises the supply and installations of the complete plumbing and sanitary system and shall be carried out in compliance with all local rules and regulations for plumbing installation. All material for plumbing and sanitary installation shall be suitable for their intended purpose and appropriately matched to each other. All material and structural components shall be standardised and shall meet the respective quality and dimensional requirements. The Contractor shall submit samples, description, catalogues and/or drawings showing all technical details, type, manufacturer etc. of the offered materials for Consultant's approval.

All plumbing and sanitary works shall be executed by a licensed or authorised plumbing supervisor or a licensed or authorised plumber and shall be in accordance with the requirements of IS:1742 and other relevant codes.

For items such as earthworks, excavation, concrete, brick work, stonework, painting etc., relevant specifications for these shall apply, unless other wise specified.

Unless otherwise specified, all exposed cast iron or mild steel components such as cisterns, brackets etc. shall be painted with one coat of red oxide paint and two coats of oil based paint of approved colour.

The diameter of pipes and fittings wherever mentioned shall mean the internal diameter or nominal bore, unless otherwise specified.

The job shall include the cost of making necessary chases, holes etc, in walls, floors and in other places and also making good on completion of the works. Any damage caused to floors, walls etc. during execution of the sanitary and plumbing works shall be made good by the Contractor to the satisfaction of the Consultant.

9.2 Standards

Unless otherwise specified herein, the following standards shall apply to the works covered by this chapter:

Roof Drainage System	
IS:1230	Cast iron rain water pipes and fittings
IS:1626	Asbestos cement building pipes, gutters and fittings (spigot and socket type)
IS:1729	Sand cast iron spigot and socket soil waste and ventilating pipes, fittings and accessories.
IS:1742	Code of practice for building drainage.
IS:2527	Code of practice for fixing rainwater gutters and down pipes for roof drainage
Pipes and fittings for sanitary plumbing and drainage	
IS:404	Lead pipes (All parts)

IS:405	Lead sheet and strip (All parts)
IS:458	Precast concrete pipes (with and without reinforcements)
IS:651	Salt glazed stoneware pipes and fittings
IS:771	Glazed fire clay sanitary appliances (All parts)
IS:774	Flushing cistern for water-closets and urinals (other than plastic cisterns)
IS:775	Cast iron brackets and supports for wash basins and sinks
IS:778	Copper alloy gate, globe and check valves for water works purposes.
IS:781	Cast copper alloy screw down bib taps and stop valves for water services
IS:782	Caulking lead
IS:783	Code of practice for laying of concrete pipes
IS:804	Rectangular pressed steel tanks
IS:1068	Electroplated coatings of nickel plus chromium and copper plus nickel plus chromium.
IS:1172	Code of basic requirement for water supply, drainage and sanitation
IS:1239	Mild steel tubes and tubulars and other wrought steel fittings (All parts)
IS:1536	Centrifugally cast(spun) iron pressure pipes for water, gas and sewage
IS:1537	Vertically cast iron pressure pipes for water, gas and sewage.
IS:1703	Copper alloy float valves (horizontal plunger type) for water supply fittings.
IS:1711	Self closing taps for water supply purposes.
IS:1726	Cast iron manhole covers and frames.
IS:1729	Sand cast iron spigot and socket soil waste and ventilating pipes, fittings and accessories.
IS:1742	Code of practice for building drainage
IS:1795	Specification for Pillar taps for water supply purposes
IS:2064	Selection, installation and maintenance of sanitary appliances - Code of practice
IS:2065	Code of practice for water supply in buildings
IS:2104	Specification for Water meter boxes (domestic type)
IS:2326	Automatic flushing cisterns for urinals (other than plastic cisterns)
IS:2470	Code of practice for installation of septic tanks (All parts)
IS:2548	Plastic seats and covers for water-closet
IS:2556	Vitreous sanitary appliance (vitreous china) (All parts)
IS:2963	Specification for Copper alloy waste-fittings for wash basins and sinks
IS:3004	Specification for Plug cocks for water supply purposes
IS:3006	Specification for chemically resistant glazed stoneware pipes and fittings
IS:3076	Low density polyethylene pipes for potable water supplies

IS:3114	Code of practice for laying of cast iron pipes
IS:3311	Waste plug and its accessories for sinks and wash basins
IS:3486	Cast iron spigot and socket drain pipes
IS:3597	Methods of test for concrete pipes
IS:4127	Code of practice for laying of glazed stoneware pipes
IS:4346	Specification for washers for use with fittings for water services
IS:4984	High density polyethylene (HDPE) pipes for potable water supply
IS:4985	Specification for Unplasticized PVC pipes for potable water supplies
IS:5219	Cast copper alloy traps: Part 1, 'P' and 'S' traps
IS:5329	Code of practice for sanitary pipe work above ground for buildings
IS:5961	Specification for Cast iron gratings for drainage purposes
IS:7634	Code of practice for plastic pipe work for potable water supplies (All parts)
IS:8008	Injection moulded high density polyethylene (HDPE) fittings for potable water supplies (All parts)
IS:10124	Fabricated PVC fittings for potable water supplies (All parts)
IS:10592	Industrial emergency showers, eye and face fountains and combination units

9.3 Materials

Sanitary Fittings
All sanitary fittings shall be procured from approved vendors and shall conform to the requirements of the relevant IS Codes listed above. The sizes shall be as specified in the drawings and where not specified, the same shall be as per Consultant's approval.

Glazed earthenware fittings shall be of reputed make, white colour and one piece construction. All metallic fixtures like taps, stop cocks, soap holders etc. shall be of Chromium Plated (CP) brass of approved make. All wall fittings shall be fixed with wooden cleats and CP brass screws and washers.

Pipes And Fittings
Cast iron pipes and specials shall be of standard quality conforming to IS:3486.
Stoneware pipes shall conform to IS:651.
RCC pipes for underground sewer shall be P1 class conforming to IS:458.
Cast Iron rain water pipes shall conform to IS:1230.
Mild steel pipes shall conform to IS:1239
Water supply lines of GI, PVC, HDPE shall conform to IS:1239, IS:4985 and IS:4984 respectively. PVC fittings for water supply lines shall conform to IS:10124.

9.4 Installation

All execution will be done on the basis of approved drawings / instructions given by the Consultant. Fittings shall be located and oriented to allow easy reach such that operation, maintenance, repairs and replacements of pipes, fittings and fixtures are conveniently possible.

Cast Iron / Stoneware Pipes For Soil And Waste Pipe Line

The laying of cast iron / glazed stoneware pipelines shall commence only after the bottom of the trench at various points have been levelled and aligned in accordance with the drawings. When the pipeline has to be laid above ground by the side of wall, it shall be securely fixed to the wall with clamps, wooden plugs and nails. The type of jointing for pipes shall be socket and spigot type.

Cast Iron Rainwater Pipes

Cast iron rainwater pipes fixed to the external walls shall be blocked out at least 20 mm from the plastered surfaces by means of cast iron bobbins. The rainwater pipes at the roof level shall be fitted with a cast iron bend with a masonry bell mouth of suitable size fitted with a cast iron grating. The bottom of the down pipe shall be fitted with a shoe fixed 150 mm above ground / apron level of the building. The socket and spigots of pipes and fittings shall be jointed as specified for cast iron soil and waste pipe line.

Galvanised Steel Water Supply Pipes

Screwed galvanised steel pipes shall be jointed with screwed joints and screwed fittings of the same materials as that of the pipes. Any burrs remaining on the pipe ends after the threads are cut, shall be removed. An approved jointing compound together with a grommet of a few strands of fine yarn shall be used for jointing pipes and fittings. Any pipe threads exposed after jointing shall be painted, or in the case of underground piping, thickly coated with approved bituminous compound to prevent corrosion.

The depth at which the underground water supply pipe is to be laid shall be as shown on the drawings. The service pipe passing into or beneath the building shall be laid at least 200 mm below the ground floor level and accommodated in a previously laid sleeve in the structure where it enters the building. The space between the sleeve and the pipe at its entry into and exit from the building shall be filled with approved bituminous sealing material for a minimum of 150 mm at both ends.

Piping shall not be buried in walls or floors as far as possible. However, when unavoidable, piping shall be buried for the shortest distance necessary and adequate protection shall be provided against damage. Galvanised steel piping shall be secured by iron or steel clamps and hooks when fixed on walls.

All pipework shall be completely watertight and the joints shall be such that there are no projections of jointing materials or the like in the interior of pipes. Before the pipeline is commissioned, all piping and fittings shall be flushed clean.

High Density Polyethylene Water Supply Pipes

All high density polyethylene pipes shall have screwed ends and shall be jointed with screwed fittings of the same materials as that of the pipes. Any burrs remaining on the pipe ends after cutting threads shall be removed. If necessary, an approved jointing compound with a few strands of fine yarn may be used for jointing pipes and fittings. All exposed high density polyethylene pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1.0m. Pipe wherever installed in wall chasing, shall be fixed as in the case of galvanised steel pipes.

PVC Water Supply Pipes

All exposed pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1.0m. Pipe wherever installed in wall chasing, shall be fixed as in the case of galvanised steel pipes.

9.5 Sanitary Appliances

All sanitary appliances shall be fixed in position rigidly on floor and walls as indicated in the drawings or as directed by the Consultant. All appliances shall be from the approved manufacturer and of approved colour.

Indian Water Closet (IWC) - Squatting type

Squatting type water closet shall be fitted on trap and shall be jointed with gasket yarn and cement mortar. Rim of the pan shall be levelled properly and set flush with the finished floor. The pan shall be connected to PVC low level push button / lever type cistern of 10 litre capacity. The flushing cistern shall be supported on a pair of CI cantilever brackets firmly embedded in the wall in cement mortar (1:4) or screwed to wall with suitable plugs. The flush pipe from the cistern shall be 32mm dia tested quality chromium plated (CP) pipe and connected to the pan inlet by means of hemp and putty joint.

European Water Closet (EWC) - Pedestal type

Pedestal type water closet shall be rigidly fixed on the finished floor by means of 75mm long brass screws with suitable plugs. The flushing cistern shall be PVC low level push button / lever type cistern of 10 litres capacity. The cistern shall be supported on a pair of cast iron or rolled steel cantilever brackets firmly fixed on wall with brass screws and suitable plugs. The flush pipe from the cistern shall be 40mm dia chromium plated with brass end cap / lining and fitted to the closet by means of rubber adapter. The closet shall be provided with double plastic seat cover conforming to IS:2548 with chromium plated hinges.

Urinals

Standing type urinals shall be firmly fitted on finished wall by means of 50mm long brass screws and suitable plugs. Height of the lip from the standing point shall be as shown in the drawings. Urinals shall be fitted with automatic flushing cistern of 10/15 litres (2/3 urinals) capacity. Flushing pipes shall be of CP pipes of 25mm dia and connected to the urinal with 15mm dia PVC connector fitted with brass cap and lining at one end. The joint to the inlet of urinal shall be neatly finished with putty.

The arrangement of waste pipes and discharge to the floor trap shall be as shown on the drawings or as directed by Consultant. For single urinal, the discharge may be directly to the floor trap through a 40mm dia waste pipe. For a range of urinals, the discharge may be collected in a common waste pipe of 50mm dia leading to the floor trap. Each urinal shall be connected to the common discharge pipe by 40mm dia waste pipes. Alternatively, the discharge from each urinal through 40mm dia pipe shall be lead to the 100 mm glazed stone ware / vitreous china / CI half round channel laid on the floor leading to the floor trap.

Wash basin
Wash basin shall be fitted in position true to level on a pair of cast iron brackets fixed to the wall with brass screws and plugs. The basin shall be fitted with 15mm dia approved quality CP pillar tap and 32 mm dia waste fittings. The type of waste pipe and their connections shall be as shown in the drawings or as directed by the Consultant.

Sink
Stainless steel sink shall be levelled properly and fitted in position on a pair of cast iron cantilever brackets firmly embedded in the wall in cement mortar (1:4). The sink shall be fitted with chromium plated brass waste fittings of standard size. The type of waste pipes and their connections shall be as shown on the drawings or as directed by the Purchaser's Owner.

Other miscellaneous fittings (e.g. mirror, towel rails, soap cases etc.)
All such fittings shall be of type and sizes specified in General Technical Specification / Specific Technical And Functional Requirements Of Civil Systems, and shall be fitted in position true to line, level and plane as shown on the drawings or as directed by the Consultant.

Water Tanks
Water storage tanks shall be food grade PVC tanks of SINTEX brand or approved equivalent make, unless otherwise specified.

In case large volume tank is to be constructed, the same shall be of GI, Masonry or RCC. They shall be fitted with a ball valve of the inlet pipe. A mosquito proof overflow pipe shall be fixed to the tank with the pipe invert about 25 mm above the top of water line. Approved type of stop valve shall be provided for every outlet pipe. All outlet and inlet pipes shall be fixed as shown in the drawings. Inside surface of galvanised steel tanks shall be painted with anti-corrosive food grade paints.

All storage tanks, water supply fittings and pipes, before being put into commission, shall be disinfected with liquid chlorine by the Contractor.

9.6 Testing And Acceptance Criteria

Sanitary Appliances
All sanitary appliances and fittings shall be inspected and tested as per the requirements of IS:1742. All defects and deficiencies detected shall be promptly rectified by the Contractor to the satisfaction of Consultant.

Soil And Waste Pipeline
On completion of laying, the cast iron soil, waste and ventilation pipelines shall be tested by the Contractor to detect leakage and any other defects in the pipelines.

Test shall be conducted using proper apparatus with attachment for smoke making machine for applying smoke to the pipelines under pressure. Only cotton waste or brown paper soaked in creosote oil shall be used and fired to obtain dense and pungent smoke. While conducting smoke test, top of soil, waste and ventilation pipes shall be kept open till smoke starts coming out of the openings. The openings shall then be securely plugged with expanding rubber or any other approved plug. The floor traps and other openings for connecting sanitary fixtures shall be sealed with water or other approved plug. The entire pipeline shall be tested in suitable sections as directed by the Consultant. The entire length of the pipelines including all joints under test shall be closely observed for any sign of smoke leakage.

Galvanised Steel Water Supply Pipes
After the laying and fixing of all galvanised steel water supply pipes and fittings are completed, the line shall be slowly and carefully charged with water to a test pressure of 5 kg per sq. cm or the specified working pressure plus 50%, as may be prescribed by the Consultant. Care shall be taken that air in pipelines is completely exhausted while filling the pipelines with water. This pressure shall be maintained for at least one hour, unless otherwise specified.

10 METAL WORK

10.1 General

This chapter covers the various metal works such as, Rolling shutter, grills, steel doors, aluminium doors and windows, ventilators, Louvers, suspended ceilings, roof and wall cladding etc.

10.2 Standards

Unless otherwise specified herein. The following standards shall apply to the works covered by this chapter.

IS:733	Wrought aluminium and aluminium alloy bars, rods and sections (for general engineering purposes)
IS:737	Wrought aluminium and aluminium alloy sheet and strips for general engineering purposes.
IS:1038	Steel doors, windows and ventilators
IS:1361	Steel windows for industrial buildings
IS:1948	Aluminium doors, windows and ventilators
IS:1949	Aluminium windows for industrial buildings.
IS:3614	Specification for fire check doors
IS:4351	Specification for steel door frames
IS:6051	Code for designation of aluminium and its alloys.
Rolling Shutters	
IS:2108	Blackheart malleable iron castings

IS:6248	Specification for metal rolling shutters and rolling grills
Glazing	
IS:1081	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators
IS:2835	Flat transparent sheet glass
IS:3548	Code of practice for glazing in buildings
Builder's Hardware	
IS:204	Tower bolts (All parts)
IS:205	Non-ferrous metal butt hinges
IS:208	Door handles
IS:281	Mild steel sliding door bolts for use with padlocks
IS:363	Hasps and staples
IS:723	Steel countersunk head wire nails
IS:1823	Floor door stoppers
IS:2209	Mortice locks (vertical type)
IS:2681	Non-ferrous metal sliding door bolts for use with padlocks
IS:3564	Hydraulically regulated door closures
IS:3847	Mortice night latches
IS:4992	Specification for door handles for mortice locks (vertical types)
IS:6607	Specification for rebated mortice locks (vertical type)

10.3 Flush Steel Doors

General

Steel doors and pressed frames shall be made of 18g steel sheets. Frames shall conform to IS:4351

No joints shall be permitted in the steel sheets.

All steel doors shall be double-skinned construction with all necessary reinforcement for hinges, locks and other fixtures. The two skins of 18g minimum thick steel sheets shall be mechanically interlocked and bonded together to form an envelope, which shall be closed at the top and bottom with two steel channels, welded to the steel sheets.

Mineral wool or equivalent material approved by the Consultant shall be provided as insulation over the whole interior area of the door and shall be fixed with a plastic binder such that no part of the door may become uninsulated due to shocks, blows or long and repeated use of the door.

All doors shall be fitted with necessary best quality hardware and fixtures conforming to relevant IS specifications and shall be capable of withstanding repeated use.

Three steel butt hinges of 100 mm length shall be provided for each door leaf.

Steel frames shall be fixed to the masonry by steel sleeve anchor bolts M12 mm passing through holes of 25 mm diameter in the frame. Steel frames shall be fixed to the steel structure by screws.

The clearance of doors shall be 2.5 mm at jambs and heads

Steel frames shall be provided with door closer fitted with rubber cushions.

External doors shall have an external weather stop.

All fire exit doors shall be provided with panic latch system with horizontal bar action parallel to the door face moving in the direction of the door travel to provide

immediate exit in the event of fire or emergency whilst providing security against unauthorised entry.
Sign plates of anodised aluminium or galvanised steel shall be screwed to the door under the horizontal bar, on which the sign, “PUSH BAR TO OPEN" shall he printed.
The thickness of the normal steel door shall be 45 mm for both single and double doors.
All the above specified details shall be applied for normal steel doors, fire resistant steel doors and fire proof steel doors.
The contractor shall provide the Consultant with following documents for the steel doors:

- Detailed shop and construction drawings as well as the door schedules and samples of hardware.
- Detailed structural analysis of the proposed supplies.
- Test certificates proving conformity of the physical properties stipulated in this specification and relevant standards

10.4 Fire Resisting And Fire Proof Doors

Fireproof doors with panic devices shall be provided at all fire exit points as per recommendations of Tariff Advisory Committee (TAC). These shall conform to IS:3614 (Part I and Part II). Fire rating of doors shall be as per TAC requirement. However, minimum requirement shall be for two hours. Type of doors shall be double cover-plated type with mineral wool insulation.

10.5 Rolling Shutter (Hand Operated, Mechanical Gear Operated And Electrically Operated) and Grills

Rolling shutters shall be fabricated from 18 gauge steel and machine rolled with 75 mm rolling centres with effective bridge depth of 12 mm lath sections, interlocked with each other and ends locked with malleable cast iron clips to IS:2108. They shall be designed to withstand a wind load of 200 Kg/m2 without excessive deflection.
The guides shall be either rolled or pressed deep channel sections 75 mm and 25 mm wide fitted with necessary fitting and fixtures.
The suspension shaft shall be formed from heavy duty tubes conforming to IS:1161 and of sufficient diameter so as to resist deflection due to weight of the rolling shutter. The deflection shall not exceed 5mm / metre width. The shaft shall be provided with CI pulleys and helical springs for counter balancing the weight of the shutter adequately.
The springs shall be approved high tensile flat springs conforming to Grade 2 of IS:4454. These shall be fitted inside the fabricated housing at either ends, which counter-balance the shutter curtain.
The ball bearings shall be double row self-aligning ball bearings fitted inside CI housing fixed on side brackets holding the suspension shaft at either end. The roller assembly shall be designed so as to be capable of producing sufficient torque to ensure easy operation of the rolling shutter in any position. The spring tension shall be adjustable by means of suitable adjustment holes drilled on the rims of the pulley.
The hood cover shall be made of 20 gauge sheets with necessary stiffeners and framework to prevent sag. The bottom lock plate shall be made of 5 mm thick

M.S. plate and 95 mm wide, reinforced with angle/T iron of suitable section with 6 mm dia M.S. rivets interlocked with last stride of curtain.
The locking arrangement shall consist of sliding bolts at both ends of the bottom plate fitted to engage with suitable receiving pockets at the bottom of guide channels.
Unless otherwise specified, for overall area of rolling shutters up to 9 sq.m, pull and push type hand-operated shutters shall be used. For area between 9 and 12 sq.m, pull and push type shutters shall be provided with ball bearings. For area larger than 12 sq.m mechanical gear type or electrically operated shutters shall be supplied.

Rolling grills shall be constructed out of 6 mm dia. rods at 35 mm on centres running horizontally flexible connected with vertical links spaced not more than 200 mm centres. Alternatively, rolling grills shall be made from perforated slats of approved design reinforced with 6 mm dia. rods.

10.6 Folding Steel Doors

The folding doors shall be used for the entrance of machine halls, workshops and similar. The unit shall be manufactured as a top hung folding door of edged steel sheets and steel sections. Clear height of the pass-gate shall be not less than 2.00 m.
Door leaves shall be manufactured with double flush skin of steel sheet, min 1.5 mm thick, edged and welded to the case. The case shall be stiffened with steel section frame. Thickness of the leaves shall not be less 60 mm.
The door shall be constructed for one way normal manual usage under subtropical conditions for exterior openings in accordance with the architectural design.
The insulation material inside the door shall be fire resistant.
The fixing of the door frame to the wall or steel structure shall be carried out by means of flat steel anchors, size not less than 250/40/4 mm and steel bolts, dia. 8 mm, either cemented into the wall or screwed to the steel structure.
Three anchors shall be provided per 2.5 m length with a minimum of six (6) anchors per door frame.
Joints between doorframe and construction shall be sealed with permanent elastic compound where the door has to be fixed to steel structure.
The door shall be furnished with heavy sturdy-built hardware of corrosion protected steel consisting of:

- truck brackets
- intermediate hinges with nylon washers
- hangers with nylon wheels, ball bearing, lubricated for life incl. wheel centre pattern
- flush handles outside
- fold-aside butt hinges, min. three (3) per 2.5 m length
- door guides with end and centre pattern
- floor channel
- furniture, bolts and screws with all fittings

The door and frame shall be galvanised and coated by epoxy paint over galvanizing.

10.7 Steel Windows and Ventilators

These shall conform in all respects to IS: 1038, IS:7452 and IS: 1361 latest editions and as shown on drawings. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, pivot arrangements for ventilators, etc. or as shown on drawings or called for in the Schedule of Items.

All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit openings are shown on drawings, the individual window units shall be joined together with requisite transoms and mullions as shown on drawings. All windows shall be outside glazed fixed with putty or metal glazing beads as shown on the drawings and/or specified under Schedule of Items. Where aluminium glazing beads are specified they shall be extruded aluminium channel 9.5 mm x 9.5 mm x 1.6 mm (Indal Section No. 2209) unless otherwise shown on drawings. Aluminium beads shall be given one coat of zinc chromate primer before fixing to windows.

10.8 Aluminium Doors, Windows, Glass Walls and Louvers

Aluminium sections for doors, windows and glass walls shall comply with IS:1948 and IS:1949.

Aluminium doors, windows and glass walls as well as aluminium frames shall be anodised in accordance with relevant Indian Standards.

All hardware shall be of concealed construction in the aluminium frame and shall be made of stainless steel. Sections of aluminium profiles shall not be less than 50 mm deep.

All doors shall be provided with door closer, door stops.

Aluminium alloys shall be of uniform quality, free from defects impairing strength and durability with regularity of surfaces and accuracy of right angles.

Aluminium windows at high levels shall be fitted with mechanical devices of type approved by the Consultant to allow for opening of such windows from the ground level.

Marble sills of 30 mm thickness shall be installed under the windows.

Door and window elements shall be fixed to the structure by means of separate rectangular hollow galvanised steel or aluminium frame.

Joints of door and window frames to the walls shall be covered with aluminium angle on each side and they shall be sealed with permanent elastic material in accordance with the manufacturer's instructions. For air-conditioned rooms, the aluminium windows shall have double glazing.

The Contractor shall provide the following documents for all aluminium profile constructions:

- Detailed shop and construction drawings including the doors and windows schedule
- Detailed structural analysis of the proposed supplies
- Test certificates proving the conformity of the physical properties stipulated in the specifications and the relevant Standards stated herein

10.9 Master Key System

An appropriate serviceable and functional master key system for the whole plant shall be installed. The elaboration of the system itself shall be made in close co-ordination with the Purchaser /Consultant and only after obtaining the Purchaser's/Consultant's approval in writing shall the order of production be placed.

The following requirements shall be met:

- the general master key shall operate all locks
- the main key shall open all locks of one building
- the single key shall open the lock of a single room.

Necessary attention shall be paid to later extensions of the master key system, which shall be suitable for the entire plant including all final stages.

The profile cylinders shall be sea water resistant and shall suit all plant requirements. The material of the cylinders shall be of massive brass, nickel-plated with six security pawl studs.

The keys shall be made of material approved by the Purchaser / Consultant and shall have an engraved indication of the applicable key system and the building or door number.

Keys shall be supplied in the following numbers:

General master key	10	
Main keys	10	nos. per each building
Single keys	3	nos. per each door

10.10 Suspended Ceilings

Suspended ceilings shall be provided for control rooms, offices, conference rooms, corridors, etc.

The panels shall be 0.8 mm thick, stove enamelled, aluminium sheets

In general the size of the panels shall be 600 mm x 600 mm. Panels of closed appearance of 75 mm or 150 mm wide and length up to 6 meters could be used as directed by the Purchaser / Consultant.

The suspension system shall be of sufficient strength and rigidity to carry the panels.

The panels shall be supported by stove enamelled aluminium panel carriers.

The rod hangers shall be made of galvanised steel of 4 mm diameter (minimum).

The joints between the panels and the light fixtures and air supply ducts shall be smooth and regular.

Power driven fasteners shall be used for fixing the rod hangers in the reinforced concrete ceiling.

10.11 Room Designation Signs

The entrance to each room shall be furnished with a room designation sign on an anodised aluminium plate of 4mm thickness

Four horizontal grooves of 10 mm width at the lower end of the sign plate shall take plastic strips on which the designation will be printed in English language. At the upper portion the room number shall be engraved with a black background.

The designation sign plates shall be screwed to the wall with non-corroding screws.

10.12 Roof And Wall Cladding System

General

All structural steel buildings shall have insulated sandwich cladding or single uninsulated cladding for roofs and walls, depending upon the requirement.

The Contractor shall provide the Purchaser / Consultant with five (5) years guarantee of the roof and wall cladding.

Coating System

The roof and wall cladding shall be a multi-layered protected metal system consisting of a galvanised steel substrate, heavy epoxy base coat and a high build exterior weather coat of polyurethane as follows:

Substrate:	Hot-dipped galvanised steel, conforming to B.S.E.N 10143 Type G275, with a minimum zinc coating weight of 275 g/m2 total both sides.
Pre-treatment:	After cleaning, a chemical conversion of the zinc coating to a non-metallic surface with corrosion inhibiting and adhesive additives.
Primer:	Nominal 15 micron thick anti-corrosive pigmented epoxy primer applied to both sides.
Epoxy Barrier Coat:	Nominal 50 micron thick epoxy barrier coat applied to both sides and baked to a hard corrosion resistant finish.
External Weather coat:	40 microns thick polyurethane exterior coating of approved colour
Internal Decorative Coat:	A stoving polyester in approved colour.
Finish:	All sheets shall have an embossed finish.

The roof and wall cladding shall meet the following performance criteria:

Classification	Test	Minimum Test Performance
Physical and Environmental:	Humidity Resistance ASTM D-2247	No effect
Chemical and Environmental:	Abrasion Resistance(falling sand method ASTM D-968) Coating System Integrity (Salt Fog : ASTM B117)	375 litres of sand No effect

The above performance criteria shall be substantiated by test results certified by recognised independent testing authority.

Insulated Sandwich Cladding

The insulated roof and wall cladding shall be formed from trapezoidal sheeting and shall meet all specified design criteria.

Roofs

External Roof	:	Profile	: Trapezoidal
Weather Sheet		Thickness	: 0.70 mm
		Depth	: 38 mm
Internal Roof	:	Profile	: Trapezoidal
Sheet		Thickness	: 0.95 mm
		Depth	: 61 mm

Loadings : The cladding system shall be suitable for the loadings and shall meet the following criteria

Deflection	: Roof area	1/200 of span, except where roof slopes are below 5 degrees when the limiting deflection shall be 1/300 of the span

Walls

External wall	:	Profile	: Trapezoidal
Weather sheet		Thickness	: 0.70 mm
		Depth	: 38 mm
Internal Wall	:	Profile	: Trapezoidal
Sheet		Thickness	: 0.95 mm
		Depth	: 61 mm

The internal liner shall be formed from a trapezoidal galvanised sheet; the exposed face shall be painted.

Deflection	:	Wall area – 1/120 of the span.
Subgirts	:	1.5 mm thick 'Z' type galvanised subgirts shall be employed to create a space to accommodate the specified thickness of the insulation. The location of the subgirts shall be such that the external weathering sheets shall meet the specified design loads. The male side lap joints shall be sealed on site with suitable preformed mastic sealant.
Insulation	:	Mineral wool lightweight rolls conforming to the requirements of IS 8183 shall be fitted into the space created by the subgirts.
Thickness	:	80 mm
Density	:	24 kg/m3
Thermal Conductivity	:	0.40 w/m2K

Acoustic Requirements Of The Roof And Wall Cladding Constructions

The roof and wall cladding shall provide an acoustic attenuation factor through the construction of at least between R'w = 36 - 40 dB

Translucent Sheeting
Translucent sheeting shall be provided where required and fixed to the walls, located in continuous bands, comprising of two skins translucent sheeting supplied to match and overlap the specified external and internal profiled metal cladding and manufactured as follows:
Polyester resin reinforced with chopped-strand glass fibre mat and made in a continuous process generally in accordance with IS Standards. A film of tedlar polyvinyl flouride or melinex polyester is bonded chemically to the external weathering surface. Flashing and accessories to be provided.
Light transmission: approx. 60-65% for clear skins

End Laps
External weathering sheet:
Where the angles of the roofs are 7 degrees or below, the end laps shall be a minimum of 200 mm. On roof slopes in excess of 7 degrees, the end laps shall be a minimum of 150 mm.
On vertical areas the end laps shall be a minimum of 100 mm.
Internal liners:
End laps shall be 75 mm on the trapezoidal internal liners; the tray shall be butt-jointed.

Sealant
The cladding shall be sealed with a non-drying, non-corrosive permanently elastic pre-formed metal sealing tape capable of performing in a temperature up to 1000^{o}C.

Fixings
The external weathering sheet shall be secured to the galvanised subgirts or structural supports with stainless steel hexagon headed self-tapping screws, each with a integral EPDM (Ethylene Propalene Die Memonoma) washer bonded to a dished aluminium washer. The internal liners shall be secured to the supporting steel structure with galvanised self-tapping screws. Galvanised subgirts dependant on their type shall be secured with galvanised self-tapping screws or rivets.

Side lap fixings shall be blind rivets.
The cladding supplier shall submit calculations, which substantiate that his fixing allowances will meet the design loads.

Flashings
Flashings required in connection with the external weathering skin shall be formed from 0.70 mm thick material as specified for the roof and/or side wall cladding.
Flashings required in connection with the internal liner shall be constructed from 0.70 mm thick galvanised steel having a painted finish on the exposed face.

Corrugation Fillers
Profiled filler pieces shall be provided at all terminal positions on the roof and side wall areas. The fillers shall be of polyethylene foam and be immune to bird and insect attack.

Gutters / Rainwater Pipes

Design procedures shall be based on appropriate Indian Standards. The materials shall be either aluminium or zinc of suitable gauge, and the appliances and components shall comply with the requirements of the applicable Indian Standards.

Single sheet uninsulated roof and wall cladding

The roof and/or side wall uninsulated cladding shall be a trapezoidal profiled metal sheeting, protected on both sides by a multi-layer coating system, and shall meet all specified design criteria.

Roof Sheeting	:Thickness	: 0.95 mm
	Depth	: 61 mm
Wall sheeting	:Thickness	: 0.70 mm
	Depth	: 38 mm

Loadings :The cladding system shall be suitable for the loadings and shall meet the following criteria

Deflection	: Roof area	1/200 of span, except where roof slopes are below 5 degrees when the limiting deflection shall be 1/300 of the span
	Wall area	1/200 of the span

End laps	:	Where the angles of the roofs are 7 degrees or below the end laps, shall be a minimum of 200 mm. On roof slopes in excess of 7 degrees, the end laps shall be a minimum of 150 mm On vertical areas the end laps shall be a minimum of 100 mm
Sealants	:	The cladding shall be sealed with a non-drying, non-corrosive permanently elastic preformed metal sealing tape capable of performing in a temperature up to 1000 deg C.
Fixings	:	The cladding shall be secured to the structural steel supports with stainless steel hexagon headed self-tapping screw. Each complete with an integral EPDM washer bonded to a dished aluminium washer. Side lap fixings shall be blind rivets. The cladding supplier shall submit calculations which substantiate that his fixing allowances will meet the design loads.
Flashings	:	Shall be formed from 0.70 mm thick material as specified for the roof and/or side wall cladding.
Corrugation Closures	:	Profiled filler pieces shall be provided at all terminal positions on the roof and side wall areas the fillers shall be of polyethylene foam and be immune to bird and insect attack.

The roof and wall cladding shall be supplied from reputed manufacturer and suppliers subject to the Purchaser's/Consultant's prior approval.

11 MISCELLANEOUS METAL & ALLIED WORKS

11.01.00 Scope

This shall include supply, fabrication and erection of miscellaneous metal items of light nature in gates, grills, balcony and stair handrails particulars, structural mullions and transoms, ladders hangers masonry anchors, shelf angles, edge angles, inserts, pipe sleeves, stair nosing, anchor bolts, fasteners, etc. as shown on drawing or as instructed by the Owner. The above items shall be of fabricated or cast M.S/ Aluminium/ Brass, cast iron, M.S. and galvanised M.S. Sheets, aluminium sheets, expanded metal, wire mesh etc. as shown on drawings and/or described in the Schedule of Items.

11.02.00 Installation

11.02.01 Fabrication/Casting

a).*General*

All work shall be done according to approved shop drawings. All workmanship shall be equal to the best practice in modern structural or foundry shop.

b). *Shop Connections*

i) All shop connections shall be riveted or welded except when noted otherwise on drawings.

ii) Welding of steel shall be done in accordance with the IS : 816. Use of metal arc welding for general construction in Mild Steel.

iii) Welding of aluminium shall be done in accordance with IS: 2812, Arc welding of Aluminium and Alloys, Special care shall be taken to grind smooth all welded surface that shall remain exposed to view. Welds shall be electrically continuous if so required by the Owner.

*c).*Shop Coat

Before leaving the shop, all metal work shall be thoroughly cleaned by effective means of all loose mill/ scale, rust and foreign matter. Except where encased in concrete, all steelwork shall be given one coat of approved metal protective paint, applied by brush thoroughly and evenly, well worked into joints and other open spaces. All paint shall be applied to dry surfaces. When specified in Schedule, steel work shall be galvanised or galvanized and painted with a coat of zinc chromate primer. Aluminium surfaces which shall come in contact with masonry

shall be given one coat of zinc chromate primer.

11.02.02 Erection

a) Bracing

The Contractor shall provide all necessary temporary guys and braces to ensure alignment and stability of the members and to take care of all loads to which the structure may be subjected including erection of equipment and operation of the same.

b) Temporary Bolting-Up

As erection proceeds the Contractor shall plumb up and level all members and shall securely bolt up to take care of all dead load, wind load and erection stresses. Wherever piles of materials, erection equipment or other loads are carried during erection, proper provision shall be made to take care of the stresses resulting from the same.

c) Turned Bolt

For field connections where bolting is specified, holes for the turned bolts may be reamed in the field, if required. All drilling or reaming for turned bolts shall be done after the parts to be connected are assembled.

d) Welding

Where specified on drawings, welding shall be done in accordance with IS : 816 for steel and IS: 2812 for Aluminium and Alloys.

e) Cutting and Fitting

No cutting of sections, flanges, webs of angles shall be done without the approval of the Owner. Where indicated on the drawings, holes, cuttings, etc. shall be provided as required for installation, to the work by the other Contractors. No additional holes or cuttings, than those shown on drawings, shall be made without the approval of the Owner.

f) Drifting

Correction of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets may be permitted. For this, light drifting may be allowed to draw holes together. Twist drills shall be used to enlarge as necessary to make connections. Reaming that weakens the members or make 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 or a moderate amount or reaming and slight chipping and cutting shall immediately be called to the attention of the Owner and approval of the method of correction obtained. The use of cutting torches to enlarge or alter rivet holes shall not be permitted.

g) Grouting

All bearing plates, loose lintels and beams, etc. shall be set to proper grade and level by the Contractor and the Owner's approval obtained before proceeding with the grouting. Grouting shall be done in 1:1.5:3 or 1:1- 1/2:3 concrete with 6 mm down stone chips.

h) *Anchor Bolting*

When shown on drawings, the miscellaneous metal items shall be fixed to concrete by case hardened and drawn carbonizing steel expander nut and bolt. The Contractor shall submit the manufacturer's literature showing the average pull out and average shear values for bolts of various sizes. The bolts shall be fixed strictly as per the manufacturer's instructions.

i) *Pipe Joints*

M.S. Pipes shall be joined by threaded sockets or by welding. Cast iron pipes shall be socket and spigot jointed and caulked with hemp and molten lead.

j) *Spot Painting*

All field rivets and bolts and also any serious abrasion to shop paint shall be spot painted with the same materials as used for the shop paint or equivalent.

k) *Making Good*

All cutting to concrete or masonry shall be made good to the satisfaction of the Owner.

11.03.00 Acceptance Criteria

a) All items shall be of correct shape, size, weight etc. shown on drawings and schedule of items.

b) For installed items, the tolerances shall be follows :

i) Permissible deviation from straightness - 1 in 1000.

ii)Seats, stiffener connections etc. shall be as per approved drawings and shall not interfere with architectural clearances.

c) All castings shall be free from blow holes, cracks and other blemishes.

11.04.00 I.S. Codes

IS : 226 - Structural Steel (Standard Quality)

IS: 800 - Code of practice for use of structural steel in general building construction.

IS : 816 - Use of metal arc welding for general construction in mild steel.

IS : 2812 - ARC WELDING OF ALUMINIUM AND ALLOYS

IS : 3150 - HEXAGONAL WIRE NETTING

IS:4948 - Welded steel wire fabric for general use.

12 JOINERY

12.1 General

This chapter covers the joinery for permanent works i.e. excluding formwork, shuttering and wood scaffolding.

12.2 Standards

Unless otherwise specified herein, the following standards shall apply to the works covered by this chapter.

IS:399	Classification of commercial timber and their zonal distribution.
IS:303	Ply wood for general purpose.
IS:451	Technical supply conditions for wood screws.
IS:723	Steel countersunk head wire nails.
IS:883	Code of practice for designing of structural timber in buildings.
IS:1003	Timber panelled and glazed shutters.
IS:2191	Wooden flush door shutters (cellular and hollow core type).
IS:2202	Wooden flush door shutters (solid core type).
IS:2366	Code of practice for nail jointed timber construction.
IS:4021	Timber door, windows and ventilator frames.

12.3 Material

Timber for joinery

All timber shall be best quality well seasoned specified wood free from large or loose knots, crack or other defects complying with relevant Indian standards. Hardwood shall be properly seasoned and free from brittle heart, rot, stain and beetle attack.

Plywood

Plywood shall comply with IS:303. The thickness of plywood shall be 6 mm.

Screws and nails

Screws shall be stainless steel or brass. All nails for external permanent work shall be sherardised steel. Screw and nails shall comply with Indian Standards.

Timber Doors

All doors shall be of solid core with minimum thickness of 44mm.The core shall consist of fully glued laminboard / block board of reverse straight grain timber strips each of which shall be continuous through the height of the door except for 150 mm rails top and bottom. The core shall be planed true overall to receive plywood facing.

All doors shall have 150 mm 1st class hardwood rails for the full thickness and width of core as well as around all openings to cover the end grains of the laminboards. The plywood facing on both sides shall be well matched teak or commercial 3 ply veneering with vertical grains or cross bands having minimum thickness of 6 mm as per requirement. Hardwood lipping of the same timber as the face veneer shall be provided at all edges of the door as well as to the opening for glazing.

All doors shall be covered by natural veneer.

Doorframes shall be minimum 50mm thick and 125 mm wide. They shall be fixed to the RCC / masonry frames around the door by screws / holdfasts (MS strip lugs) and shall be provided with adequate rubber sealing. The minimum number of fixtures shall be five screws or three holdfasts on each side of the frame. Holes for screws shall be drilled with a rotary drill and filled with wooden plugs, rawl plugs or hold fasteners.

Clearance of doors shall be 3 mm at jambs and heads.

All hardware shall be heavy duty of non-corroding materials (stainless steel / anodised aluminium / oxidised copper / brass).
Each door leaf shall be furnished with the following:

- 3 hinges preferably 140 mm high pivoted with ball bearings
- 1 heavy door lock with profile cylinder for master-key system
- 2 stainless door level handles of 125 mm
- 2 stainless door handle plates or roses
- 1 door stop sealed with PVC or rubber strips to reduce impact sound
- Toilet room doors shall be provided with automatic door closer.

13 GLAZING

13.1 General

This chapter shall apply to all parts of the works in which glazing will be used.

13.2 Standards

Unless otherwise specified herein, the following standards shall apply to the works covered by this chapter.

IS:1081	Code of practice for fixing and glazing of metal (steel and aluminium) door, window and ventilators.
IS:2553	Safety glasses.
IS:2835	Flat transparent sheet glass for glazing and framing purposes.
IS:3548	Code of practice for glazing in buildings.

13.3 Acoustic Requirements

The glazing shall provide an acoustic attenuation factor according to the functional requirement and as per relevant Indian Standards.

13.4 Materials

General

The thickness and type of the glass should meet the acoustic requirements, serviceability and adequacy to the purpose of the glazing. The minimum thickness of glass of the various types shall be 5 mm for openings of areas of less than two square meters, and 6mm for openings of areas of two square meters and more. All air-conditioned rooms shall have double glazing. The Contractor shall submit samples of each different type of glass to the Consultant for approval.
Unless otherwise specified herein the types of glass shall comply with IS:2553 and IS:2835.

Solar control glass

Solar control glass shall be formed from two panes of glass bonded together with a lamination between them of thin metallic film vacuum deposited on the inner surface of one of the panes in accordance with relevant IS standards.

Wired glass

Wired glass shall be polished on both sides and shall be transparent, complying with IS:5437. It shall be square pattern wired. The wired glass will be used for doors and windows etc. and also used in fire resistant doors of up to 30 minutes resistance.

Multiple glazing units
Multiple glazing shall be formed from two or more panes of glass separated by a profiled aluminium spacer with the compete periphery of the unit sealed by the application of a highly impervious moisture vapour resistant polysulphide material.

Multiple glazing with solar control
Multiple glazing with solar control shall have the same properties as multiple glazing units except the inner pane shall be clear float glass and the outer pane solar control glass.

Putty
Putty for glazing to wood shall be linseed oil putty in accordance with relevant IS standards.

13.5 Execution Of The Work
Glazing and fixing techniques for glass, handling and care on site shall be generally in accordance with IS:3548. Outer glazing shall be rain-proof. For metal and aluminium frames, structural U-channel gaskets of synthetic rubber (neoprene) shall be use as sealing strips.

14 PAINTING

14.1 General
This chapter covers the preparation of surfaces, application of paints and making good any defects. Unless otherwise specified herein, the procedures and workmanship of painting shall be carried out in accordance with relevant IS codes.

14.2 Standards
Unless otherwise specified hereinafter, the following standards shall apply to the works covered by this chapter.

White washing, colour washing and distempering	
IS:427	Distemper, dry, colour as required.
IS:428	Distemper, oil emulsion, colour as required.
IS:6278	Code of practice for white washing and colour washing.
Painting	
IS:5	Colours for ready mixed paints and enamels.
IS:102	Ready mixed paint, brushing, red lead, non-setting, priming.
IS:123	Ready mixed paint, brushing, finishing, semigloss, for general purposes.
IS:1477	Code of practice for painting of ferrous metals in buildings.
IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming.
IS:2338	Code of practice for finishing of wood and wood based materials.
IS:2339	Aluminium paint for general purposes in dual container.

IS:2395	Code of practice for painting concrete, masonry and plaster surface.
IS:2932	Enamel, synthetic, exterior, a) undercoating, b) finishing.
IS:2933	Enamel, exterior, a) undercoating, b) finishing.
IS:5410	Specification for cement paint, colour as required.
IS:5411	Specification for plastic emulsion paint.

14.3 Preparation of Surfaces

General

All surfaces to be painted shall be smooth, even and free from dirt or rubbish and shall be dry and protected from dampness. In general, all surfaces shall be free of any material which will adversely affect the adhesion or appearance of paint.

Plaster surface

All defective plaster shall be cut out and trimmed. All holes in internal plaster faces shall be made good with approved material. All dirt and powdery substrate shall be removed by wiping with slightly damp cloth.

Concrete surface

All laitance shall be removed by wire brush . All holes, defects shall be filled and repaired by epoxy grouts.

New metal surface

All dust and/or mill scale etc. shall be removed with a wire brush or chipping hammer or grinding if necessary. The surface of the metal work shall then be primed with an approved metal primer before application of the undercoat.

Galvanised surface

Pre-treatment of the galvanised surfaces including etch-cleaning and coating shall be carried out as per requirement. Sweep blasting or emery paper may be used to roughen the galvanised surface to get better anchor pattern.

Wood surface

All iron mongery shall be removed prior to the preparation of surfaces and shall be re-fixed upon completion of painting. All knots and resinous parts in wood surfaces shall be treated by two coats of shellac varnish. All cracks and holes shall be treated by one coat of primer and filled with approved filler.

14.4 Painting Systems

Emulsion paints

Emulsion paints shall be used for internal cement plastering and internal fair faced concrete of walls and ceilings. All emulsion paints shall be washable.

One coat of Acrylic primer sealer

Two coats of filler based on alkaline resistant polyvinyl-acetate

Two coats of polyvinyl-acetate emulsion flat finish

Oil Bound Distemper
Oil bound distemper (IS: 428), of approved make shall be used for internal cement plastering and internal fair faced concrete of walls and ceilings. Two or coats of distemper, as found necessary shall be applied to obtain even shade.

Water proof Cement Paint
It shall be made from best quality white cement and lime resistant colours with accelerators, water proofing agents and fungicides. The paint shall conform to IS: 5410.

Oil paints
Oil paints shall be used for wood surface and internal cement plastering and internal fair faced concrete in confined humid areas such as bathrooms.
One coat of Acrylic primer sealer
Two coats of filler based on alkaline resistant polyvinyl-acetate
Two finish coats based on alkyd resins

Varnishes
Varnishes shall be used for wood surfaces and shall be of one of the following types

- polyurethane varnish
- synthetic varnish of linseed oil alkyd resin

Other systems of paints
Oil resistant paints shall be epoxy paint resistant to all types of oil. Paints for steel and galvanised surfaces are specified in Section 5.14

14.5 Application Of Paints (General)

Before applying the paint, all prepared surfaces shall be dry and clean. All priming paints shall be applied by brush except for etch primer which may be applied by brush or spray. Paints shall be applied as evenly as possible to provide a smooth coating of uniform thickness. Damaged areas of priming coats or undercoats shall be made good before further coats of paints are applied. The various coats of paint shall be distinguishable from each other by their shade. The Contractor shall inform the Consultant in good time before starting to apply the next coat so that the Consultant shall have the opportunity of approving the previous coat. Painting systems shall not be carried out at temperature below 50C or above 450C. Trial coats shall be prepared at the request of the Consultant. The Contractor shall, upon completion, remove all paint where it has been spilled, splashed or spattered on surfaces including sanitary fixtures, glass and hardware. It shall be removed without marring the surface finish of the item being cleaned.

15 TILING AND FLOORING

SCOPE

This specification covers furnishing, installation, finishing, curing, testing, protection, maintenance till handing over various types of floor finishes and allied items of work as listed below:

a) In Situ Finishes

i) Integral finish to concrete base

ii) Red Oxide of Iron finish

iii) Terrazzo finish

iv) Granolithic finish

v) Patent Stone

vi) Metallic Hardener like "Ironite" finish

vii) Mastic Asphalt finish

viii) Chemical Resistant finish

b) Tiled Finishes

i) Terrazzo tile

ii) Chequered tile

iii) Glazed tile

iv) Tesserae (Mosaic etc.)

v) Chemical Resistant

vi) Rubber, Vinyl etc.

vii) Stone slab

Standards
Unless otherwise specified herein, the following standards shall apply to the works covered by this chapter.

IS:777	Specification for glazed earthenware wall tiles.
IS:2114	Code of practice for laying in situ terrazzo floor finish
IS:2571	Codes of Practice for laying in-situ concrete flooring
IS:3461	Specification for PVC Asbestos floor tiles.

IS:3462	Specification for unbacked flexible PVC flooring.
IS:4457	Ceramic unglazed vitreous acid-resistant tiles
IS:5318	Code of practice for laying PVC flooring.
IS:5491	Code of practice for laying in-situ granolithic concrete floor topping

15.01.00 Base

The base to receive the finish is covered under other relevant specifications.

15.02.00 Sequence

Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Owner in view the activities of other agencies working in that area. However, the Contractor for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damage whatsoever till handing over.

15.03.00 Installation

15.03.01 Special Materials

Basic materials are covered under Specification "Properties Storage and Handling of Common Building Materials". Special materials required for individual finishing items are specified under respective items. In general, all such materials shall be as per relevant I.S. Codes where available. In all cases these materials shall be of the best quality available indigenously, unless specified otherwise.

The materials for finishing items must be procured from well-reputed specialised manufacturers and on the basis of approval of samples by the Owner. The materials shall be ordered, procured and stored well in advance to avoid compulsion to use substandard items to maintain in the construction schedule.

15.03.02 Workmanship

Only workers specially experienced in particular items of finishing work shall be engaged, where such workers are not readily available, with the Owner's permission, experienced supervisors recommended by the manufacturer shall be engaged. In particular cases where the Owner so desires the Contractor shall get the finishing items installed by the manufacturer.

15.03.03 Preparation of the Base Surface

The surface to be treated shall be thoroughly examined by the Contractor. Any rectification necessary shall be brought to the notice of the Owner and his approval shall be taken regarding method and extent of such rectification work.

For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall be adequately roughened by chipping, raking out joints and

cleaning thoroughly all dirts, grease etc. with water and hard brush and detergent if required, unless otherwise directed by the manufacturer of any special finishing materials or specifically indicated in this specification under individual item.

To prevent of water from the finishing treatment the base shall be thoroughly soaked with water and all excess water mopped up.

The surface shall be done dry where adhesives are used for fixing the finishes.

Prior to commencement of actual finishing work the approval of the Owner shall be taken as per the acceptability of the surface.

15.04.00 In Situ Finishes

15.04.01 Integral Finish to Concrete Base

While the surface of the concrete laid as per specification for 'Cement Concrete' has been fully compacted and levelled but the concrete is still green a thick slurry made with neat cement shall be applied evenly and worked in with iron floats. When the slurry starts to set it shall be pressed with iron floats to have a firm compact smooth surface without trowel mark or undulations. This finish shall be as thin a possible by using 2.2 kg. of cement per sq.m. of area.

The surface shall be kept in shade for 24 hours and then cured for at least 7 days continuously by flooding with water. The surface shall not be subjected to any load or abrasion till 21 days after laying.

As desired by the Owner the surface, while still 'green' shall be indented by pressing strings. The marking shall be of even depth, in straight lines and the panels shall be of uniform and symmetrical patterns.

15.04.02 Red Oxide of iron finish

It shall consist of an underbed and a topping over already laid and matured concrete base.

a) Thickness

Unless otherwise specified the total thickness of the finish shall be minimum 50 mm or as per schedule of item for horizontal and 20 mm or as per schedule of item for vertical surface of which the topping shall (not less than 10 mm) while the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project out 6 mm from the adjacent plaster or other finishes. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All junctions of vertical with horizontal shall be rounded neatly to uniform radius off 25 mm.

b) Mix

i)Underbed

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 2 parts coarse sand and 4 parts 10 mm down graded stone chips by volume. For vertical and similar surfaces the mix shall consist of 1 part cement to 3 parts coarse sand by volume.

ii)Topping

For the topping cement, screened through a fine mesh and red oxide of iron pigment powder similarly screened shall be dry mixed thoroughly in right proportions to produce the desired colour when laid. The mix shall then be prepared with 1 part cement (mixed with pigment) and 3 parts coarse sand by volume. The whole quantity required for each visible area shall be prepared in one batch to ensure uniform colour.

c) Laying

The underbed shall be laid in panels of mixing area 5 Sq.M. each and no side shall be more than 2.5 along. For outdoor locations the maximum area shall be 2.0 Sq.M. The forms for the panels shall have perfectly aligned edges to the full depth of the total thickness of finish. If specified aluminium or glass dividing strips shall be used.

The panels shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid until the contraction of the latter has taken place. The underbed shall be laid, compacted, levelled and brought to proper grade with a screed or float. The topping shall be placed after about 24 hours while the underbed is still somewhat 'green' but firm enough to receive the topping. The surface of the underbed shall be roughened for better bonding. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water to achieve a compact dense mass fully bonded with the underbed. The topping shall then be levelled up by trowelling and finished smooth with a slurry made with already prepared cement and pigment mixture. About 2.0 kg. of the mixture shall be consumed/per sq.m. for horizontal surface, and 1.0 kg. for vertical surface. The surface shall be cured for seven days by keeping it moist.

d) Polishing

About 36 hours after laying when the surface has hardened sufficiently it shall be polished with polishing stone till a smooth shiny surface to the satisfaction of the Owner, is achieved. The finish shall be washed and cleaned just before handing over.

15.04.03 Terrazo Finish : In Situ

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

a) Thickness

Unless otherwise specified the total thickness of the finish shall be minimum 50 mm for horizontal and 20 mm or as per schedule of items for vertical surface of which the topping shall be not less than 10 mm or as per schedule of items. While the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project cut 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

b) Mix

i) Underbed

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 1.½ Parts sand and 3 parts stone chips by volume. For vertical surfaces the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10 mm down well graded. Only sufficient water to be added to give a workable consistency.

ii) Topping

The mix for the topping shall be composed of cement, colour pigment, marble dust and marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour texture and pattern approved by the Owner. The cement shall be white or grey or a mixture of the two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture 1 part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 1½ parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and nonfading. It must be very finely ground. The marble powder shall be from white marble and shall be finer than IS Sieve No. 30. The size of marble chips may be between 1 mm to 20 mm.

Sufficient quantity to cover each visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.

c) Laying

The underbed shall be laid in panels. The panels shall not be more than 5 Sq.M. in area of which no side shall be more than 2.5 M long. For exposed locations the maximum area of a panel shall be 2.0 Sq.M. The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of underbed plus topping.

After laying, the underbed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still somewhat "green" but firm enough to receive the topping. A slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be trowelled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in a even pattern of distribution.

d) Curing

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

e) Grinding and Polishing

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no. 60) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. The surface shall be cured for 7 days by keeping it moist and then ground with fine grit blocks (no. 120). It shall again be cleaned with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for 5 days. Finally, the surface is ground a third time with very fine grit blocks (no. 320) to get smooth surface without any pinhole. The grinding shall be done by a suitable machine. Where grinding machine can not be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no. 60), second rubbing with medium grade (no. 80) and final rubbing and polishing with fine grade (no. 120).

The surface shall be cleaned with water, dried and covered with soil free, clean sawdust if directed by the Owner. The final polishing shall be postponed till before handing over if desired by the Owner. Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. per. sq.m. water

sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. However, all excess wax polish to be wiped off and the surface to be left glossy but not slippery.

15.04.04 Granolithic Finish

Granolithic finish shall either be laid monolithically over base concrete or separately over hardened base concrete.

a) Thickness

The finish shall be average 20 mm and minimum 12 mm thick, unless specified otherwise.

b) Mix

The mix shall consist of 1 part cement : 1 part coarse sand : 2 parts coarse aggregate by volume. The coarse aggregate shall be very hard like granite and well graded between 6 mm and 12 mm. Minimum quantity of water to get workability shall be added.

c) Laying of Monolithic Topping

The concrete base shall be laid as per specification "Cement Concrete" and levelled upto the required grade. The form shall remain sufficiently protruding to take the finish.

Within about 3 hours of laying the base while it is still fully "green" the topping shall be laid evenly to proper thickness and grade. If considered necessary the surface of the base shall roughened by wire brushing. Unless manual operation is permitted by the Owner, mechanical vibrators of suitable design shall be used to press the topping firmly and work vigorously and quickly to secure full bond with concrete base.

The laitance brought to the surface during compression shall be removed carefully without disturbing the stone chips. The surface shall then be lightly trowelled to remove all marks. When sufficiently set, hand trowelling shall be done to secure a smooth surface without disturbing the stone chips.

For large areas the laying shall be in panels of maximum 25 Sq.M. area. The panels shall be laid in chequered board pattern.

d) Laying of Topping Separately on Hardened Base.

The base concrete shall be prepared as stated in clause 15.04.03 and a slurry of neat cement applied just prior to laying the granolithic concrete mix (1:1:2). The method of compaction etc. shall be same as for monolithic topping.

e) Curing

Immediately after laying, the finish shall be protected against rapid drying. As soon as the surface had hardened sufficiently, it shall be kept continuously moist for at least 10 days by means of wet gunny bags or pounding of water on the surface. The floor shall not be exposed to heavy traffic during this period.

f) Grinding

If grinding is specified, it shall start only after the finish has fully set. Clause 15.04.03 (e) shall be followed. However, the ultimate polish required shall be decided upon by the Owner.

g) Finishing

Where specified, sodium silicate or magnesium or zinc silico fluoride treatment shall be done. The number of coats to be applied shall be as specified in the Schedule of Items. The concentration and method of application of the solutions shall be as specified in IS:5491.

15.04.05 Patent Stone

It shall consist of an underbed and a topping laid on an already laid and matured concrete base.

a) Thickness

The patent stone finish shall have thickness as stipulated under clause 15.04.03(a) except that the topping shall be 6 mm thick.

b) Mix

i)Underbed

The mix shall be as stipulated under clause 15.04.03 (b).

ii)Topping

The mix for the topping shall consist of 1 part cement and 1 part fine sand by volume.

c) Laying

The Patent Stone finish, including the underbed shall be laid in alternate bays or in chequered board pattern. No panel shall be as in contact with another already laid till the contraction of the latter has already taken place.

The maximum area of each panel shall be 3 Sq.M. of which no side shall be more than 2 M long.

A cement grout shall be applied and worked into the surface to receive the finish, the underbed then laid, compacted and levelled to proper grade with a screed or float. The topping shall be applied evenly on the underbed while it is not fully set but firm enough and rolled and pressed to get full bond. The topping shall trowelled to a dense finish to the satisfaction of the Owner. All trowel marks shall be mopped out with a soft cloth to give a clean smooth surface.

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing. If desired the finish shall be polished as directed by the Owner.

15.04.06 Metallic Hardener Like "Ironite" Finish

This will consist of a topping (incorporating iron particles) to bond with concrete base while the latter is "Green".

a) Thickness

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth.

b) Material

The hardening compound shall be uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand soluble alkaline compounds or other injurious materials. When desired by the Owner, actual samples shall be tested.

c) Mix

Proportion of the metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction 1 part metallic hardener shall be mixed dry with 4 parts cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in proportion of 1 part cement (mixed with hardener) to 2 parts of stone chips by volume and uniformly mixed. Minimum quantity of water shall be added to make it workable.

d) Laying

The concrete floor shall be laid as per specification "Cement Concrete" and levelled upto the required grade. The forms, if any shall remain sufficiently projecting to take the finish. The surface shall be roughened by wire brush as soon as possible.

The finish shall be laid while the concrete underbed is still very "green" within about 3 hours of laying of the latter. The finish shall be of uniform thickness and even dense surface without trowel marks, pin holes etc. This topping layer shall be pressed firmly and worked vigorously and quickly to secure full bond with the concrete base. Just when the initial set starts the surface shall be finished smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

15.04.07 Mastic Asphalt Finish

This is a one layer treatment on concrete or brick base.

a) Thickness

The thickness shall be as specified in the drawing or schedule of items.

b) Materials

Bitumen shall be industrial bitumen of the grades 90/20 and 75/20 conforming to IS:702.

Mineral filler shall be dry stone dust passing through 75-micron IS Sieve.

Fine aggregate shall be crushed and graded natural lime stone or other hard-work.

Coarse aggregate shall be crushed siliceous stone or other approved aggregate 6 mm stone chips shall be used for finish upto 20 mm thick and 10 mm chips for thicker finish.

c) Composition

Bitumen mastic shall conform to IS:1195 and shall be either brought to site in blocks weighing about 25 Kg. or prepared at site. If brought in blocks, these shall be remelted in mechanically agitated mastic cookers and coarse aggregate, preferably preheated fed in successive portions until the complete change is thoroughly incorporated. At no stage during the remelting and mixing process, shall the temperature exceed 205^{o} C.

d) Laying

The hot mastic shall be laid on dry base surface cleaned thoroughly by wire brushing and sweeping. The mastic shall be levelled and when cooled to some extent shall be finished with a wooden float with addition of small quantity of fine sand if required. No load shall be allowed till the finish has cooled to normal temperature.

The mastic shall be laid in suitable panels of about 20 Sq.M. in area each formed by formers. Succeeding panels shall be laid overlapping the finish panel so as to melt its edges and form a continuous finish without joint.

15.04.08 Chemical Resistant in Situ Finish

Chemical resistant in situ finish shall be an epoxy resin with suitable filler material over a primer or called for in the Schedule of Items. The minimum thickness shall be 6 mm. About its performance the Owner shall have to be fully satisfied by test results and examination of similar treatment already in existence. The Contractor shall get it done by a specialised manufacturer, get guarantee of performance from the organisation and pass it on to the Owner in addition to his own guarantee.

15.05.0 Tiled Finish

These shall include finish tiles, stone slabs and similar manufactured or natural items over already laid and matured base of concrete or masonry by means of an underbed or an adhesive layer.

15.05.01 Terrazzo Tile Finish

The finish will consist of manufacture terrazzo tile and an underbed.

a) Thickness

The total thickness including the underbed shall be minimum 40 mm for floors 30 mm for walls unless otherwise specified.

The skirting, dado and similar vertical surfaces shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the tiled finish, to accommodate the specified thickness shall be done.

b) Tiles : Terrazzo

The tiles shall, unless specifically permitted in special cases be machine made under quality control in a shop. The tile shall be pressed hydraulically to a minimum of 140 Kg. per Sq.Cm.

Each tile shall bear on its back permanent and legible trade mark of the manufacturer. All angles of the tiles shall be right angles all arises sharp and true, colour and texture of the wearing face uniform throughout. Maximum tolerance allowance length and breadth shall be $\pm$ 1 mm and the thickness $\pm$ 3 mm. Face of the tile shall be plane, free from pin holes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 10 mm.

The total thickness including the topping shall be as specified but not less than 20 mm in any case.

The backing shall be composed of 1 part ordinary grey cement and 3 parts of stone chips by weight mixed with water.

The topping shall be as specified under clause 15.04.03 (b).

The tile shall be cured at the shop for at least 14 days before delivery to the site. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be carefully stored to prevent staining by damp, rust, oil, and grease or other chemicals.

Tiles made in each batch shall be kept and used separately so that colour of each area of the floor may remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers for the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

c) Mix : Underbed

The underbed for floor and similar horizontal surfaces shall be 1 part lime putty : 1 part surkhi : 2 parts coarse sand by weight mixed with sufficient water to form a stiff workable mass. For skirting and dado and all vertical surfaces it shall be about 12 mm thick and composed of 1 part cement and 3 parts coarse sand by weight.

d) Laying

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The surface shall be roughened for better bond. Before the underbed had time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and the tiles shall immediately be placed upon and firmly pressed by wooden mallet on to the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match the dimensions these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Owner taken.

At the junction of horizontal surface with vertical surface the tiles on the former shall enter at least 12 mm under the latter.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 7 days. Heavy traffic shall not be allowed.

If desired dividing strips as specified under Clause 15.04.02 (c) may be used for dividing the work into suitable panels.

c) Grinding and Polishing

Procedure shall be same as Clause 15.04.03(e) . Grinding shall not commence earlier than 14 days after laying of tiles.

15.05.02 Chequered Tile Finish

The finish shall consist of manufactured grey or coloured cement tiles or terrazzo tiles with chequered face and an underbed laid over concrete or brick surface.

a) Thickness

Thickness shall be same as in clause 15.04.03(a)

b) Tiles : Chequered

The tiles shall have chequers not less than 2.5 cm. c/c and not more than 5 cm c/c, Depth of grooves shall be not less than 5 mm. The grooves shall be uniform and straight.

The tiles shall conform to clause 15.05.01 (b) except that these may have the topping in terrazzo or plain grey cement or colour pigment added to cement as specified.

c) Underbed

As per clause 15.04.03 (c).

d) Laying

As per clause 15.04.03 (d)

e) Grinding and Polishing

As per clause 15.04.03 (e) except that the tiles shall be ground and polished by hand after laying taking special care in polishing the grooves properly and uniformly.

15.05.03 Glazed Tiles Finish

This finish shall be composed of glazed earthenware tiles with an underbed laid over a concrete or masonry base.

a) Thickness

The total thickness shall be between 20 mm and 25 mm including the underbed.

The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish, to accommodate the specified thickness shall be done.

b) Tiles : Glazed

The tiles shall be of earthenware, covered with glaze white or coloured, plain or with designs, of 200 mm x 200 mm nominal sizes and 10 mm thick unless otherwise specified. The tolerance shall be $\pm$ 1.5 mm for length and breadth and $\pm$ 0.5 mm for thickness specials like internal and external angles, beads, covers, cornices, corner pieces etc. shall match. The top surface of the tiles shall be glazed with a gloss or matt unfading stable finish as desired by the Owner. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in textures, dense and homogeneous. The tiles shall be strong and free from flaws like cracks, craze, specks, crawlings, etc. and other imperfections. The edge and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar.

The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

c) Mix : Underbed

The mix for the underbed shall consist of 1 part cement and 3 parts coarse sand by weight mixed with sufficient water or any other mix if specified.

d) Laying

Same as clause 15.04.02 (d).

e) Finishing

The joints shall be cleaned and flush pointed with white cement and cured for 7 days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully and wiped with soft cloth to prevent scratching before handing over.

15.05.04 Tesserae Finish (Mosaic etc.)

This finish consists of manufactured vitreous, glass, ceramic or similar hard small pieces set in an underbed over a concrete or masonry surface, already laid.

a) Thickness

The total thickness including the underbed shall be between 16 mm and 25 mm.

b) Tesserae Finish

These shall usually be 6 mm thick small piece of ceramic vitreous china, tinted glass or similar hard wearing, strong and durable material in desired shapes and sizes and patterns.

The supply shall come in the desired pattern in full or sections conveniently for handling, stuck to pieces of strong thick paper on the surface to be exposed. The gum used for this purpose must be water soluble and non-staining. The sections shall be properly marked to avoid mistakes and master drawing shall be available at the site for guidance.

c) Mix : Underbed

Same as clause 15.04.03(b)

d) Laying

The specification for laying if given by the manufacturer of the item shall be followed provided it is approved by the Owner. Otherwise clause 20.04.03(d) shall generally be followed. However, instead of grey cement the slurry shall be made with white cement to fix the panels. The paper mounted patterns in sections shall be carefully placed and pressed in position true to lines and levels. Earliest possible the paper shall be peeled off and surface examined and cleaned, joints flush pointed with white cement and cured for 7 days by keeping it wet.

15.05.05 Chemical Resistant Tiled Finish

This shall include all varities of special tiles used for specific chemical resistance function and an underbed over already laid concrete or masonry.

a) Tiles

The chemical resistant tiles as detailed in the Schedule of items shall be of the best indigenous manufacture unless otherwise specified and shall be resistant

to the chemical described in the Schedule of Items. The tiles shall have straight edges, uniform thickness, plain surface, uniform nonfading colour and textures.

Glazed tiles if permitted to act as chemical resistant finish shall be considered under clause 15.04.03.

Usually the chemical resistant tiles shall not absorb water more than 2% by weight. The tiles shall have at least compression strength of 700 Kg/Cm2. The surface shall be abrasion resistant and durable.

b) Laying

The mortar used for setting or for underbed the tiles shall be durable and strong. The grout which shall be to the full depth of tile shall have equal chemical resistant properties. Joints shall be pointed if so desired. The setting and fixing shall be according to the manufacturer's specification approved by the Owner.

15.05.06 Rubber, Vinyl or Vinyl Asbestos Tiles Finish

This shall include various types of tiles manufactured from rubber, vinyl, etc. set with a adhesive on concrete or masonry base. An underbed may be required to secure desirable surface and grade.

a) Thickness

The thickness of the tiles shall be mentioned in the Schedule or in drawing.

b) Tiles

Unless otherwise desired the tiles shall be squares of approved dimensions. The tolerance in dimensions shall be $\pm$ 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or either physical defects which affect appearance or serviceability. All edges shall be cut true and square. The colour shall be nonfading and uniform in appearance, insoluble in water and resistant to alkalies, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trade mark, the thickness, sizes, batch number and date of manufacture.

Tiles shall be delivered securely packed and stored in clean, dry well ventilated place at a temperature near about to that the tiles shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles shall be approved by the tile manufacturer. The adhesive shall have a short drying time and long life in addition to toughness.

c) Mix : Underbed

The underbed where required to make up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part like putty : 1 part cement : 4 parts coarse sand mixed with just sufficient water to make it workable.

d) Laying

The tiles shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air conditioned space, the air-conditioning shall be completed before tiling is taken up.

The surface to receive this finish shall be firm even textured but not too smooth, without undulations and other deficiencies. If an underbed is laid the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease if any shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles and allowed to surface dry. The tiles shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl, weights are to be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

e) Finishing

If any adhesive mark is there on the surface a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft soap, dried and polished with an approved type of polish just before handing over.

15.05.07 Stone Slab Finish : Marble, Stone and Similar Fine Grained Stone

a) Thickness

The underbed shall be minimum 12 mm and average 20 mm thick. The slabs may be 25 mm, 30 mm or 40 mm thick as specified.

b) Stone Slab

The stone slabs shall be made from selected stock which are hard, sound, homogeneous and dense in texture and free from flaws. Angles and edges shall be true, square, free from chipping and surface shall be plane. The slabs shall preferably be machine cut to the required dimensions. Tolerance of ± 5 mm in dimensions and ± 2 mm in thickness will be allowed. Unless specified the slabs shall be minimum 300 mm x 300 mm.

The stone slabs shall come from specific regions and in specified quality with top surface fine chisel dressed. All sides shall also be fine chisel dressed to the full depth to allow finest possible joints.

The slabs shall be delivered to the site well protected against damages and stored in dry place under cover.

c) Mix : Underbed

Same as clause 20.04.03 (c).

d) Laying

The sides and top surface of the slabs shall be machine rubbed or table rubbed with coarse sand stone and washed clean before laying.

The underbed mortar shall be evenly spread and brought to proper level on the area under each slab. The slab shall be laid over the underbed, pressed and tapped down with wooden mallet to the proper level. The slab shall then be lifted and the underbed corrected as necessary and allowed to stiffen a little. Next, a thick cement slurry shall be spread over the surface. The edges of the slab shall be buttered with slurry of cement, grey/white/mixed with pigment matching the colour of the stone slabs. The slab shall be gently laid and tapped with wooden mallet to bed properly to a very fine joint and to the required level. All surplus cement slurry shall be removed and the surface mopped clean with wet soft cloth. The laid finish shall be cured for 7 days by keeping it wet.

e) Polishing, Finishing

Fine chiseling shall be done to remove the slight undulations that usually exist at the joints. The polishing and finishing shall be done as specified under clause 20.04.03 (e). However, the joints shall be so fine in the case of stone slabs that grouting shall not be called for.

15.05.08 Stone Slab Finish : Sand Stone and Similar Coarse Grained Stone Finish

Generally clause 15.04.03 shall be followed except that the workmanship and finish shall not be fine as which are explained hereunder.

The slabs shall be rough chiseled or fine chiseled as specified. Tolerance may be allowed upto ± 6 mm for rough finish, but no sharp unevenness and shall be allowed. For fine chiseling the unevenness shall be limited to ± 2 mm. The sides shall be chisel dressed at least to half slab depth so that the maximum deviation from straight line shall be within 25 mm. Beyond this depth the edge may be slightly splayed.

The joint thickness shall be kept limited to 5 mm in case of rough finish and 3 mm in case of fine finish unless wider joints are specified. The joints shall be grouted with white or coloured cement.

15.06.00 Acceptance Criteria

The finish shall be checked specially for :

a) Level, Slope, Plumb as the case may be

b) Pattern and Symmetry

c) Alignment of joints, dividing strip etc.

d) Colour, texure

e) Surface finish

f) Thickness of joints

g) Details at edges, junctions etc.

h) Performance

i) Precautions specified for durability

16 FALSE CEILING

SCOPE

The work under this Section shall include the supply and insulation of false ceiling using insulation / acoustic boards, plaster of paris boards. Perspex etc. together with the suspension system as shown on drawing or specified in Schedule with all materials labour and equipment. The work shall also include providing of openings in the ceiling for lighting, air conditioning diffusers etc. as shown on drawings or instructed by the Owner.

16.01.00 Installation

16.02.00 Suspension System

16.02.01 General

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural walls, slabs and beams or trusses.

All members of the suspension system shall be of sufficient strength and rigidity to carry the ceiling boards or sheets in a true and level plane without exceeding a deflection of 1/360th of their span. All joints in ceiling panels shall run straight and cross joint shall be securely fixed to walls. All drillings of structural concrete or welding to steel for installation of the suspension system shall be included in the rate. All M S sections used for supports etc. shall be given one coat of synthetic enamel paint over a coat of red lead primer. All wood supports shall be painted with two coats of "So lignum" or other approved wood preservative before erection.

16.02.02 Metal Grid Suspension System

Aluminium grid ceiling system shall be "Bead lock" as manufactured by W A Beardshell and Co. Pvt. Ltd. or approved equal. Steel grid ceiling system shall be ..... snap grid as manufactured by Anil Hardboards Ltd. or approved equal.

Angle cleats or other suitable fixing device shall be fixed to the structural beam or slab above for fixing of hangers. Main runners shall be hung by M S flats angles or 12 g or heavier galvanized tie wire hangers at maximum 1.2 centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be as shown on drawings.

The cross tees shall intersect main runners in pattern shown on drawing and positively looked together with intersection clips. All perimeter areas shall have angle mouldings fixed to vertical wall surfaces and end tees shall rest on the moulding, unless otherwise shown on drawings.

16.02.03 Timber Grid Suspension System

Unless otherwise shown on drawings, the suspension system shall consist of 50 mm x 50 mm pretreated teakwood batten grid false in the same manner described for metal grid system. The spacing of timber battens shall be as shown on drawing. Extra battens shall be provided where necessary for openings for light fixtures A C grills etc.

16.03.00 Ceiling Panels

16.03.01 Materials

Ceiling panels shall be best quality material in thickness and properties call for in the "Schedule of Items". The Contractor shall submit test certificates to the

Owner for approval before bulk supply. The ceiling panels may be of the following types:

a) Plaster of Paris boards

b) Expanded polystyrene insulation boards

c) Fibre insulation boards

d) Wood particle boards

e) Glass fibre reinforced polystyrene sheets

f) Flat asbestos sheets

Acrylic plastic sheets translucent or figured glass sheets moulded plastic louvres etc. shall be from approved manufacturers and in thickness specified in schedule.

16.03.02 Installation of Ceiling Panels

Installation of ceiling panels shall be strictly as per manufacturer's instruction.

For exposed grid ceiling system, tile hold down clips shall be used at the rate of minimum one per 1.2 meter length of perimeter. These shall however be omitted in access panels which shall be located as per the instruction of the Owner.

For concealed grid ceiling system, tiles shall be fixed to the supporting grid in manner shown on drawing or as specified by the manufacturer. Where V joints in tiles are called for in drawings, these shall begin true lines. Where flush surface is required, the joints shall be filled with approved filler material and finished to give a neat uniform surface. Where shown on drawings and schedule of items, 6 mm thick cement: lime : sand surface of ceiling boards and finished in a true and even surface without undulations suitable for subsequent painting. Special care shall be taken to neatly finish the ceiling at junctions with walls, light fixtures, diffusers etc.

16.04.00 Acceptance Criteria

Finished ceiling shall be at the correct plane and present a pleasing and uniform appearance, free from sags, warps, figures or damaged boards, joints, exposed grids etc. shall be in true lines and symmetrically placed in manner shown on drawings. Cutouts for light fixtures, diffusers etc. Shall be of exact dimensions and in exact locations.

16.05.00 Rates

Shall be unit rates for complete items called for in the "Schedule of Items". No extra payment will be made for arrangement for lighting fixtures air conditioning diffusers access panels, etc. The rate shall include all cutting and wastage from standard size sheets boards, runners, etc.

16.07.00 I. S. Codes

IS:2441 - Code of Practice for fixing ceiling coverings.

17.00.00 FALSE FLOORING

SCOPE

This specification covers supplying, installation, repairing, finishing, testing, protection and maintenance till handing over of removable free access false flooring systems consisting of an assembly of panels mounted on adjustable pedestal and supporting steel grid system to provide an under floor space.

17.01.00 False Flooring System

17.01.01 Base

The system shall be placed over a base of R.C.C. floor slab and with necessary grouting etc. to fix the supporting structure.

17.01.02 Supporting Structure

The supporting structure shall comprise of fabricated jacks made out of 25 mm. dia. MS rounds having 150 mm. threads at top. This jack shall be welded to 100 mm x 100 mm x 6 mm thick MS base plate pedestal. Pedestals shall be vertically true and located at 600 mm. centre to centre to conform to the size of the floor panels and shall be fixed to the RCC floor slab with ARALDITE. The jack shall be equipped with locking device to prevent loss of finished elevation. Adjustment shall be provided by the threaded rod member and elevating nut. The capital shall be of aluminium alloy die cast and shall receive cold rolled MS floor supporting channels of size 40 mm x 40 mm x 3.15 mm thickness as per drawings, both for main and cross runners. The pedestal shall be equipped with conducting grounding pad. All MS members shall be treated with steel protective paint as per drawing.

17.01.03 Floor Panel

The floor panels shall be made of phenol for maldehyde bonded particle board treated with fire resistant paint as per schedule items. Size of each panel shall be 600 mm. x 600 mm. with all panel edges finished to a tolerance of $\pm$ 0.25 mm. on the diagonals. The edges of the floor panels shall be covered by 4

mm. thick rigid PVC edging. The underside of the panel shall have 0.05 mm. thick Aluminium foil which shall be fixed to the particle board with resin based adhesive.

17.01.04 Strength

Each 600 mm x 600 mm floor panel must be capable of supporting an uniform minimum live load of 1220 Kg/Sq. or a concentrated minimum load of 450 Kg. applied through a phenolic caster 75 mm in diameter and 45 mm wide, or a rolling minimum load of 450 Kg. at any point with a maximum deflection of 2 mm. The ultimate strength shall be capable of carrying a 2300 Kg. axial load without deformation of any part.

17.01.05 Surface Finish

All removable panels shall have the top surface finished with 2 mm thick Antiatatic Vinyl Flooring bonded to the surface with adhesive as per manufacturer's specification.

17.01.06 Skirting

Skirting shall be of the same Antistatic Vinyl tiles, 150 mm. high and 2 mm. thick, completely matching with the false flooring surface and shall be fixed with the plastered wall surface as per manufacturer's specification.

17.01.07 Installation

All steel surfaces are to be protected by pointing over a primer as per schedule of items and any damage to the paint during installation shall be made good. Finished floor surface, when specified by the Owner-in-Charge shall be protected by the Contractor with Kraft paper taped and sealed at edges to prevent tearing.

Any damage to the sub floor during installation of the false flooring system shall be made good by the Contractor without any extra cost to the owner.

17.02.00 Acceptance Criteria

The false flooring system shall be checked specially for:

a) Level

b) Alignment of joints

c) Thickness of joints

d) Surface finish

e) Colour and texture

18 SHEET WORK IN ROOF AND SIDING

SCOPE

This specification covers the erection of asbestos, C.G.I., aluminium or other sheet covering to roof and side walls at various elevations and the fabrication and/or installation of asbestos, C.G.I or aluminium gutters, flashings etc., as shown on drawings and schedule of items.

IS Codes

The following are some of the important IS Codes relevant to this sections :

IS : 3007 : Code of practice for laying of asbestos cement sheets

IS : 2527 : Code of practice for fixing rain water gutters and down pipes for roof drainage

IS : 1626 : Specification for asbestos cement building pipes gutters and fittings

IS : 277 : Specification for galvanised steel sheets (plain and corrugated)

18.01.00 Installation

18.02.00 Storage of Materials

All materials shall be stored by the Contractor in proper way to prevent all damage. If the materials are issued at site by the Owner, the Contractor shall at the time of issue, satisfy himself about the condition of issued sheets, gutters, etc. and no complaints shall be entertained later.

18.03.00 Workmanship

The workmanship shall be according to best construction practice to give a water tight finish to the satisfaction of the Owner fixing of gutters and down pipes shall be according to IS:2527.

18.03.01 *Asbestos Sheeting*

Asbestos sheets of profiles as stated in the Schedule of Items, shall be fixed with minimum 150 mm end lap and side laps as per manufacturer's specification Hook bolts or J-bolts shall be 8 mm dia. at 305 centres 6 mm dia galvanised iron seam bolt and nut with G.I. flat washers and bitumen washers shall be used for stiching ridge cappings, corner pieces, ventilators, north light curves etc.

18.03.02 *C.G.I. Sheeting and Aluminium Sheeting*

Side laps shall be 2 corrugations for roof and one corrugation for side sheeting. End laps shall be minimum 150 mm for roof and 100 mm for side sheeting. In ridges and hips where plain sheets are used the end laps shall be minimum 100 mm. Holes in C.G.I sheets shall preferably be made on the ground the sheets should be placed on trestles and holes punched in the ridge of the corrugation from the outside inward for obtaining proper seating of limpet washets. Sheets shall be secured to sheet framing by 8 mm dia. galvanised iron hooks or J-bolts and maximum 305 mm apart. The length of the hook or J-bolts shall be to suit the sections of the bearers.

Sheets shall also be bolted at the ends at every third corrugation with 6 mm dia. galvanised iron seam bolts and G.I. flat washers and bituminous washers.

18.03.03 *Fibre Glass Reinforced Plastic Sheeting*

This shall be of thickness and profile as mentioned in the Schedule of Item. Colour and light transmittance shall be as mentioned in drawings and or schedules. Where used in conjunction with C.G.I. or asbestos sheeting the end and side laps and fixing device shall be same as used for general sheeting. Where used in lieu of glass, the fixing shall be by means of timber or metal glazing beads as mentioned in schedule of items. In all cases, the installation shall be completely watertight and able to withstand the designed wind-pressure as mentioned in Schedule.

18.03.04 Precoated metal sheeting for roof shall be of precoated cold rolled sheet of total coated thickness (TCT) 0.58 to 0.68 mm of approved manufacturer. The sheet shall be metallic hot deep coated with an alloy of 55% aluminium, 43% zinc and 1.55 silicon coating mass shall be 150 gms/sq.m. sheet shall be fixed with fastening clip and self tapping fastener. Ridge for slope roof shall be of similar material and shall be fixed with necessary self tapping screws as per manufacturer details.

Thermally insulated sandwiched metal cladding for external facaade shall be of approved manufacturer. Sheeting shall Hi Rib 0.5 mm troughed sheeting manufactured from aluminium alloy high tensile steel (550Mpa) coated with fluro polymer (PV F2 or equivalent) and shall have life span sustenance against aggressive weathering action. Inner profiled sheet shall be with profile sheet of .6 mm thick (total coated thickness) permanently coated galvanised sheet.

Galvanised coating shall be not less than 120 gm/sq.m. and sandwiched insulation of 25 mm thick or as per design requirement shall be bonded mineral wool blanket or equivalent conforming to IS: 8183 (minimum density of 32/kg/cum for glass wool and 48/kg/cum for rock wool) having minimum coefficient of thermal conductivity of 0.49 mW/cm deg C (at 50 degree) Cladding shall be fixed to supports/rails by nuts, bolts, hooks, washers self tapping screws of stainless steel Austentic grade) conforming to IS:1367 (part 14) including sealents, gaskets, PVC tape 0.25 mm thick, flashing, black synthetic rubber external trough filler and 25X3 mm aluminium earthing.

18.04.00 Acceptance Criteria

The installations shall present a neat appearance and shall be checked for water tightness. The following shall be checked:

a) Side and end laps

b) Absence of cracks, holes or damages in sheet

c) Spacing of bolts

d) Provision of double washers (G.I. and asbestos or bituminous washers)

e) Proper installation of flashing

19 DRAINAGE AND SEWERAGE

19.1 General

The work to be carried out under this chapter comprises various kinds of drainage culverts, pipes, and the like, including all accessories as well as pipes and accessories for sewerage.

The Contractor shall design and prepare a flow diagram of the drainage system to be executed. The diagram shall show material and dimensions of the pipes to be used and the proportion of slope, as well as the invert level at all connection points. The flow diagram is subject to approval of the Consultant.

The pipes and structures of the drainage system shall be placed with sufficient safety against buoyancy. All earthworks in connection with the work specified hereunder shall be carried out as described under chapter-"Earth work"

All concrete work in connection with the work specified hereunder shall be carried out as described under chapter- "Plain and Reinforced Concrete".

19.2 Standards

Unless otherwise specified herein, the following standards shall apply to the works covered by this chapter:

IS:404	Lead pipes (All parts)
IS:405	Lead sheet and strip (All parts)
IS:458	Precast concrete pipes (with and without reinforcements)
IS:651	Salt glazed stoneware pipes and fittings
IS:782	Caulking lead
IS:783	Code of practice for laying of concrete pipes
IS:1172	Code of basic requirement for water supply, drainage and sanitation
IS:1230	Cast iron rain water pipes and fittings
IS:1239	Mild steel tubes and tubulars and other wrought steel fittings (All parts)
IS:1536	Centrifugally cast(spun) iron pressure pipes for water, gas and sewage
IS:1537	Vertically cast iron pressure pipes for water, gas and sewage.
IS:1626	Asbestos cement building pipes, gutters and fittings (spigot and socket type).
IS:1726	Cast iron manhole covers and frames
IS:1729	Sand cast iron spigot and socket soil waste and ventilating pipes, fittings and accessories.
IS:1742	Code of practice for building drainage
IS:2470	Code of practice for installation of septic tanks (All parts)
IS:2527	Code of practice for fixing rainwater gutters and down pipes for roof drainage
IS:3006	Specification for chemically resistant glazed stoneware pipes and fittings
IS:3114	Code of practice for laying of cast iron pipes
IS:3486	Cast iron spigot and socket drain pipes
IS:3597	Methods of test for concrete pipes
IS:4127	Code of practice for laying of glazed stoneware pipes

19.3 Material

Material and structural parts shall be standardised and shall be adequate for the purpose required. All material shall comply with local regulations (if any) regarding quality and dimensions subject to the approval of the Consultant.

Piping and fittings shall comply with the following standards:
Unplasticized PVC pipes for gravity sewers and for underground drainage shall comply with IS:4985.
Cast iron pipes and ductile iron pipes shall comply with relevant Indian Standards as mentioned above.
Stoneware pipes shall conform to IS:651.
RCC pipes for underground sewer and culverts shall be of class NP2 or NP3 conforming to IS:458.
Cast Iron rain water pipes shall conform to IS:1230.
Glass reinforced plastics (GRP) shall comply with IS:12709.
Manhole covers and frames shall comply with IS:1726.

All pipes shall be marked immediately after manufacture and the marking shall include:

- name of manufacturer
- date of manufacturing and serial number
- nominal diameter and pipe class

Pipe Trenches

Prior to laying of pipes, the respective pipe trenches shall be subject to thorough inspection by the Consultant with respect to alignment, slope, dimensions and suitability of bottom to meet requirements of proper pipe laying.

In general, each pipe trench deeper than 1.5 m shall be secured by means of planks, sheet piling, struts and bracings, whatever is required according to the soil conditions, groundwater, nearby road vibration resulting from traffic. The spacing of bracings shall be such as to allow mechanical excavation of the trench where required. All pipes, water mains, cables etc. met within the course of excavation shall be carefully protected and supported.

The width of a trench shall be adequate for satisfactory jointing of pipes and thorough tamping of the bedding material under and around the pipes. The bedding surface shall provide a firm but slightly yielding foundation of uniform density throughout the entire length of the pipe or the culvert and shall in general be slightly cambered in a direction parallel to the pipe centreline to compensate for expected settlement and ensure tight joint in the lower half of the pipe.

Pipes shall be bedded in an earth foundation of uniform density and carefully shaped by means of a template. Where rock in either edge or boulder formation is encountered, it shall be removed below grade and replaced with suitable materials in such a manner as to provide a compacted earth cushion having a thickness of 200 mm minimum. Where a firm foundation is not encountered at the grade established, due to soft or other unstable soil, all such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed and replaced with suitable selected material as approved by the Consultant, properly compacted to provide adequate support for the pipes.

Deviations from given levels shall not be greater than ± 20 mm.

19.4 Transport, Placing And Support Of Pipes

Special care shall be taken to avoid any damage during transport, loading and off-loading, storage, etc.

The excavated material shall be thrown on one side of trench and the pipes stacked on the other side. Storing of pipes alongside trenches shall be done only for the shortest time possible before placing in the trench. All pipes shall be checked for defects and damages prior to placing.

Material that does not conform to the specification or which is found to be defective or damaged shall be rejected and removed from the site. If more than 10 % of the pipes are rejected because they do not conform to the specification, the Consultant retains the right to reject the whole consignment.

During connection of pipe sections, the contact surfaces carrying sealing compounds shall be kept clean. All open ends for later connections shall be closed to avoid entering of soil or other contamination into the bores. The pipes shall be laid with their socket ends facing the direction of the flow (such that flow is from socket end to spigot end). The pipes shall be lowered in the trenches by a method as approved by the Consultant. The pipes shall then be joined by

caulking. After placing, each pipe section shall be thoroughly checked as to alignment, level and slope.
After each section of the pipeline has been laid it shall be tested for water tightness before backfilling the trench. On successful completion of testing, the trench shall be backfilled with the excavated earth in layers of 200 mm and shall be watered and rammed. Any subsidence occurring in the line of trenches after backfilling shall be repaired by the Contractor

Pipe supports shall be so constructed as to guarantee the uniform transmission of loads. For concrete supports, a cement-mortar layer shall be applied before placing the pipes to guarantee a uniform transmission of forces.

Dimensions
Nominal diameters shall refer to internal diameters of pipes. The nominal length of a pipe shall be the effective length of the installed pipe.

19.5 Structures of Drainage System

Inspection and Diversion Pits / Manholes
Reinforced concrete or rubble masonry (in 1:4 cement mortar) pits / manholes shall be placed at every change of dimension, direction and/or slope; furthermore, on straight lines at a maximum distance of 50 m, or as shown on the approved working drawings. The grade of concrete for manholes shall be M20 for cast in-situ. Manholes may be prefabricated or cast in place. Sections of connecting pipes shall be incorporated into the construction of manholes and placed at the elevation, direction, and grade required. The inner ends of the pipes shall be flush with the inner faces of the walls, unless otherwise specified. Half round channels of size suitable for the inlet and outlet pipe diameters shall be formed on the floor of the pit with PCC 1:3:6. The floor of the pit shall be haunched towards the channel as per requirement. Inside of pits shall be finished with cement-sand plaster (1:4) and finished smooth with cement punning. Care shall be taken to avoid unevenness on the surface and sharp bends in the channel. The invert level after finishing shall be as shown in the drawings.

Gully trap pits
Gully trap pits shall be constructed as indicated in the drawings. The construction and finishing of the pit shall be as described above for inspection pits. The cast iron grating shall be set flush with the finished ground / floor level.

Oil Separator
Oil polluted sanitary drainage shall be led through mud traps and oil separators installed immediately outside the buildings before entering the sanitary drainage system. The oil separator tank shall be made from reinforced concrete.

Septic Tanks
For the treatment of sanitary sewage, a septic tank having a minimum of 3 chambers shall be constructed. Septic tank shall consist of the RCC/masonry tank with inlet and outlets therefrom, complete with all necessary earthwork and backfilling. The details of septic tank shall be as per IS:2470. The chambers shall be separated by walls with slits. Each chamber shall have one manhole cover for cleaning with mobile pump. Before the outlet in the last chambers, a screen

board shall be provided to prevent the passage of floating matter into the discharge pipe.

Septic tank shall also include ventilating pipe of at least 100 mm dia whose top shall be provided with a suitable mosquito proof wire meshes and cowl. Ventilating pipe shall extend to a height of about 2 meter when the septic tank is at least 15 meter away from the nearest building and to a height of 2 meter above the top of building when it is located closer than 15 meter. Ventilating pipes can be connected to the normal soil ventilating system of the building where allowed.

After the Septic Tank has been tested to be watertight and the sewage system is checked, the tank shall be filled with water to its outlet before the sewage is let into the tank. It shall be seeded with well-digested sludge obtained from septic tank or sludge digestion tank. In the absence of digested sludge, small quantity of decaying organic matter such as digested cow dung may be introduced.

The volume of the septic tank shall be adequate for the sanitary sewage owing to the number of persons occupying the building, subject to the Consultant approval.

The effluent from the septic tank shall be disposed by any of the following methods depending on the project requirements:

- Connecting to a treatment plant.
- Connecting to soak pit for absorption by soil.
- Allowing to be absorbed by soil through open jointed stoneware pipes laid in a trench filled with broken bricks.

Soak Pit

A soak pit shall be arranged at the location shown on drawings for the disposal of sanitary sewage from the outlet of the septic tank. The soak pit shall be constructed in-situ.

It shall consist of a minimum 900 mm dia pit 1.0m in depth below the invert level of the inlet pipe. The pit shall be lined with stone, brick or concrete blocks set in cement mortar (1:6). The lower part shall be perforated and filled with brickbats. Inspection opening of 700 mm x 700 mm shall be provided. The cover of the inspection opening shall be of cast-iron. Inlet pipe shall be taken down to a depth of 900 mm from the top as an anti mosquito measure.

19.6 Concrete Encasement Of Pipes

Pipelines running under roads, etc. shall be encased in concrete of Grade M20 for full length. Before concrete is placed, the pipe and all fittings shall receive a double wrapping of bituminous felt. The thickness of the concrete encasement around the pipeline shall be at least the same as the pipe diameter. The concrete shall be reinforced by reinforcing steel bars in case of lack of space in any direction, side or top.

19.7 Accessories

Cast Iron Covers and Frames

Cast-iron covers and frames shall be of sound manufacture and free from projections or voids, treated with two heavy coats of an approved paint.

Thereafter, the covers shall be fixed on to the previously installed frames after lining from the inside with grease and sand mix.
Frames shall be square and covers shall be of the circular type according to the dimensions indicated on the drawings.
Covers and frames shall be fixed in such a way as to match adjacent surface levels with tolerances not exceeding ±3 mm.

Rising and Lifting Bars
One rising and lifting bar of approved design shall be supplied by the Contractor with each ten (10) manhole covers and frames.

Grates and Frames for Gullies
Grates and frames for horizontal gullies shall be made of cast-iron and according to the dimensions shown on the drawings. They shall be treated on both sides with two coats of approved rustproof paint.

Step Irons
Step irons shall be either galvanised steel or corrosion protected cast-iron. Steps should be a minimum of 300 mm long and 150 mm away from the wall.

19.8 Testing

General
The Contractor shall test all drainage and sewerage pipelines, joints and fittings before back filling the trenches. The tests shall be carried out between each two manholes in the presence of the Consultant.
The following points shall be considered when conducting the tests:
pipelines shall be clean and dry and the joints shall not be covered with soil
the underground water level shall be at the lowest possible level
testing shall be carried out by water subject to the Consultant's approval.

Testing by Water
Water shall be so filled in all parts of pipes, of whatever diameter to be tested, that all air in the pipes is expelled and the pipes are completely filled with water. The pipes shall be tested for 0.5 bar pressure of water and the time for test shall be 12 hours.
If any leak is noticed in the pipeline, the Contractor shall repair such leak to the satisfaction of the Consultant.
If in the opinion of the Consultant any damage had occurred in the pipelines in the process of pouring the concrete or backfilling, he shall have the right to order re-testing of the doubtful part. If a second testing proves that the pipeline is not serviceable, then the Contractor shall have to locate the damage, make it good and carry out re-testing until he secures satisfactory results.
The Contractor shall fix plugs in ends of pipes to be tested and shall take necessary precautions to prevent plugs or fixing tools from getting inside the pipes as a result of water flushing.

20 CONCRETE ROADS AND PAVEMENT

20.01.0 SCOPE

This specification covers all work required for the construction of rigid pavement including box cutting, edging, sub grade, dry lean concrete sub base, cement concrete pavement, 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.

20.01.01 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, materials, equipment, tools and plants, transportation etc. required for the work.

b) Submit for approval detailed schemes of all operations required for executing the work e.g. material handling, placement, services, approaches etc.

c) To carry out and submit to the Engineer results of tests whenever required by the Engineer to assess the quality of work.

20.01.02 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.

20.01.03 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.

1. Specification for road and bridge works of Ministry of shipping & Transport (Roads wing) Published by the IRC.

2.IRC-58 Guidelines for the design of plain jointed rigid pavements for highways.

3.IRC:SP-11 Hand Book of Quality Control for Construction of Roads and Runways.

4.IS:456 Indian Standard Code of Practice for Plain and Reinforced Concrete.

5.IS:2212 Code of Practice for Brickwork.

6.IS:783 Code of Practice for Laying of Concrete Pipes.

7.IRC:SP-49 Guidelines for the use of dry lean concrete as the sub base for rigid pavements.

8.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.

Conformity with Designs

The contractor shall carryout 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.

20.01.04 Materials to be Used

General

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

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.

i) 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± 25 mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be± 40 mm.

ii) 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.

iii) 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.

20.01.05 EXECUTION

i) Shoulder Construction

a) 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 or as directed by the Engineer.

b) Materials

Shoulder may be of selected earth or granular material conforming to the requirements of embankment construction or granular sub- base construction respectively.

c) 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 throughly cleaned.

During all stages of shoulder construction, the required cross- fall shall be maintained to drain off surface water.

ii) Kerb

a) 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.

b) 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.

20.02.00 SUB-BASE (DRY LEAN CONCRETE SUB BASE)

Description

This work shall consist of construction of dry lean concrete sub base for cement concrete pavement on a prepared sub grade in accordance with the requirements of this specification. The work shall conform to lines grades and cross section shown on drawing and as directed by Engineer.

a) Materials

The materials to be used shall be as follows.

b) Cement

Following type of cement shall be used with prior approval of Engineer.

Ordinary Portland cement, Portland slag cement, Portland Puzzolona cement conforming to IS:269. IS:455, IS:1489 respectively.

c) Aggregates

All aggregates for lean concrete shall be of natural material complying with IS:383. The aggregate shall not be alkali deactive. The limits of deleterious material shall not exceed the requirements in IS:383. all aggregates shall be free from dirt, washed and drained for at least 72 hrs before batching.

d) Coarse aggregates

Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of the coarse aggregate shall be 25 mm.

e) Fine aggregate

The fine aggregate shall consist of clean, natural sand or crushed stone sand or a combination of the two and shall conform to IS : 383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica, organic and other foreign matter.

The coarse and fine aggregates may be obtained in either of the following manner:

(i) In separate nominal sizes of coarse and fine aggregates and mixed together intimately before use.

(ii) Separately as 25 mm nominal single size, 12.5 mm nominal size graded aggregates and fine aggregate of crushed stone dust or sand or a combination of these two.

The material after blending shall conform to the grading as indicated in Table.

AGGREGATE GRADATION FOR DRY LEAN CONCRETE

Sieve designation	**Percentage passing the sieve by weight**
26.50 mm	100
19.00 mm	80–100
9.50 mm	55-75
4.75 mm	35-60
600.00 micron	10-35
75.00 micron	0-8

f) Water

Water used for mixing and curing of concrete shall be clean and free from injurious amounts of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS : 456.

g) Storage of materials
All materials shall be stored in accordance with the provisions indicated elsewhere in the document.

20.02.01 Proportioning of Materials for the Mix

a) The mix shall be proportioned with a maximum aggregate cement ratio of 15:1. The water content shall be adjusted to the optimum so as to ensure full compaction under rolling which shall be accessed at the time of rolling. The strength and density requirements of concrete shall be determined by making trial mixes.

b) Moisture content

The right amount of water for the lean concrete in the main work shall be decided so as to ensure full compaction under rolling and shall be assessed at the time of rolling the trial length. Too much water will cause the lean concrete to be heaving up before the wheels and picked up on the wheels of the roller and too little will lead to inadequate compaction, a low in-situ strength and an open-textured surface.

The optimum water content shall be determined and demonstrated by rolling during trial length construction and the optimum moisture content and degree of compaction shall be got approved from the Engineer. While laying in the main work, the lean concrete shall have moisture content between the optimum and optimum +2 per cent, keeping in view the effectiveness of compaction achieved and to compensate for evaporation losses.

c) Cement content

The minimum cement content in the lean concrete shall not be less than 150 kg/cu.m. of concrete. If this minimum cement content is not sufficient to produce concrete of the specified strength, it shall be increased as necessary without additional cost compensation to the Contractor.

d) Concrete strength

The average compressive strength of each consecutive group of 5 cubes made in accordance with Clause 903.5.1.1.(As per MOST standards) shall not be less than 10 MPa at 7 days. In addition, the minimum compressive strength of any individual cube shall not be less than 7.5 MPa at 7 days. The design mix complying with the above Clauses shall be got approved from the Engineer and demonstrated in the trial length construction.

20.02.02 Subgrade

The subgrade shall conform to the grades and cross sections shown on the drawings and shall be uniformly compacted to the design strength in accordance with these Specifications and Specification stipulated in the Contract. The lean concrete subbase shall not be laid on a subgrade softened

by rain after its final preparation; surface trenches and soft spots, if any, must be properly back-filled and compacted to avoid any weak or soft spot. As far as possible, the construction traffic shall be avoided on the prepared subgrade. A day before placing of the sub-base, the subgrade surface shall be given a fine spray of water and rolled with one or two passes of a smooth wheeled roller after a lapse of 2-3 hours in order to stabilise loose surface. If Engineer feels it necessary, another fine spray of water may be applied just before placing sub-base.

20.02.03 Construction

a) General
The pace and programme of the lean concrete sub base construction shall be matching suitably with the programme of construction of the cement concrete pavement over it. The sub-base shall be overlaid with cement concrete pavement only after 7 days after sub-base construction.

b) Batching and mixing

The batching plant shall be capable of proportioning the materials by weight, each type of material being weighed separately in accordance with Clause 602.9.3.2 of MOST standards. The cement from the bulk stock shall be weighed separately from the aggregates. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity for the laying arrangements. The batching and mixing shall be carried out preferably in a forced action central batching and mixing plant having necessary automatic controls to ensure accurate proportioning and mixing. Other types of mixers shall be permitted subject to demonstration of their satisfactory performance during the trial length. The type and capacity of the plant shall be got approved by the Engineer before commencement of the trial length. The weighing balances shall be calibrated by weighing the aggregates, cement, water and admixtures physically either by weighing in the large weighing machine or in a weigh bridge. The accuracy of weighing scales of the batching plant shall be within $\pm$ 2 per cent in the case of aggregates and $\pm$ 1 per cent in the case of cement and water.

The design features of Batching Plant should be such that the shifting operations of the plant will not take very long time when they are to be shifted from place to place with the progress of the work.

c) Transporting

Plant mix lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering the tippers/dumpers with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner. The lead of the batching plant to paving

site shall be such that the travel time available from mixing to paving as specified in Clause 601.5.5.2 of MOST standards will be adhered to.

d) Placing

Lean concrete shall be laid/placed by a paver with electronic sensor. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction the total thickness is as specified. The paving machine shall have high amplitude tamping bars to give good initial compaction to the sub-base.

The laying of the two-lane road subbase done either in full width or lane by lane. Preferably the lean concrete shall be placed and compacted across the full width of the road, by constructing it in one go or in two lanes running forward simultaneously. Transverse and longitudinal construction joints shall be staggered by 500-1000 mm and 200-400 mm respectively from the corresponding joints in the overlaying concrete slabs.

e) Compaction

The compaction shall be carried out immediately after the material is laid and levelled. In order to ensure thorough compaction which is essential, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is closed. The minimum dry density obtained shall be 97 per cent of that achieved during the trial length construction vide Clause 601.7 of MOST standards. The densities achieved at the edges i.e 0.5 m from the edge shall not be less than 95 percent of that achieved during the trial construction vide Clause 601.7 of MOST standards.

The spreading, compacting and finishing of the lean concrete shall be carried out as rapidly as possibly and the operation shall be so arranged as to ensure that the time between the mixing of the first batch of concrete in any transverse section of the layer and the final finishing of the same shall not exceed 90 minutes when the concrete temperature is above 25 and below 30 degree Celsius and 120 minutes if less than 25 degree Celsius. This period may be reviewed by the Engineer in the light of the results of the trial run but in no case shall it exceed 2 hours. Work shall not proceed when the temperature of the concrete exceeds 30 degree Celsius. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. It is desirable to stop concreting when the ambient temperature is above 35^{o} C. After compaction has been completed, roller shall not stand on the compacted surface for the duration of the curing period except during commencement of next day's work near the location where work was terminated the previous day.

Double drum smooth-wheeled vibratory rollers of minimum 80 to 100 kN static weight are considered to be suitable for rolling dry lean concrete. In case any other roller is proposed, the same shall be got approved from the Engineer, after demonstrating its performance. The number of passes required to obtain maximum compaction depends on the thickness of the lean concrete, the compatibility of the mix, and the weight and type of the roller etc., and the same

as well as the total requirement of rollers for the job shall be determined during trial run by measuring the in-situ density and the scale of the work to be undertaken.

In addition to the number of passes required for compaction there shall be a preliminary pass without vibration to bed the lean concrete down and again a final pass without vibration to remove roller marks and to smoothen the surface.

Special care and attention shall be exercised during compaction near joints, kerbs, channels, side forms and around gullies and manholes. In case adequate compaction is not achieved by the roller at these points, use of plate vibrator shall be made, if so directed by the Engineer.

The final lean concrete surface on completion of compaction and immediately before overlaying, shall be well closed, free from movement under roller and free from ridges, low spots, cracks, loose material, pot holes, ruts or other defects. The final surface shall be inspected immediately on completion and all loose, segregated or defective areas shall be corrected by using fresh lean concrete material laid and compacted as per Specification. For repairing honeycombed surface, concrete with aggregates of size 10 mm and below shall be spread and compacted. It is necessary to check the level of the rolled surface for compliance. Any level/thickness deficiency should be corrected after applying concrete with aggregates of size 10 mm and below after roughening the surface. Similarly the surface regularity also should be checked with 3 m straight edge. The deficiency should be made up with concrete with aggregates of size 10 mm and below.

Segregation of concrete in the dumpers shall be controlled by premixing each fraction of the aggregates before loading in the bin of the batching plant, by moving the dumper back and forth while discharging the mix on it and other means. Even paving operation shall be such that the mix does not segregate.

f) Joints

Contraction and longitudinal joints shall be provided as per the drawing.

At longitudinal or transverse construction joints, unless vertical forms are used, the edge of compacted material shall be cut back to a vertical face where the correct thickness of the properly compacted material has been obtained.

g) Curing

As soon as the lean concrete surface is compacted, curing shall commence. One of the following two methods shall be adopted:

(a) The initial curing shall be done by spraying with liquid curing compound. The curing compound shall be white pigmented or transparent type with water retention index of 90 per cent when tested in accordance with BS 7542. Curing compound shall be sprayed immediately after rolling is complete. As soon as

the curing compound has lost its tackiness, the surface shall be covered with wet hessian for three days.

(b) Curing shall be done by covering the surface by gunny bags/hessian, which shall be kept continuously moist for 7 days by sprinkling water.

20.02.04 Trial Mixes

The Contractor shall make trial mixes of dry lean concrete with moisture contents like 5.0, 5.5, 6.0, 6.5 and 7.0 per cent using cement content specified and the specified aggregate grading but without violating the requirement of aggregate-cement ratio specified in Clause 601.3.1 of MOST standards. Optimum moisture and density shall be established by preparing cubes with varying moisture contents. Compaction of the mix shall be done in three layers with vibratory hammer fitted with a square or rectangular foot as described in Clause 903.5.1.1 of MOST standards. After establishing the optimum moisture, a set of six cubes shall be cast at that moisture for the determination of compressive strength on the 3rd and the seventh day. Trial mixes shall be repeated if the strength is not satisfactory either by increasing cement content or using higher grade of cement. After the mix design is approved, the Contractor shall construct a trial section in accordance with Clause 601.7 of MOST standards.

If during the construction of the trial length, the optimum moisture content determined as above is found to be unsatisfactory, the Contractor may make suitable changes in the moisture content to achieve a satisfactory mix. The cube specimens prepared with the changed moisture content should satisfy the strength requirement. Before production of the mix, natural moisture content of the aggregate should be determined on a day-to-day basis so that the moisture content could be adjusted. The mix finally designed should neither stick to the rollers nor become too dry resulting in raveling of surface.

20.02.05 Trial Length

The trial length shall be constructed at least 14 days in advance of the proposed date of commencement of work. At least 30 days prior to the construction of the trial length, the Contractor shall submit for the Engineer's approval a "Method Statement" giving detailed description of the proposed materials, plant, equipment, mix proportion, and procedure for batching, mixing, laying, compaction and other construction procedures. The Engineer shall also approve the location and length of trial construction which shall be a minimum of 60 m length and for full width of the pavement. The trial length shall contain the construction of at least one transverse construction joint involving hardened concrete and freshly laid sub-base. The construction of trial length will be repeated till the Contractor proves his ability to satisfactorily construct the subbase.

In order to determine and demonstrate the optimum moisture content which results in the maximum dry density of the mix compacted by the rolling equipment and the minimum cement content that is necessary to achieve the

strength stipulated in the drawing, trial mixes shall be prepared as per Clause 601.6 of MOST standards.

After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method with 20 cm dia density cone. Three density holes shall be made at locations equally spaced along a diagonal that bisects the trial length; average of these densities shall be determined. These main density holes shall not be made in the strip 50 cm from the edges. The average density obtained from the three samples collected shall be the reference density and is considered as 100 per cent. The field density of regular work will be compared with this reference density in accordance with Clauses 601.5.5.1 and 903.5.1.2 of MOST standards. A few cores may be cut as per the instructions of the Engineer to check segregation or any other deficiency.

The hardened concrete shall be cut over 3 m width and reversed to inspect the bottom surface for any segregation-taking place. The trial length shall be constructed after making necessary changes in the gradation of the mix to eliminate segregation of the mix. The lower surface shall not have honey-combing and the aggregates shall not be held loosely at the edges.

The trial length shall be outside the main works. The main work shall not start until the trial length has been approved by the Engineer. After approval has been given the materials, mix proportions, moisture content, mixing, laying, compaction plant and construction procedures shall not be changed without the approval of the Engineer.

20.02.06 Tolerances for Surface Regularity, Level, Thickness, Density and Strength

The tolerances for surface regularity, level, thickness, density and strength shall conform to the requirements given in Clause 903.5 of MOST standards. Control of quality of materials and works shall be exercised by the Engineer in accordance with section 900 of MOST standards.

20.02.07 Traffic

No heavy commercial vehicles like trucks and buses shall be permitted on the lean concrete sub-base after its construction. Light vehicles if unavoidable may, however, be allowed after 7 days of its construction with prior approval of the Engineer.

20.03.00 BASE COURSE - CEMENT CONCRETE PAVEMENT

20.03.01 Materials

a) Source of materials

The Contractor shall indicate to the Engineer the source of all materials to be used in the concrete work with relevant test data sufficiently in advance, and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work. If the Contractor later proposes to obtain materials from a different source, he shall notify the Engineer for his approval, at least 45 days before such materials are to be used with relevant test data.

b) Cement

Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer, but the preference should be to use at least the 43 Grade or higher.

i) Ordinary Portland Cement, 33 Grade IS : 269.

ii) Ordinary Portland Cement, 43 Grade IS : 8112.

iii) Ordinary Portland Cement, 53 Grade IS : 12269.

If the soil around has soluble salts like sulphate in excess of 0.5 per cent, the cement used shall be sulphate resistant and shall conform to IS : 12330.

c) Admixtures

Admixtures conforming to IS : 6925 and IS : 9103 shall be permitted to improve workability of the concrete or extension of setting time, on satisfactory evidence that they will not have any adverse effect on the properties of concrete with respect to strength, volume change, durability and have no deleterious effect on steel bars. The particulars of the admixture and the quantity to be used, must be furnished to the Engineer in advance to obtain his approval before use. Satisfactory performance of the admixtures should be proved both on the laboratory concrete trial mixes and in trial paving works. If air entraining admixture is used, the total quantity of air in air-entrained concrete as a percentage of the volume of the mix shall be 5 $\pm$ 1.5 per cent for 25 mm nominal size aggregate.

d) Aggregates

Aggregates for pavement concrete shall be natural material complying with IS : 383 but with a Los Angeles Abrasion Test result not more than 35 per cent. The limits of deleterious materials shall not exceed the requirements set out in IS : 383.

The aggregates shall be free from chert, flint, chalcedony or other silica in a form that can react with the alkalies in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06 per cent by weight and the total sulphate content expressed as sulphuric anhydride (SO_3) shall not exceed 0.25 per cent by weight.

i) Coarse aggregate

Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of coarse aggregate shall not exceed 25 mm for pavement concrete. Continuously graded or gap graded aggregates may be used, depending on the grading of the fine aggregate. No aggregate which has water absorption more than 2 per cent shall be used in the concrete mix. The aggregates shall be tested for soundness in accordance with IS : 2386 (Part-5). After 5 cycles of testing the loss shall not be more than 12 per cent if sodium sulphate solution is used or 18 percent if magnesium sulphate solution is used.

Dumping and stacking of aggregates shall be done in an approved manner. In case the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hrs before batching as directed by the Engineer.

ii) Fine aggregate

The fine aggregate shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS : 383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter. The fine aggregate shall not contain deleterious substances more than the following:

Clay lumps	4.0 percent
Coal and lignite	1.0 percent
Material passing IS Sieve No. 75 micron	4.0 percent

e) Water

Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS : 456.

f) Mild steel bars for dowels and tie bars

These shall conform to the requirements of IS : 432, IS : 1139 and IS : 1786 as relevant. The dowel bars shall conform to Grade S 240 and tie bars to Grade S 415 of I.S.

g) Premoulded joint filler

Joint filler board for expansion joints which are proposed for use only at some abutting structures like bridges and culverts shall be of 20-25 mm thickness within a tolerance of ± 1.5 mm and of a firm compressible material and complying with the requirements of IS :1838, or BS Specification Clause No. 2630 of MOST standards or Specification for Highway Works, Vol .I Clause 1015. It shall be 25 mm less in depth than the thickness of the slab within a tolerance of ± 3 mm and provided to the full width between the side forms. It shall be in suitable lengths which shall not be less than one lane width. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit in the dowel bars.

h) Joint sealing compound

The joint sealing compound shall be of hot poured, elastomeric type or cold polysulphide type having flexibility, resistance to age hardening and durability. If the sealant is of hot poured type it shall conform to AASHTO M282 and cold applied sealant shall be in accordance with BS 5212 (Part 2).

i) Storage of materials

All materials shall be stored in accordance with the provisions of Clause 1014 of the MOST standards and other relevant IS Specifications. All effort must be made to store the materials in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for the work. The platform where aggregates are stock piled shall be levelled with 15 cm of watered, mixed and compacted granular sub-base material. The area shall have slope and drain-to-drain off rainwater. The storage space must also permit easy inspection, removal and storage of the materials. Aggregates of different sizes shall be stored in partitioned stack-yards. All such materials even though stored in approved godowns must be subjected to acceptance test as per Clause 903 of MOST specifications immediately prior to their use.

20.03.02 Proportion of Concrete

After approval by the Engineer of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighed proportions of all ingredients for the approval of the Engineer. The mix design shall be submitted at least 30 days prior to the paving of trial length and the design shall be based on laboratory trial mixes using the approved materials and methods as per IS : 10262 (Recommended Guidelines for Mix Design) or on the basis of any other rational method agreed to by the Engineer. Guidance in this regard can also be obtained from IS : SP : 23 Handbook on Concrete Mixes. The target mean strength for the design mix shall be determined as indicated in Clause 903.5.2. of MOST standards. The mix design shall be based on the flexural strength of concrete.

a) Cement content

The cement content shall not be less than 350 kg per cu.m. of concrete. If this minimum cement content is not sufficient to produce in the field, concrete of the strength specified in the drawings/design, it shall be increased as necessary without additional compensation under the Contract. The cement content shall, however, not exceed 425 kg per cu.m. of concrete.

b) Concrete strength

While designing the mix in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of at least thirty tests on samples. However, quality control in the field shall be exercised on the basis of flexural strength. It may, however, be ensured that the materials and mix proportions remain substantially unaltered during the daily concrete production. The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density as determined by the trial mixes or other means approved by the Engineer and the maximum free water cement ratio shall be 0.50.

The ratio between the 7 and 28 day strengths shall be established for mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage on at least six batches of trial mix. The average strength of the 7 day cured specimens shall be divided by the average strength of the 28 day specimens for each batch, and the ratio 'R' shall be determined. The ratio 'R' shall be expressed to three decimal places.

If during the construction of the trial length or during normal working, the average value of any four consecutive 7 day test results falls below the required 7 day strength as derived from the value of 'R', then the cement content of the concrete shall, without extra payment, be increased by 5 per cent by weight or by an amount agreed by the Engineer. The increased cement content shall be maintained at least until the four corresponding 28 day strengths have been assessed for its conformity with the requirements as per Clause 602.3.1 of MOST standards. Whenever the cement content is increased, the concrete mix shall be adjusted to maintain the required workability.

c) Workability

The workability of the concrete at the point of placing shall be adequate for the concrete to be fully compacted and finished without undue flow. The optimum workability for the mix to suit the paving plant being used shall be determined by the Contractor and approved by the Engineer. The control of workability in the field shall be exercised by the slump test as per IS : 1199.

The workability requirement at the Batching Plant and paving site shall be established slump tests carried during trial paving. These requirements shall be established from season to season and also when the lead from Batching plant site to the paving site changes. The workability shall be established for the type

of paving equipment available. A slump value in the range of 30 ± 15 mm is reasonable for paving works but this may be modified depending upon the site requirement and got approved by the Engineer. These tests shall be carried out on every truck/dumper at Plant site and paving site initially when the work commences but subsequently the frequency can be reduced to alternate trucks or as per the instructions of the Engineer.

d) Design mix

The Contractor shall carry out laboratory trials of design mixes with the materials from the approved sources to be used. Trial mixes shall be made in presence of the Engineer or his representative and the design mix shall be subject to the approval of the Engineer. They shall be repeated if necessary until the proportions that will produce a concrete, which complies in all respects with this Specification, and conforms to the design/drawings have been determined.

The proportions determined as a result of the laboratory trial mixes may be adjusted if necessary during the construction of the trial length. Thereafter, neither the materials nor the mix proportions shall be varied in any way except with the written approval of the Engineer.

Any change in the source of materials or mix proportions proposed by the Contractor during the course of work shall be assessed by making laboratory trial mixes and the construction of a further trial length unless approval is given by the Engineer for minor adjustments like compensation for moisture content in aggregates or minor fluctuations in the grading of aggregate.

20.03.03 Sub-base

The cement concrete pavement shall be laid over the sub-base constructed in accordance with the relevant drawings and Specifications contained in Clause 601 of MOST standards. If the sub-base is found damaged at some places or it has cracks wider than 10mm, it shall be repaired with fine cement concrete or bituminous concrete laying separation layer. Prior to laying of concrete it shall be ensured that the separation membrane as per Clause 602.5 of MOST standards is placed in position and the same is clean of dirt or other extraneous materials and free from any damage.

20.03.04 Separation Membrane

A separation membrane shall be used between the concrete slab and the subbase. Separation membrane shall be impermeable plastic sheeting 125 microns thick laid flat without creases. Before placing the separation membrane, the sub-base shall be swept clean of all the extraneous materials using air compressor. Wherever overlap of plastic sheets is necessary, the same shall be at least 300 mm and any damaged sheeting shall be replaced at the Contractor's expense. The separation membrane may be nailed to the lower layer with concrete nails.

20.03.05 Joints

The location and type of joints shall be as shown in the drawing. Joint shall be constructed depending upon their functional requirement as detailed in the following paragraphs. The location of the joints should be transferred accurately at the sire and mechanical saw cutting of joints done as per stipulated dimensions. It should be ensured that the full required depth of cut is made from edge to edge of the pavement. Transverse and longitudinal joints in the pavement and sub-base shall be staggered so that they are not coincident vertically and are at least 1 m and 0.3 m apart respectively. Sawing of joints shall be carried out with diamond studded blades soon after the concrete has hardened to take the load of the sawing machine and personnel without damaging the texture of the pavement. Sawing operation could start as early as 6-8 hours depending upon the season.

a) Transverse joints

Transverse joints shall be contraction and expansion joints constructed at the spacing described in the Drawings. Transverse joints shall be straight within the following tolerances along the intended line of joints which is the straight line transverse to the longitudinal axis of the carriageway at the position proposed by the Contractor and agreed to by the Engineer, except at road junctions or roundabouts where the position shall be as described in the drawings:

(i) Deviations of the filler board in the case of expansion joints from the intended line of the joint shall not be greater than ± 10 mm.

(ii) The best fit straight line through the joint grooves as constructed shall be not more than 25 mm from the intended line of the joint.

(iii) Deviations of the joint groove from the best fit straight line of the joint shall not be greater than 10 mm.

(iv) Transverse joints on each side of the longitudinal joint shall be in line with each other and of the same type and width. Transverse joints shall have a sealing groove which shall be sealed in compliance with Clause 602.11.

b) Contraction joints

Contraction joints shall consist of a mechanical sawn joint groove, 3 to 5 mm wide and 1/4 to 1/3 depth of the slab ± 5 mm or as stipulated in the drawings and dowel bars complying with Clause 602.6.5 of MOST standards and as detailed in the drawings.

The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take the load of joint sawing machine without causing damage to the slab.

c) Expansion joints

The expansion joints shall consist of a joint filler board complying with Clause 602.2.7 of MOST standards and dowel bars complying with Clause 602.6.5 of MOST standards and as detailed in the drawings. The filler board shall be positioned vertically with the prefabricated joint assemblies along the line of the joint within the tolerances given in Clause 602.6.2.1 of MOST standards and at such depth below the surface as will not impede the passage of the finishing straight edges or oscillating beams of the paving machines. The adjacent slabs shall be completely separated from each other by providing joint filler board. Space around the dowel bars, between the sub-base and the filler board shall be packed with a suitable compressible material to block the flow of cement slurry.

d) Transverse construction joint

Transverse construction joints shall be placed whenever concreting is completed after a day's work or is suspended for more than 30 minutes. These joints shall be provided at the regular location of contraction joints using dowel bars. The joint shall be made butt type. At all construction joints, steel bulk heads shall be used to retain the concrete while the surface is finished. The surface of the concrete laid subsequently shall conform to the grade and cross sections of the previously laid pavement. When positioning of bulk head/stop-end is not possible, concreting to an additional 1 or 2 m length may be carried out to enable the movement of joint cutting machine so that joint grooves may be formed and the extra 1 or 2 m length is cut out and removed subsequently after concrete has hardened.

e) Longitudinal joint

The longitudinal joints shall be saw cut as per details of the joints shown in the drawing. The groove may be cut after the final set of the concrete. Joints should be sawn to at least 1/3 the depth of the slab $\pm$ 5 mm as indicated in the drawing.

Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the drawing and in accordance with Clause 602.6.6 of MOST standards.

20.03.06 Dowel bars

Dowel bars shall be mild steel rounds in accordance with Clause 602.2.6 of MOST standards with details/dimensions as indicated in the drawing and free from oil, dirt, loose rust or scale. They shall be straight, free of irregularities and burring restricting slippage in the concrete. The sliding ends shall be sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. The dowel bar shall be supported on cradles/dowel chairs in pre-fabricated joint

assemblies positioned prior to the construction of the slabs or mechanically inserted with vibration into the plastic concrete by a method which ensures correct placement of the bars besides full re-compaction of the concrete around the dowel bars.

Unless shown otherwise on the drawings, dowel bars shall be positioned at mid depth of the slab within a tolerance of ± 20 mm, and centered equally about intended lines of the joint within a tolerance of ± 25 mm. They shall be aligned parallel to the finished surface of the slab and to the centre line of the carriageway and to each other within tolerances given hereunder, the compliance of which shall be checked as per Clause 602.10.7 of MOST standards.

(i) For bars supported on cradles prior to the laying of the slab:

(a) All bars in a joint shall be within ± 3 mm per 300 mm length of bar

(b) 2/3rd of the bars shall be within ± 2mm per 300 mm length of bar

(c) No bar shall differ in alignment from an adjoining bar by more than 3 mm per 300 mm length of bar in either the horizontal or vertical plane

(d) Cradles supporting dowel bar shall not extend across the line of joint i.e. no steel bar of the cradle assembly shall be continuous across the joint.

(ii) For all bars inserted after laying of the slab:

(a) Twice the tolerance for alignment as indicated in (i) above

Dowel bars, supported on cradles in assemblies, when subject to a load of 110 N applied at either end and in either the vertical or horizontal direction (upwards and downwards and both directions horizontally) shall conform to be within the following limits:

(i) Two-thirds of the number of bars of any assembly tested shall not deflect more than 2 mm per 300 mm length of bar

(ii) The remainder of the bars in that assembly shall not deflect more than 3 mm per 300 mm length of bar.

The assembly of dowel bars and supporting cradles, including the joint filler board in the case of expansion joints, shall have the following degree of rigidity when fixed in position:-

(i) For expansion joints, the deflection of the top edge of the filler board shall be not greater than 13 mm, when a load of 1.3 kN is applied perpendicular to the vertical face of the joint filler board and distributed over a length of 600 mm by means of a bar or timber packing, at mid depth and midway between individual fixings, or 300 mm from either end of any length of filler board, if a continuous fixing, is used. The

residual deflection after removal of the load shall be not more than 3 mm.

(ii) The joint assembly fixings to sub-base shall not fail under the 1.3 kN load applied for testing the rigidity of the assembly but shall fail before the load reaches 2.6 kN.

(iii) The fixings for contraction joint shall not fail under 1.3 kN load and shall fail before the load reaches 2.6 kN when applied over a length of 600 mm by means of a bar or timber packing placed as near to the level of the line of fixings as practicable.

(iv) Fixings shall be deemed to fail when there is displacement of the assemblies by more than 3mm with any form of fixing, under the test load. The displacement shall be measured at the nearest part of the assembly to the centre of the bar or timber packing.

Dowel bars shall be covered by a thin plastic sheath for at least two-thirds of the length from one end for dowel bars in contraction joints or half the length plus 50 mm for expansion joints. The sheath shall be tough, durable and of an average thickness not greater than 1.25 mm. The sheathed bar shall comply with the following pull-out tests:

i. Four bars shall be taken at random from stock and without any special preparation shall be covered by sheaths as required in this Clause. The ends of the dowel bars which have been sheathed shall be cast centrally into concrete specimens 150 x 150 x 600 mm, made of the same mix proportions to be used in the pavement, but with a maximum nominal aggregate size of 20 mm and cured in accordance with IS:516. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bond stress to achieve this movement shall not be greater than 0.14 MPa.

For expansion joints, a closely fitting cap 100 mm long consisting of waterproofed card board or an approved synthetic material like PVC or GI pipe shall be placed over the sheathed end of each dowel bar. An expansion space at least equal in length to the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar by using compressible sponge. To block the entry of cement slurry between dowel and cap it may be taped.

20.03.07 Tie bars

Tie bars in longitudinal joints shall be deformed steel bars of strength 415 MPa complying with IS:1786 and in accordance with the requirements given below. The bars shall be free from oil, dirt, loose rust and scale.

Tie bars projecting across the longitudinal joint shall be protected from corrosion for 75 mm on each side of the joint by a protective coating of bituminous paint with the approval of the Engineer. The coating shall be dry when the tie bars are used.

Tie bars in longitudinal joints shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab. Alternatively, tie bars at longitudinal joint may be mechanically or manually inserted into the plastic concrete from above by vibration using a method which ensures correct placement of the bars and recompaction of the concrete around the tie bars.

Tie bars shall be positioned to remain within the middle third of the slab depth as indicated in the drawings and approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bar on the intended line of the joints within a tolerance of $\pm$50 mm, and with a minimum cover of 30 mm below the joint groove.

20.03.08 Weather and Seasonal Limitations

a) Concrete during monsoon months

When concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulin or other water proof cloth shall be provided along the line of the work. Any time when it rains, all freshly laid concrete which had not been covered for curing purposes shall be adequately protected. Any concrete damaged by rain shall be removed and replaced. If the damage is limited to texture, it shall be retextured in accordance with the directives of the Engineer.

b) Concreting in hot weather

No concreting shall be done when the concrete temperature is above 30 degree Centigrade. Besides, in adverse conditions like high temperature, low relative humidity, excessive wind velocity, imminence of rains etc., if so desired by the Engineer, tents on mobile trusses may be provided over the freshly laid concrete for a minimum period of 3 hours as directed by the Engineer. The temperature of the concrete mix on reaching the paving site shall not be more than 30^{o}C. To bring down the temperature, if necessary, chilled water or ice flakes should be made use of.

No concreting shall be done when the concrete temperature is below 5 degree Centigrade and the temperature is descending.

20.03.09 Side Forms, Rails and Guidewires

a) Side forms and rails

All side forms shall be of mild steel of depth equal to the thickness of pavement or slightly less to accommodate the surface regularity of the sub-base. The

forms can be placed on series of steel packing plates or shims to take care of irregularity of sub-base. They shall be sufficiently robust and rigid to support the weight and pressure caused by a paving equipment. Side forms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms. The forms and rail shall be firmly secured in position by not less than 3 stakes/pins for each 3m length so as to prevent movement in any direction. Forms and rails shall be straight within a tolerance of 3 mm in 3m and when in place shall not settle excess of 1.5 mm in 3 m while paving is being done. Forms shall be cleaned and oiled immediately before each use. The forms shall be bedded on a continuous bed of low moisture content lean cement mortar or concrete and set to the line and levels shown on the drawings within tolerances $\pm$10 mm and $\pm$3 mm respectively. The bedding shall not extend under the slab and there shall be no vertical step between adjacent forms of more than 3 mm. The forms shall be got inspected from the Engineer for his approval before 12 hours on the day before the construction of the slab and shall not be removed until at least 12 hours afterwards.

At all times sufficient forms shall be used and set to the required alignment for at least 200 m length of pavement immediately in advance of the paving operations, or anticipated length of pavement to be laid within the next 24 hrs whichever is more.

b) Use of guide wires

Where slip form paving is proposed, a guide wire shall be provided along both sides of the slab. Each guide wire shall be at a constant height above and parallel to the required edges of the slab as described in the contract/drawing within a vertical tolerance of $\pm$ 3 mm. Additionally, one of the wires shall be kept at a constant horizontal distance from the required edge of the pavement as indicated in the contract/drawing within a lateral tolerance of $\pm$10 mm.

The guide wires shall be supported on stakes not more than 8 m apart by connectors capable of fine horizontal and vertical adjustment. The guide wire shall be tensioned on the stakes so that a 500 gram weight shall produce a deflection of not more than 20 mm when suspended at the mid point between any pair of stakes. The ends of the guide wires shall be anchored to fixing point or winch and not on the stacks.

The stack shall be positioned and the connectors maintained at their correct height and alignment from 12 hours on the day before concreting takes place until 12 hours after finishing of the concrete. The guidewire shall be erected and tensioned the connectors at any section for at least 2 hours before concreting that section.

The Contractor shall submit to the Engineer for his approval of line and level, the stakes and connectors which are ready for use in the length of road to be constructed by 12 hours on the working day before the day of construction of slab. Any deficiencies noted by the Engineer shall be rectified by the Contractor who shall then re-apply for approval of the affected stakes. Work shall not

proceed until the Engineer has given his approval. It shall be ensured that the stakes and guidewires are not affected by the construction equipment when concreting is in progress.

20.03.10 Construction

A systems approach may be adopted for construction of the pavement, and the Method Statement for carrying out the work, detailing all the activities including indication of time-cycle, equipment, personnel etc., shall be got approved from the Engineer before the commencement of the work. The above shall include the type, capacity and make of the batching and mixing plant besides the hauling arrangement and paving equipment. The capacity of paving equipment, batching plant as well as all the ancillary equipment shall be adequate for a paving rate of at least 300 m in one day.

a) Batching and mixing

Batching and mixing of the concrete shall be done at a central batching and mixing plant with automatic controls, located at a suitable place which takes into account sufficient space for stockpiling of cement, aggregates and stationary water tanks. This shall be, however, situated at an approved distance, duly considering the properties of the mix and the transporting arrangements available with the Contractor.

b) Equipment for proportioning of materials and paving

Proportioning of materials shall be done in the batching plant by weight, each type of material being weighed separately. The cement from the bulk stock may be weighed separately from the aggregates and water shall be measured by volume. Wherever properly graded aggregate of uniform quality cannot be maintained as envisaged in the mix design, the grading of aggregates shall be controlled by appropriate blending techniques. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity of the laying/paving equipment.

Batching plant and equipment:

(1) General- The batching plant shall include minimum four bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a separate scale for cement shall be included. The weighing hoppers shall be properly sealed and vented to preclude dust during operation. Approved safety devices shall be provided and maintained for the protection of all personnel engaged in plant operation, inspection and testing. The batch plant shall be equipped with suitable non-resettable batch counter which will correctly indicate the number of batches proportioned.

(2) Bins and hoppers- Bins with minimum number of four adequate separate compartments shall be provided in the batching plant.

(3) Automatic weighing devices- Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells.

(4) Mixers- Mixers shall be pan type, reversible type or any other mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specific mixing period, and of discharging the mixture, without segregation. Each stationary mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warring device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, provided that each batch is mixed 90 seconds or as per the manufacturer's recommendation. The mixer shall be equipped with a suitable non-resettable batch counter which shall correctly indicate the number of batches mixed.

The mixers shall be cleared at suitable intervals. The pickup and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down 20 mm or more. The Contractor shall (1) have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or (2) provide permanent marks on blade to show points of 20 mm wear from new conditions. Drilled holes of 5 mm diameter near each end and at mid point of each blade are recommended. Batching Plant shall be calibrated in the beginning and thereafter at suitable interval not exceeding 1 month.

(5)Control cabin- An air-conditioned centralised control cabin shall be provided for automatic operation of the equipment.

Paving equipment

The concrete shall be placed with an approved fixed form or slip paver with independent units designed to (i) spread, (ii) consolidate, screed and float-finish, (iii) texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and Specifications. The paver shall be equipped with electronic controls to control/sensor line and grade from either or both sides of the machine.

Vibrators shall operate at a frequency of 8300 to 9600 impulses per minute under load at a maximum spacing of 60 cm. The variable vibration setting shall be provided in the machine.

Concrete saw

The Contractor shall provide adequate number of concrete saws with sufficient number of diamond-edge saw blades. The saw machine shall be either electric or petrol/diesel driven type. A water tank with flexible hoses and pump shall be made available in this activity on priority basis. The Contractor shall have at least one standby saw in good working condition. The concreting work shall not commence if the saws are not in working condition.

c) Hauling and placing of concrete

Freshly mixed concrete from the central batching and mixing plant shall be transported to the paver site by means of trucks/tippers of sufficient capacity and approved design in sufficient numbers to ensure a constant supply of concrete. Covers shall be used for protection of concrete against the weather. The trucks/tippers shall be capable of maintaining the mixed concrete in a homogeneous state and discharging the same without segregation and loss of cement slurry. The feeding to the paver is to be regulated in such a way that the paving is done in an uninterrupted manner with a uniform speed throughout the days work.

Placing of concrete

Concrete mixed in central mixing plant shall be transported to the site without delay and the concrete which, in the opinion of the Engineer, has been mixed too long before laying will be rejected and shall be removed from the site. The total time taken from the addition of the water to the mix, until the completion of the surface finishing and texturing shall not exceed 120 minutes when concrete temperature is less than 25^{o}C and 90 minutes when the concrete temperature is between 25^{o}C to 30^{o}C. Trucks/tippers delivering concrete shall not run on plastic sheeting nor shall they run on completed slabs until after 28 days of placing the concrete. The Paver shall be capable of paving the carriageway as shown in the drawings, in a single pass and lift.

Where fixed form pavers are to be used, forms shall be fixed in advance as per Clause 602.8 of the MOST standards. Before any paving is done, the site shall be shown to the Engineer, in order to verify the arrangement for paving besides placing of dowels, tie-bars etc., as per the relevant Clauses of this Specification. The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

The addition of water to the surface of the concrete to facilitate the finishing operations will not be permitted except with the approval of the Engineer when it shall be applied as a mist by means of approved equipment.

If considered necessary by the Engineer, the paving machines shall be provided with approved covers to protect the surface of the slab under construction from direct sunlight and rain or hot wind.

While the concrete is still plastic, its surface shall be brush textured in compliance with Clause 602.9.8 of MOST specifications and the surface and edges of the slab cured by the application of a sprayed liquid curing membrane in compliance with Clause 602.9.9 of MOST specifications. After the surface texturing, but before the curing compound is applied, the concrete slab shall be marked with the chainage at every 100 m interval.

As soon as the side forms are removed, edges of the slabs shall be corrected wherever irregularities have occurred by using fine concrete composed of one part of cement to 3 parts of fine chips and fine aggregate under the supervision of the Engineer.

If the requirement of Clause 902.4. of MOST specifications for surface regularity fails to be achieved on two consecutive working days, then normal working shall cease until the cause of the excessive irregularity has been identified and remedied.

d) Construction by fixed form paver

The fixed form paving train shall consist of separate powered machines which spread, compact and finish the concrete in a continuous operation.

The concrete shall be discharged without segregation into a hopper spreader which is equipped with means for controlling its rate of deposition on to the subbase. The spreader shall be operated to strike off concrete upto a level requiring a small amount of cutting down by the distributor of the spreader. The distributor of spreader shall strike off the concrete to the surcharge adequate to ensure that the vibratory compactor thoroughly compacts the layer. If necessary, poker vibrators shall be used adjacent to the side forms and edges of the previously constructed slab. The vibratory compactor shall be set to strike off the surface slightly high so that it is cut down to the required level by the oscillating beam. The machine shall be capable of being rapidly adjusted for changes in average and differential surcharge necessitated by changes in slab thickness or cross fall. The final finisher shall be able to finish the surface to the required level and smoothness as specified, care being taken to avoid bringing up of excessive mortar to the surface by overworking.

e) Construction by slip form paver

The slip form paving train shall consist of power machine which spreads compacts and finishes the concrete in a continuous operation. The slip form paving machine shall compact the concrete by internal vibration and shape it between the side forms with either a conforming plate or by vibrating and oscillating finishing beams. The concrete shall be deposited without segregation in front of slip form paver across the whole width and to a height

which at all times is in excess of the required surcharge. The deposited concrete shall be struck off to the necessary average and differential surcharge by means of the strike off plate or a screw auger device extending across the whole width of the slab. The equipment for striking-off the concrete shall be capable of being rapidly adjusted for changes of the average and differential surcharge necessitated by change in slab thickness or cross fall.

The level of the conforming plate and finishing beams shall be controlled automatically from the guide wires installed as per Clause 602.8 of MOST specifications by sensors attached at the four corners of the slip form paving machine. The alignment of the paver shall be controlled automatically from the guide wire by at least one set of sensors attached to the paver. The alignment and level of ancillary machines for finishing, texturing and curing of the concrete shall be automatically controlled relative to the guide wire or to the surface and edge of the slab.

Slip-form paving machines shall have vibrators of variable output, with a maximum energy output of not less than 2.5 KW per metre width of slab per 300 mm depth of slab for a laying speed upto 1.5 m per minute or pro-rata for higher speeds. The machines shall be of sufficient mass to provide adequate reaction during spreading and paving operations on the traction units to maintain forward movements during the placing of concrete in all situations.

If the edges of the slip formed slab slump to the extent that the surface of the top edge of the slab does not comply with the requirements of Clause 602.14 of MOST specifications, then special measures approved by the Engineer shall be taken to support the edges to the required levels and work shall be stopped until such time as the Contractor can demonstrate his ability to slip form the edges to the required levels.

f) Construction by hand-guided method

Areas in which hand-guided methods of construction become indispensable shall be got approved by the Engineer in writing in advance. Such work may be permitted only in restricted areas in small lengths. Work shall be carried out by skilled personnel as per methods approved by the Engineer. The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength of concrete and all other quality control measures shall be the same as in the case of machine laid work.

g) Surface texture

After the final regulation of the slab and before the application of the curing membrane, the surface of concrete slab shall be brush-textured in a direction at right angles to the longitudinal axis of the carriageway.

The brushed surface texture shall be applied evenly across the slab in one direction by the use of a wire brush not less than 450 mm wide but longer brushes are preferred. The brush shall be made of 32 gauge tape wires grouped together in tufts spaced at 10 mm centres. The tufts shall contain an

average of 14 wires and initially be 100 mm long. The brush shall have two rows of tufts. The rows shall be 20 mm apart and the tufts in one row shall be opposite the centre of the gap between tufts in the other row. The brush shall be replaced when the shortest tuft wears down to 90 mm long.

The texture depth shall be determined by the Sand Patch Test as described in Clause 602.12 of MOST specifications. This test shall be performed at least once for each day's paving and wherever the Engineer considers it necessary at times after construction as under:

Five individual measurements of the texture depth shall be taken at least 2 m apart anywhere along a diagonal line across a lane width between points 50 m apart along the pavement. No measurement shall be taken within 300 mm of the longitudinal edges of a concrete slab constructed in one pass.

Texture depths shall not be less than the minimum required when measurements are taken as given in Table below nor greater than a maximum average 1.25 mm.

TABLE : Texture Depth

	Time of Test	Number of Measurements	Required Texture Depth (mm)	
			Specified Value	Tolerance
1.	Between 24 hours and 7 days after the constn., of the slab or until the slab is first used by vehicles.	An average of 5 measurements	1.00	0.25
2.	Not later than 6 weeks before the road is opened to public traffic.	An average of 5 measurements	1.00	+0.25 -0.35

After the application of the brushed texture, the surface of the slab shall have a uniform appearance.

Where the texture depth requirements are found to be deficient, the Contractor shall make good the texture across the full lane width over length directed by the Engineer, by retexturing the hardened concrete surface in an approved manner.

h) Curing

Immediately after the surface texturing, the surface and sides of the slab shall be cured by the application of approved resin-based aluminised reflective curing compound which hardens into an impervious film or membrane with the help of a mechanical sprayer.

Curing compounds shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The compound shall become stable and impervious to evaporation of water from the surface of the concrete within 60 minutes of application and shall be of approved type. The curing compounds shall have a water retention efficiency index of 90 per cent in accordance with BS Specification No. 7542.

The curing compound shall not react chemically with the concrete and the film or membrane shall not crack, peel or disintegrate within three weeks after application. Immediately prior to use, the curing compound shall be thoroughly agitated in its containers. The rate of spread shall be in accordance with the manufacturer's instructions checked during the construction of the trial length and subsequently whenever required by the Engineer. The mechanical sprayer shall incorporate an efficient mechanical device for continuous agitation and mixing of the compound during spraying.

In addition to spraying of curing compound, the fresh concrete surface shall be protected for at least 3 hours by covering the finished concrete pavement with tents as described in Clause 602.7.2, during adverse weather conditions as directed by the Engineer. After three hours, the pavement shall be covered by moist hessian and the same shall then be kept damp for a minimum period of 14 days after which time the hessian may be removed. The hessian shall be kept continuously moist. All damaged/torn hessian shall be removed and replaced by new hessian on a regular basis.

The Contractor shall be liable at his expense to replace any concrete damaged as a result of incomplete curing or cracked on a line other than that of a joint.

20.03.11 Trial Length

The trial length shall be constructed at least one month in advance of the proposed start of concrete paving work. At least one month prior to the construction of the trial length, the Contractor shall submit for the Engineer=s approval a detailed method statement giving description of the proposed materials, plant, equipment and construction methods. All the major equipments like paving train, batching plant, tippers etc., proposed in the construction are to be approved by the Engineer before their procurement. No trials of new materials, plant, equipment or construction methods, nor any development of them shall be permitted either during the construction of trial length or in any subsequent paving work, unless they form part of further, approved trials. These trial lengths shall be constructed away from the carriageway but with at least a subbase layer below it.

The Contractor shall demonstrate the materials, plant, equipment and methods of construction that are proposed for concrete paving, by first constructing a trial length of slab, at least 60 m but not more than 300 m long for mechanised construction and at least 30 m long for hand guided methods. If the first trial is unsatisfactory, the Contractor shall have to demonstrate his capability to satisfactorily construct the pavement in subsequent trials.

The trial length shall be constructed in two parts over a period comprising at least part of two separate working days, with a minimum of 30 m constructed each day for mechanised construction and a minimum of 15 m on each day for hand guided construction. The trial length shall be constructed at a similar rate (speed, around 1m/hr) to that which is proposed for the main work.

Transverse joints and longitudinal joints of each type that are proposed for dowel-jointed unreinforced concrete slabs in the main work shall be constructed and assessed in the trial length. If in the trial length the construction of expansion joint and longitudinal joint is not demonstrated, the first 2 expansion joints and at least the first 150 m of longitudinal construction joint for mechanised paving in the main work, shall be considered as the trial length for these joints.

The trial length shall comply shall the Specification in all respects, with the following additions and exceptions:

a) Surface levels and regularity

(i)In checking for compliance with Clause 903.5 the levels shall be taken at intervals at the locations specified in this Clause along any line or lines parallel to the longitudinal centre line of the trial length.

(ii)The maximum number of permitted irregularities of pavement surface shall comply with the requirements of Clause 902.4. Shorter trial lengths shall be assessed pro-rata based on values for a 300 m length.

b) Joints

Alignment of dowel bars shall be inspected as described in Clause 602.10.7 in any two consecutive transverse joints. If the position or alignment of the dowel bars at one of these joints does not comply with Clause 602.6.5, if that joint remains the only one that does not comply after the next 3 consecutive joints of the same type have been inspected, then the method of placing dowels shall be deemed to be satisfactory. In order to check sufficient joints for dowel bar alignment without extending the trial length unduly, the Contractor may, by agreement with the Engineer, construct joints at more frequent joint intervals than the normal spacing required in the Contract.

If there are deficiencies in the first expansion joint that is constructed as a trial, the next expansion joint shall be a trial joint. Should this also be deficient, further

trial expansion joints shall be made as part of the trial length which shall not form part of the permanent works, unless agreed by the Engineer.

c) Density

Density shall be assessed as described in Clause 602.3.3. from at least 3 cores drilled from each part of the trial length.

d) Position of tie bars

Compliance with Clause 602.6.6 for the position and alignment of tie bars shall be checked by drilling additional cores from the slab unless they can be determined from cores taken for density.

e) Approval and acceptance

Approval of the materials, plant, equipment and construction methods shall be given when a trial length complies with the Specification. The Contractor shall not proceed with normal working until the trial length has been approved and any earlier defective trial lengths have been removed, unless that can be remedied to the satisfaction of the Engineer. If the Engineer does not notify the Contractor of any deficiencies in any trial length within 10 days after the completion of that trial length, the Contractor may assume that the trial length, and the materials, plant, equipment and construction methods adopted are acceptable.

When approval has been given, the materials, plant, equipment and construction methods shall not thereafter be changed, except for normal adjustments and maintenance of plant, without the approval of the Engineer. Any changes in material, plant, equipment and construction methods shall entitle the Engineer to require the Contractor to lay a further trial length as described in this Clause to demonstrate that the changes will not adversely affect the permanent works.

Trial lengths which do not comply with the Specification, with the exception of areas which are deficient only in surface texture and which can be remedied in accordance with Clause 602.9.8.6 of MOST specifications shall be removed immediately upon notification of deficiencies by the Engineer and the Contractor shall construct a further trial length.

f) Inspection of dowel bars

Compliance with Clause 602.6.5 of MOST specifications for the position and alignment of dowel bars at construction and expansion joints shall be checked by measurements relative to the side forms or guide wires.

When the slab has been constructed, the position and alignment of dowel bars and any filler board shall be measured after carefully exposing them in the plastic concrete across the whole width of the slab. When the joint is an expansion joint, the top of the filler board shall first be exposed sufficiently in

the plastic concrete to permit measurement of any lateral or vertical displacement of the board. During the course of normal working, these measurements shall be carried out in the pavement section at the end of day=s work by extending slab length by 2 m. After sawing the transverse joint groove, the extended 2 m slab shall be removed carefully soon after concrete has set to expose dowels over half the length. These dowels can be tested for tolerances.

If the position and alignment of the bars in a single joint in the slab is unsatisfactory then the next two joints shall be inspected. If only one joint of the three is defective, the rate of checking shall be increased to one joint per day until the Engineer is satisfied that compliance is being achieved. In the event of non-compliance in two or more successive joints, the Contractor shall revert to the construction of fresh trial lengths and make any necessary alteration to concrete mix, paving plant or methods until the dowel bar position and alignment are satisfactory.

After the dowel bars have been examined, the remainder of the concrete shall be removed over a width of 500 mm on each side of the line of the joint and reinstated to the satisfaction of the Engineer. The dowels shall be inserted on both sides of the 1 m wide slab by drilling holes and grouting with epoxy mortar. Plastic sheath as per Clause 602.6.5.5 of MOST specifications shall be provided on dowels on one of the joints. The joint groove shall be widened and sealed as per Clause 602.11 of MOST specifications.

20.03.12 Preparation and Sealing of Joint Grooves

a) General

All transverse joints in surface slabs shall be sealed using sealants described in Clause 602.2.8 of MOST specifications. Joints shall not be sealed before 14 days after construction.

b) Preparation of joint grooves for sealing

Joint grooves usually are not constructed to provide the minimum width specified in the drawings when saw cut joints are adopted. They shall be widened subsequently by sawing before sealing. Depth/width gauges shall be used to control the dimension of the groove.

If rough arises develop when grooves are made, they shall be ground to provide a chamfer approximately 5 mm wide. If the groove is at an angle upto 10 degree from the perpendicular to the surface, the overhanging edge of the sealing groove shall be sawn or ground perpendicular. If spalling occurs or the angle of the former is greater than 10 degrees, the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass the defects upto a maximum width, including any chamfer, of 35 mm for transverse joints and 20 mm for longitudinal joints. If the spalling cannot be so eliminated then the

arises shall be repaired by an approved thin bonded aris repair using cementitious materials.

All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. If need arises the Engineer may instruct cleaning by pressurised water jets. Depending upon the requirement of the sealant manufacture, the sides of the grooves may have to be sand blasted to increase the bondage between sealant and concrete.

The groove shall be cleaned and dried at the time of priming and sealing.

Before sealing the temporary seal provided for blocking the ingress of dirt, soil etc., shall be removed. A highly compressible heat resistant paper-backed debonding strip as per drawing shall be inserted in the groove to serve the purpose of breaking the bond between sealant and the bottom of the groove and to plug the joint groove so that the sealant may not leak through the cracks. The width of debonding strip shall be more than the joint groove width so that it is held tightly in the groove. In the case of longitudinal joints, heat resistant tapes may be inserted to block the leakage through bottom of the joint.

c) Sealing with sealants

When sealants are applied, an appropriate primer shall also be used if recommended by the manufacturer and it shall be applied in accordance with their recommendation. The sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint groove to be sealed is below $7^{o}C$.

If hot applied sealant is used it shall be heated and applied from a thermostatically controlled, indirectly heated preferably with oil jacketed melter and pourer having recirculating pump and extruder. For large road projects, sealant shall be applied with extruder having flexible hose and nozzle. The sealant shall not be heated to a temperature higher than the safe heating temperature and not for a period longer than the safe heating period, as specified by the manufacturer. The dispenser shall be cleaned out at the end of each day in accordance with the manufacturers' recommendations and reheated material shall not be used.

Cold applied sealants with chemical formulation like polysulphide may be used. These shall be mixed and applied within the time limit specified by the manufacturer. If primers are recommended they shall be applied neatly with an appropriate brush. The Movement Accommodation Factor (MAF) shall be more than 10 per cent

The sealants applied at contraction phase of the slabs would result in bulging of the sealant over and above the slab. Therefore, the Contractor in consultation with the Engineer shall establish the right temperature and time for

applying the sealant. Thermometer shall be hung on a pole in the site for facilitating control during the sealing operation.

Sealant shall be applied, slightly to a lower level than the slab with a tolerance of 5 $\pm$ 2 mm.

During sealing operation, it shall be seen that no air bubbles are introduced in the sealant either by vapors or by the sealing process.

d) Testing of applied sealants

Manufacturer's certificate shall be produced by the Contractor for establishing that the sealant is not more than six months old and stating that the sealant complies with the relevant standard as in Clause 602.2.8. The samples shall meet the requirement of AASHTO M 282 for hot applied sealant or BS 5212 : (Part- 2) for cold applied sealant.

e) Measurement of Texture Depth - Sand Patch Method

The following apparatus shall be used:

(i) A cylindrical container of 25 ml internal capacity

(ii) A flat wooden disc 64 mm diameter with a hard rubber disc, 1.5 mm thick, stuck to one face, the reverse face being provided with a handle.

(iii) Dry natural sand with a rounded particle shape passing a 300 micron IS sieve and retained on a 150 micron IS sieve.

d) Method
The surface to be measured shall be dried, any extraneous mortar and loose material removed and the surface swept clean using a wire brush both at right angles and parallel to the carriageway. The cylindrical container shall be filled with the sand, tapping the base 3 times on the surface to ensure compaction, and striking off the sand level with the top of the cylinder. The sand shall be poured into a heap on the surface to be treated. The sand shall be spread over the surface, working the disc with its face kept flat in a circular motion so that the sand is spread into a circular patch with the surface depressions filled with sand to the level of peaks.

The diameter of the patch shall be measured to the nearest 5 mm. The texture depth of concrete surface shall be calculated from 31000/(DxD) mm where D is the diameter of the patch in mm.

20.03.13 Opening to Traffic

No vehicular traffic shall be allowed to run on the finished surface of a concrete pavement within a period of 28 days of its construction and until the joints are permanently sealed. The road may be opened to regular traffic after completion

of the curing period of 28 days and after sealing of joints is completed including the construction of shoulder, with the written permission of the Engineer.

20.03.14 Tolerance for Surface Regularity, Level, Thickness and Strength

The tolerances for surface regularity, level, thickness and strength shall conform to the requirements given in Clause 903.5 of MOST specifications. Control of quality of materials and works shall be exercised by the Engineer in accordance with Section 900 of MOST specifications.

21 CHAIN LINK FENCING

SCOPE

This specification covers furnishing of all labor, supervision, materials, tools, equipment and services necessary for or incidental to the fabrication and installation of the Fencing in accordance with the drawings and as specified herein.

The following work shall be included :

Chain link fences

Gates

Foundations

Padlocks

21.01.00 Materials / Details

21.01.01 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.

21.01.02 Toe wall shall be minimum 200 mm above finished grade level.

21.01.03 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 galvanised 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 galvanised nuts and bolts.

21.01.04 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 concrete with 12mm security fasteners.

21.01.05 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

21.01.06 Toe walls either of brick masonry with bricks of minimum 50 kg/cm2 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 finished grade level with PCC coping (1:2:4). All gates shall be of hot dip galvanised structural steel as per specification.

21.01.07 All structural steel work for the fencing shall be painted with synthetic enamel paint over a suitable primer or two coats of epoxy paint depending upon site condition.

21.01.08 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 Contractor. 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/m2 unless noted otherwise. Stub members, anchor bolts shall be having heavier zinc coating not less than 0.80 kg/m2.

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

21.01.09 The Fencing post including stays and corner braces may be of precast concrete of shape and size furnished for steel post above the grade of Reinforced concrete shall not be less than M-25 with foundation as per site conditions. The cross section of area of the post shall not be less than 150mm x 150mm reinforced with 4Nos. of 10mm longitudinal bar with closed stirrups of 8mm Dia.bar at 150mm c/c.

21.02.00 Installation

21.02.01 Installation shall be in accordance with manufacturer's instructions. Corners shall be square where required. Posts shall be aligned in the horizontal and vertical directions.

21.02.02 Fabric shall be in tension so as to eliminate sagging.

21.02.03 Posts shall not deflect in any direction thereby causing gates not to close properly.

21.02.04 Hold open and meeting stop shall be provided for all gates, securely anchored into the ground and/or pavement.

21.03.00 Shop Drawings

21.03.01 Shop drawings shall be submitted for approval prior to fabrication and delivery of materials. Shop drawings shall indicate the following minimum information:

Types and gages of materials

Plan and layout of total fencing

Location, fabrication and sizes of gates

Typical sections through fencing

Bracing locations

Details of foundations

21.03.02 Approval of shop drawings will be for arrangement only and shall not relieve the Contractor of the responsibility for errors, omissions or the accuracy of his own dimensions.

22.00.00 **LAND SCAPING**

22.01.00 General

This specification covers broadly the requirements for Landscaping within the Plant Area. Landscaping shall be carried out after all the underground utilities and drainage systems are in place. The entire work *of* Landscaping shall be carried out to the satisfaction *of* the Engineer and in a manner to have a beautiful appearance after completion *of* the work.

Before the site grading is started the contractor shall prepare a plan for Landscaping and get it approved from the Engineer. The Landscaping plan should be prepared by the Contractor with the help *of* an expert horticulturist with due considerations for Fauna & Flora grown in the adjacent area and which can sustain in the saline climate.

The area to be landscaped shall be clearly demarcated at site and got approved by the Engineer.

The work shall be divided into following sub-items.

22.01.01 Preparing Lawn

For this purpose, within the area where lawn is to be grown, about 0.3 metres of earth shall be removed. This shall be replaced by fresh garden soil and manure in 2: I proportions spread evenly. Fresh garden soil & manure shall be mixed thoroughly, well watered and left overnight. The next morning, the variety *of* lawn, as per approved plan and as directed by the Engineer, shall be planted. This grass shall be maintained till well established by watering, weeding, clipping, rolling etc

22.01.02 PREPARING CLIPPED HEDGES

Hedges made *of* Casuarinas or other shrubs as directed by the Engineer shall form borders between footpath and the Lawns. The shrubs shall be planted at spacing not more than 25 cms.

27.01.03 Planting Shrubs

Shrubs with coloured leaves like Crotons, Acalyphia, Oleander and Bougainvillea, Hibiscus etc. which are perennial shall be planted in clusters or over a large area at locations and in the manner as per approved layout. These shrubs shall be planted at spacing *of* not more than 25 cms.

27.02.00 INSTALLATION OF WATERING SYSTEM

or shall prepare and submit watering System *for* the Plants. Drip Irrigation and Spray System consisting *of* complete G I pipe with all necessary bends, Tees, Elbows etc., valves, stop cocks, Spray nozzles, sufficient lengths *of* Flexible PVC pipes to reach all area *of* Landscaping shall be included in the watering system. Only after approval of the Engineer, the Contractor shall commence the work. The engineer, however, reserves the right to modify the layout system if he deems necessary although he earlier approved it.

23.0 BORED CAST IN SITU CONCRETE PILE

23.1 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:29ll (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.

23.2 GENERAL

23.2.1 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) 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 pile installation equipment.

g) Provide all necessary work mentioned under "Technical Specification for Cement Concrete (Plain and Reinforced)", as may be applicable.

23.2.2 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.

23.3 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. (Part-I/Sec.2)

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.

23.4 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.

23.5 MATERIALS

23.5.1 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.

23.5.2 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.

23.5.3 Concrete

Concrete type M-25 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 would be 400 kg/m^3 based on subsoil condition requirement besides that required from strength and other considerations.

23.5.4 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.

23.6 STORAGE OF MATERIALS

23.6.1 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.

23.6.2 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.

23.7 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

23.7.1 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.

23.8 INSTALLATION

All installation requirements shall be in accordance with IS : 2911 (Part - II 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.

23.8.1 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 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.

23.8.2 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 abovementioned 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.

23.8.3 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.

23.8.4 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.

23.8.5 Boring

a) 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 labeled 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.

b) 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 chiseling, 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).

23.8.6 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.

23.8.7 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.

23.8.8 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 carried 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.

23.8.9 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/m3) 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.

23.8.10 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.

23.8.11 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 concreted 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.

23.8.12 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.

23.8.13 Trimming of Pile Heads

Completed piles shall be trimmed 10 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.

23.8.14 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 6(1:2 mix) immediately before the new concrete is placed.

23.8.15 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.

23.8.16 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 I :4:8 so that resistance to lateral forces on neighbouring piles are developed.

23.8.17 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.

23.8.18 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.

23.8.19 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.

23.8.20 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.

23.8.21 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.

23.9 TESTING AND ACCEPTANCE CRITERIA

23.9.1 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.

23.9.2 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).

23.9.3 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.

23.9.4 Load Tests

a) 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 c3pacities 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.

b) 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 over load 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 offload :

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 of the relevant Indian Standards and as supplemented herein.

b) 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 over load 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 docs not exceed 0.01” per tonne of the test load or ½” (12 mm) whichever is less.

d) 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 12 mm 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:

(i) Two-thirds of the total load at which the load displacement is 12 mm.

(ii) Half the load at which the load-displacement curve shows a clear break (downward trend).

Non-destructive Dynamic Test on Working Piles

e) "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 Ibs. 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.

f) "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 below, 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.

23.10 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 inc!. 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 50 mm.

23.11 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

23.12 INFORMATION TO BE SUBMITTED

23.12.1 With Tender

The tenderer should submit the following information along with his tender.

a) 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.

b) 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.

23.12.2 After Award

After award of the contract, the successful tenderer is to submit the following details

a) 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.

b) 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.

c) 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.

23.12.3 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.